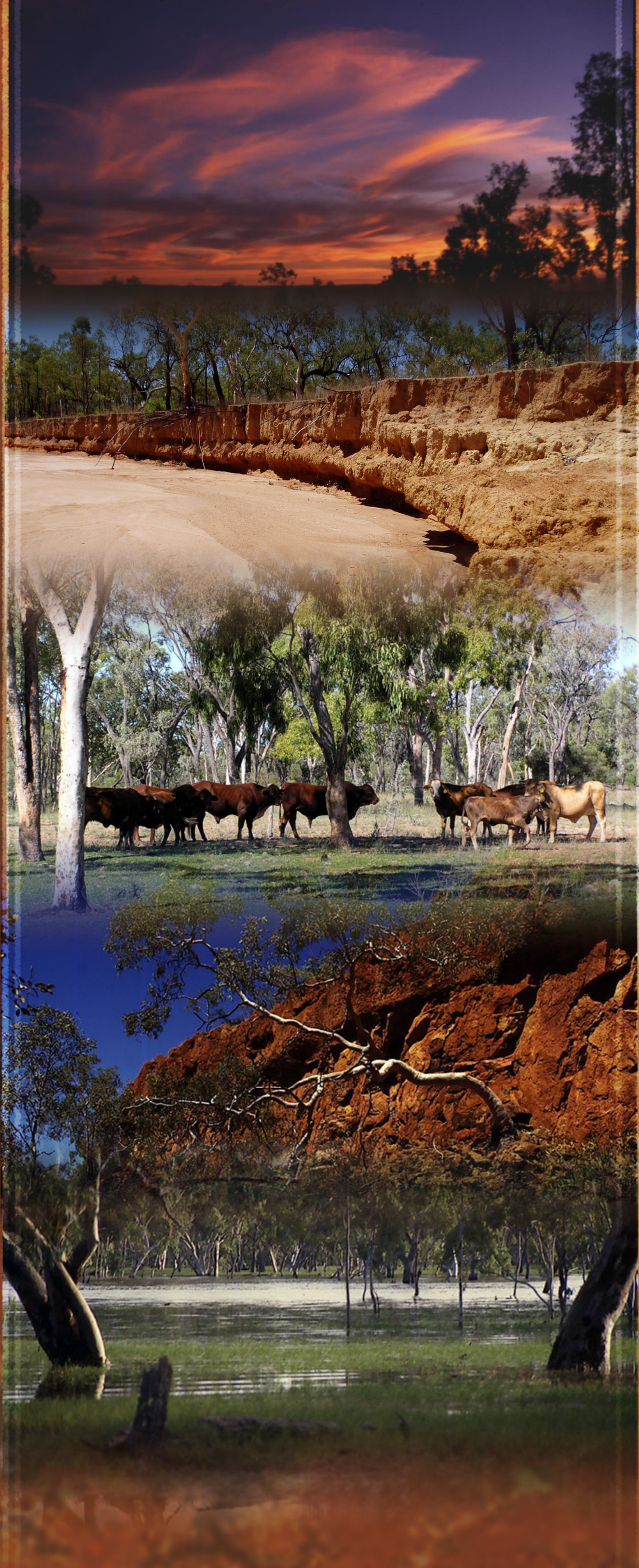
The Desert Uplands: an overview of the Strategic Land Resource Assessment Project

2005



A partnership between...

Desert Uplands Build-up and Development Strategy Committee

Queensland Government
Environmental Protection Agency

Natural Heritage Trust
Helping Communities Helping Australia

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Acknowledgements

This project grew enormously since the members of the Desert Uplands Build-Up and Development Strategy Committee (DUBDSC) first proposed it in 1997, and along the way to completion many people have been involved. Lack of space and a fading memory prevent all from being mentioned here, suffice to say, all contributions large or small in the form of information, advice, assistance or finance in creating the Desert Uplands database have been most welcome and truly appreciated.

There are some, however, that require a special mention:

- First of all, Mrs Lesley Marshall (land owner and inaugural chairperson of the DUBDSC) and Margaret House (landholder and a founding member of the DUBDSC) have been outstanding in their commitment to raise the level of land management, and to address the issues and difficulties facing land owners and the general community, within the Desert Uplands. Both Lesley and Margaret remained positive throughout the project as they could see the long-term benefits of a community working in partnership with the Environmental Protection Agency on this major project. The culmination of almost six years work to produce the Desert Uplands Land Resource Database is testament to that resolve. After eight challenging, but very productive, years Lesley stepped down from the role of Chairperson, but continues to be an active committee member. Thank you Lesley for your unwavering support and encouragement, all the way from preparing the initial project proposal and application for funding right through to this final report. It has been an honour to work with such a dedicated group of people.
- Sincere thanks to the members of the original project field team: David Phillips (field-team leader), Marnie McCullough (botanist) and Adam Marks (technical officer). Their efforts during the many week-long field trips, often under trying conditions, were quite remarkable. The soil, vegetation and landscape data collected during those first three years is the 'foundation stone' upon which this report is constructed. Equally important is the contribution by the original GIS/database team of Michael Hartcher and Rod Nielson, to be followed in the latter half of the project with great enthusiasm by Cherie Stafford, Mirjam Alewjnse and Michelle Richards. Digitising all the line work to create maps and collating all the information into tables, checking and double-checking the database for errors and missing data, and presenting the final report on compact discs was a huge task, done professionally and with great pride. Further information about each team member and their role in the project can be found in Appendix 1.
- Thank you also to the landowners within the study area, who made the field team welcome on their properties and provided time-saving information on condition of tracks and access to various areas of interest, as well as volunteering personal experiences on the management and performance of different land types. Scientific information can always be collated and summarised, but it must be combined with local knowledge and compared with the kind of land management practices currently in use, before any worthwhile statements can be made on sustainable levels of productivity, maintenance of biodiversity, or susceptibility of different land types to various processes of land degradation. The information collected in the field and summarised in this report is available to all landholders in the Desert Uplands, whether or not the information was collected from their properties. Good land management is based on a knowledge and understanding of the inherent capabilities and limitations of different land types for specific uses, and being able to operate within those constraints to achieve maximum, sustainable levels of productivity. I am confident that this report will add to the existing knowledge and understanding of landowners in the Desert Uplands.
- The partnership between the DUBDSC and the Environmental Protection Agency (EPA) during the project never wavered. In fact, the level of support and positive input by Dr. Margaret Card (Director Environment, Northern Region) and Murray Whitehead (Manager Biodiversity Planning, Northern Region), both of EPA Townsville, has been outstanding. Recognising the high environmental benefits of knowledge-based management, the EPA has strongly value-added to the original project by providing additional funds and staff to ensure the project was completed and presented in a user-friendly format. Sincere thanks to Gethin Morgan (Senior Principal Biodiversity Planning Officer), for identifying the appropriate regional ecosystems for the vegetation communities described in the land units and for his constructive comments on the general text, particularly the land management aspects, of the report; Sharon King (Team Leader, GIS), who guided the GIS team along the right path, ensuring the database structure was sound, and providing excellent advice regarding the presentation of the report onto compact discs; Sue Gardiner (Team Leader, Extension services), who took such a personal, enthusiastic approach to editing and arranging the text to conform with the standard format of EPA; Cheryl Culleton for 'translating' hundreds of pages of my handwriting into a WORD document for the initial report in 2003, and Jean McMahon and Ellyse Miflin for arranging the text in this final technical report.

- The monetary contribution from other sources is another feature of this project. This involvement and therefore part-ownership of the project gave enormous strength to the original application for Natural Heritage Trust funding, not to mention the 'encouragement' from time to time by these stakeholders to hurry up and produce the maps and land resource information, as promised, because they "wanted the information". A very grateful thankyou to the Department of Natural Resources and Mines ($105,000), the Co-operative Research Centre for Tropical Savannas ($42,290), and the shire councils, who contributed in proportion to the area of the Desert Uplands study area in their shire, viz Aramac ($9,400); Barcaldine ($3,100); Belyando ($4,100); Blackall ($2,300); Flinders ($9,700); and Jericho ($9,400).
- Mr Con Lockers (field naturalist, Townsville) kindly provided a list of plants, complete with botanical and common names, which filled many gaps in the list of more than one thousand four hundred and seventy four plant species for the Desert Uplands bioregion, thus helping to produce a complete data set.
- Dr Ross Coventry, James Cook University, reviewed the overview sections on geomorphology and soils, despite a very busy schedule. His constructive suggestions have been included, resulting in an interesting story of the processes and results of soil and landscape formation within the study area.
- Dr Christian Roth, CSIRO, provided valuable support in establishing a Memorandum of Understanding with EPA to provide services and technical information, particularly the specialised satellite images with AMG referencing. He also provided a review of the contents and structure of the final report.
- David Jacquier, CSIRO Canberra and David Maschmedt, Dept of Water, Land and Biodiversity Conservation Adelaide, kindly allowed photographs of soil profiles from 'Australian soils and landscapes – An illustrated compendium' (2004) to be used in Section 4 of this report.
- Thankyou to INCITEC Ltd. (Morningside, Queensland 4170) for their analysis of soil samples: the short time period between dispatching the batches of samples and receiving the chemical analyses was greatly appreciated.
- Thanks to Andrew Parker of Practical Solutions Engineering for advice and assistance in the initial development of an ACCESS database.
- Memorandums of Understanding were established with the CRC Tropical Savannas (Atlas of Desert Uplands), and the (then) Department of Mines and Energy (radiometric images) to facilitate the use of information that would assist the planning of fieldwork and the interpretation of data collected.
- The maps presented in the Desert Uplands Strategic Land Resource Assessment Database use data layers from numerous agencies. The projection used is Universal Transverse Mercator – Map Grid of Australia Zone 55, Spheroid is Australian and Datum is Geocentric Datum of Australia 1994. All maps have been produced by the GIS Unit – Northern Region, EPA, and are current as of November 2005.
- The EPA (incorporating the Queensland Herbarium and Queensland Parks and Wildlife Service) has provided the data delineating land systems and land units, DUSLARA sites, Herbarium sites, CORVEG sites, Buchanan – Lake Galilee sites, study area boundary, bioregional and subregional boundaries and bio-climatic rainfall surface.
- The EPA has also used the following data and gratefully acknowledges the permission of the data custodians:

Property boundaries are reproduced from the Queensland Pastoral Holdings Address Data with permission of ERSIS Australia Pty Ltd, November 2003.

- Last, but equally important, the Natural Heritage Trust (NHT) is acknowledged for supporting this project with two grants of money: $600,980 for the first part of the project and $68,400 to include the Desert Uplands portion of the Dalrymple Shire, thereby allowing the production of a complete database for the whole bioregion. This comprehensive land resource database is now readily available to the whole Desert Uplands community, which includes individual land owners, community groups, local government, regional planning bodies, government agencies, universities and research organisations, and ensures the information can be used to provide a sound basis for land use planning and land management options for decades into the future.

Dr Mal. Lorimer
Project leader, co-ordinator and author
Principal Conservation Officer
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Summary

This report and the accompanying digital database, present the results of the Desert Uplands Strategic Land Resource Assessment (DUSLARA) project and the Rationalisation of Dalrymple Land Resource Data project, which were initiated by the Desert Uplands Build-up and Development Strategy Committee (DUBDSC) in partnership with the Environmental Protection Agency (EPA). The report and database provide land resource information that will help land managers achieve long-term economic and social stability in the Desert Uplands region.

The land resource study is based on the land system concept and involves the use of remote sensing techniques initially to identify broad geomorphic features, followed by an intensive period of field work to collect site, soil and vegetation information and finally, to present the data in a ‘user-friendly’ format. The land system method, in which soil-vegetation associations conform to a predictable and recurring pattern within areas of similar geology, physiography and climate, provides a consistent, logical identification of different land types across the whole bioregion. Once identified, the different land types are described according to inherent limitations and capabilities for current and future land uses.

The technical report has six overview sections:

- Section 1 introduces the project and its objectives, and describes how project data was collected and analysed.
- Section 2 is an overview of the climate of the bioregion, and also discusses the effects of climate on plant growth, soil water storage, and erosion.
- Section 3 describes the geomorphology of the Desert Uplands, including descriptions of the four component subregions. Significant geomorphic features are considered and described.
- Section 4 discusses soils and their importance, soil classification systems, and includes descriptions, distribution maps and illustrations of the major soil types in the region.
- Section 5 describes the major vegetation communities in the Desert Uplands, and contains summary maps of their distributions.
- Section 6 summarises the large range of different land types into fifteen Land Management Units, with descriptions of their inherent characteristics and any implications those characteristics may have on land management practices or land use.

These sections are followed by a number of appendices, a glossary of terms and abbreviations and a bibliography.

Approximately 4,135 field sites from five different sources have been used to collate the vast amount of information contained in this database. In total, 47 map sheets at a scale of 1:100,000, 79 land system information sheets, 335 land unit information sheets, 3,218 site information sheets and 524 individual property maps have been prepared, all of which can be viewed or printed from the database.

The Desert Uplands Strategic Land Resource Database is extremely versatile as it can provide general information for the whole bioregional right through to detailed information at a property level and individual sites. The database is available on CD-ROM from the DUBDSC office in Barcaldine or the EPA office in Townsville.

All this land resource information is available to the whole Desert Uplands community, from individual land managers to community groups, local government, regional planning bodies, government agencies and research organisations. The database has been prepared with the objective of providing a sound basis for current and future land-use planning and land-management decisions.

1. Introduction

1.1 Project background

The Desert Uplands Strategic Land Resource Assessment project (DUSLARA) evolved from concerns expressed by members of the Desert Uplands community that land management is one of the important issues that needs to be addressed to ensure the long-term economic and social sustainability of the region. The Desert Uplands Build-Up and Development Strategy Committee was formed in the mid-1990s and produced a comprehensive position paper in 1996 (DUBDSC 1996) after extensive community consultation. The DUBDSC then developed a strategic plan (DUBDSC 1998) for integrated regional adjustment and community development, which the State and Federal governments supported with a grant of $4 million for the 'Desert Uplands Community Scheme'. During the period of intensive activity following the allocation of this grant, the DUBDSC realised that their community needed better land resource information than was currently available. The information also needed to be consistent across the whole region and at a level of detail that could be used at the scale of individual properties.

Fortuitously, at this time, the EPA and a combined team from the Department of Primary Industries (DPI) and Commonwealth Scientific Industry Research Organisation (CSIRO) were completing detailed land studies in two areas: the Lake Buchanan/Galilee catchments and the Dalrymple Shire, respectively. The DUBDSC decided that it would like to develop the same level of detailed land resource mapping for the whole Desert Uplands bioregion. They prepared an application, in partnership with the EPA, who would provide the technical input, for Natural Heritage Trust (NHT1) funding. The project was approved, and attracted total funding of $1.5 million, which included monetary and 'in-kind' contributions from EPA, DUBDSC, Department of Natural Resources and Mines (DNRM), Tropical Savannas CRC and the Shires of Aramac, Barcaldine, Blackall, Belyando, Jericho and Flinders.

The EPA project team commenced work, under the supervision of Dr. Mal Lorimer, in March 1999. Three years of intensive fieldwork followed collecting site, soil, and vegetation information from six of the seven shires involved in the study area. A further eighteen months was spent analysing the data, preparing 1:100,000 map sheets and individual property maps, information sheets for land systems, land units and individual sites, writing a regional overview of the climate, geomorphology, soils, vegetation and land use implications, and finally, creating a user-friendly digital database.

The second part of the project involved collating all the existing site data for the Desert Uplands portion of the Dalrymple Shire, which accounts for approximately 35 percent of the study area, and presenting it in the same format and level of detail as the first part of the study. A preliminary map of land systems and land units was prepared from interpretations of satellite images and aerial photographs, and then modified according to specific site information on the soils and vegetation obtained from previous land resource studies. One field trip to verify land unit descriptions and obtain representative photographs, prior to finalising the text, covered approximately 1,400 kilometres. The additional area within the Dalrymple Shire required a further 18 months, bringing the total period of time for the whole project to six years.

The Desert Uplands Land Resource Database, including this technical report, is available on CD-ROM from:

The EPA Customer Service Centre.
Ground Floor, 160 Ann Street,
Brisbane. 4000. Queensland.
Ph. 07 3227 8187 or 3227 8197.

or

The DUBDSC Office.
PO Box 310,
Barcaldine. 4725. Queensland.
Ph. 07 4651 1002,

1.2 Project objectives

The two main project objectives were:

- To identify and map the land types, including all soil and vegetation information, in a consistent format at a scale of 1:100,000 for the Desert Uplands 'designated area' * occurring in the shires of Aramac, Barcaldine, Blackall, Belyando, Dalrymple, Jericho and Flinders.
- To ensure all the land resource data generated by the project is readily accessible to individual land managers, community groups, regional bodies and government agencies.

(* Any property that had at least ten percent of the Desert Uplands bioregion within its boundaries was included in the 'designated area' and is therefore able to access funding and assistance through the DUBDSC described above. This extension to the bioregional boundary added approximately 16,270sq.km to the study area, giving a total of 85,101sq.km covered by the DUSLARA project).

1.3 The study area

Figure 1.1 shows the location of the Desert Uplands bioregion and study area covered by this project. The Desert Uplands bioregion is situated in north-central Queensland between Charters Towers and Hughenden in the north, and Alpha, Blackall and Barcaldine in the south and covers an area of approximately 68,827sq.km (four percent of the State). It is one of 85 distinctive bioregional landscapes recognised in Australia (Environment Australia 2000), and one of thirteen described for Queensland (Sattler and Williams1999). The bioregion straddles the Great Dividing Range between Blackall and Pentland.

The bioregion is a remnant of an old land surface, which forms part of the Great Dividing Range. To the northeast and east the catchments of the Burdekin, Belyando, Cape and Campaspe Rivers drain into the Coral Sea; in the northwest corner the Flinders River drains into the Gulf of Carpentaria, and to the west Torrens Creek and the Alice and Barcoo Rivers drain into the Lake Eyre Basin.

The Desert Uplands derives its name mainly from the semi-arid climate, in which the summer rainfall is both erratic and unreliable, and also from the sandstone ranges, the elevated sand plains, and the plateau underlain by laterite, which occur throughout the bioregion. All of these factors result in soils that, in general, have poor structure and low fertility (Ahern *et al*. 1994), and pastures that are in many areas dominated by spinifex. However, the most important feature of the bioregion is its diversity of soil-vegetation associations, which range from heathlands and very sparse low woodlands on shallow sands, which are almost devoid of nutrients and overlay a ferricrete hardpan, to closed woodlands of gidgee and blackwood, or open grasslands on fertile clay soils.

Beef-cattle production on native pastures is the dominant land use, although the pressure on landowners to increase production and remain viable has resulted in a dramatic increase over the last decade in clearing the native vegetation, mainly the blackwood (*Acacia argyrodendron*), brigalow (*A. harpophylla*) and gidgee (*A. cambagei*) woodlands on deep clay soils, and more recently, the ironbark-poplar box woodlands on sandy texture-contrast and gradational-textured soils. Although approximately 80 percent of the bioregion remains uncleared (Environmental Protection Agency 2005), some of the highest rates of clearing in Queensland occurred between 1995 and 2004 in the south-eastern and north-western parts of the Desert Uplands bioregion. Despite increases in productivity on many properties with the introduction of buffel grass (*Cenchrus ciliaris*), land degradation, whether it be in the form of weed infestation, soil erosion, loss of biodiversity or declining vigour of the native plant species, still remains a major issue, since it was first highlighted in 1996 in the position paper prepared by the Desert Uplands Build-Up and Development Strategy Committee (DUBDSC 1996).

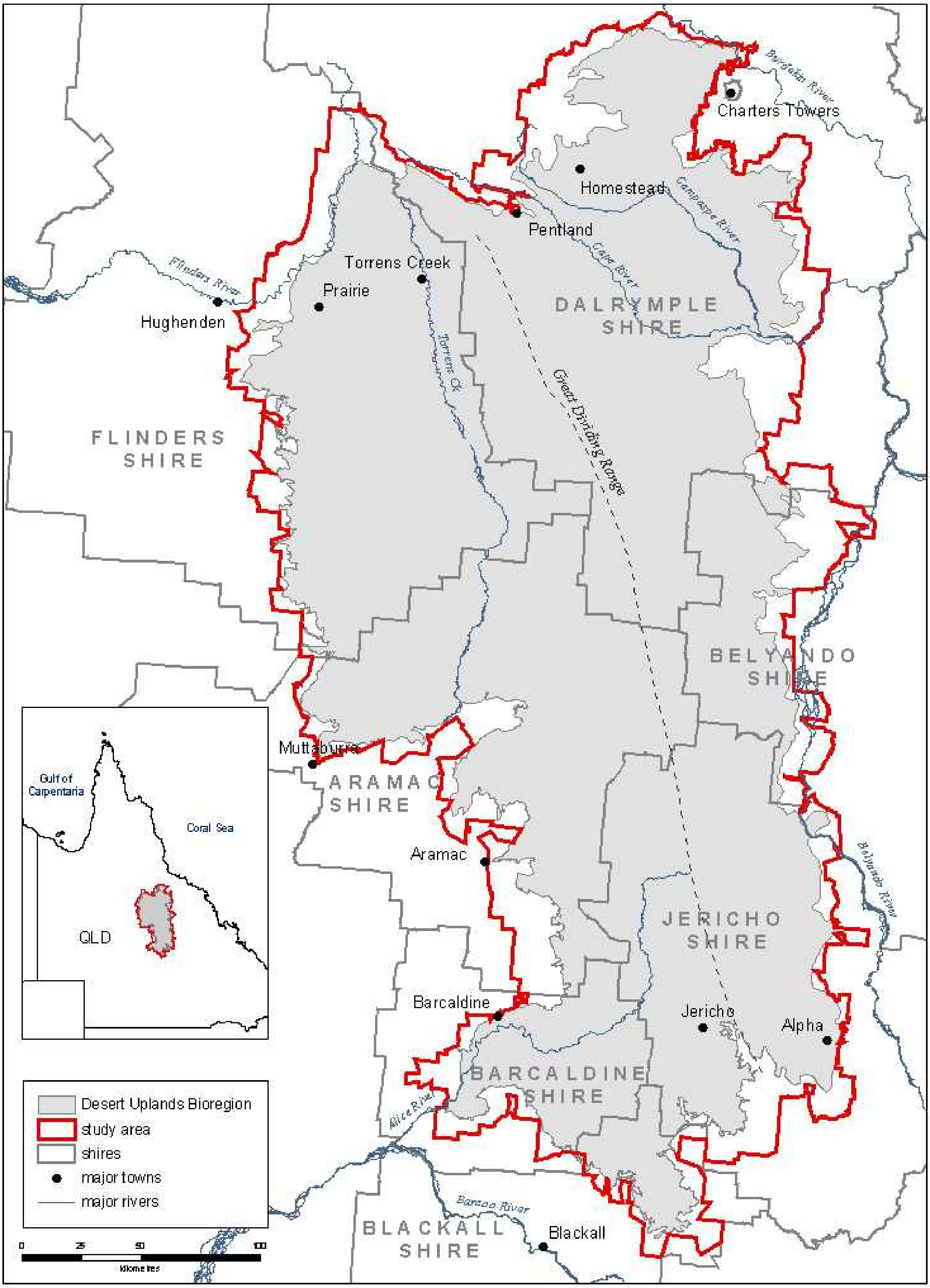

Figure 1.1 **The Desert Uplands Bioregion, showing the DUSLARA project area**

1.4 Project methods

1.4.1 The land resource assessment framework

The DUSLARA project uses the widely adopted land system approach to sample, classify and describe the land resources of the project area. The land system method of recognising and mapping landform patterns, and identifying the landscape position of different soil-vegetation associations, was first used over fifty years ago (Downes 1949, Christian and Stewart 1953). It is now used throughout Australia as an efficient method of mapping large areas of country. The methodology is described in the *Australian Soil and Land Survey Handbook* (Gunn *et al*. 1988).

Land systems delineate areas of land with a specific geology, landform pattern and climatic range, and a consistent pattern of land units: each land unit having a distinctive landscape position and a characteristic soil – vegetation association. While land systems have been mapped previously over the Desert Uplands, the component land units have only been broadly described, not mapped (Gunn et al. 1967, Perry et al. 1964, Turner et al. 1978, Turner et al. 1993). Consequently, the original maps are too coarse for use at a property level. This report however, identifies and delineates 79 land systems comprising 335 different land units at a scale of 1:100,000, and provides a detailed description of the land unit characteristics, together with a brief outline of the implications those characteristics may have for land use. Land units are the most useful scale of land resource mapping for property planning and management.

Regional ecosystems are also created, somewhat loosely, on the land system concept. A bioregion is subdivided on the basis of geology and landform patterns into land zones, which are then subdivided according to the soil and vegetation association into Regional Ecosystems (REs) - a further subdivision into 'vegetation units' may be necessary to accommodate variations in the number of plant species and their proportions. The mapping of vegetation across the Desert Uplands bioregion (Thompson and Turpin, 2003) identified 77 REs and was completed while the DUSLARA project was still in progress, and subsequent revisions of the Regional Ecosystem Description Database have taken place. This report refers only to the RE information in Version 5 (Environmental Protection Agency 2005), which lists a total of 75 REs for the Desert Uplands. The two map products (land systems and REs) overlap and are complimentary, but one cannot be a surrogate for the other as the object, methodology, and final use are different for each one.

The land systems also provide a hierarchical framework for gathering information and for establishing the project database. This enables data to be placed or extracted according to the level of detail contained in the data being entered, or the kind of information required from the database. Figure 1.2 illustrates this concept of increasing detail as each level of information is subdivided. The database is discussed further in Section 1.4.4.

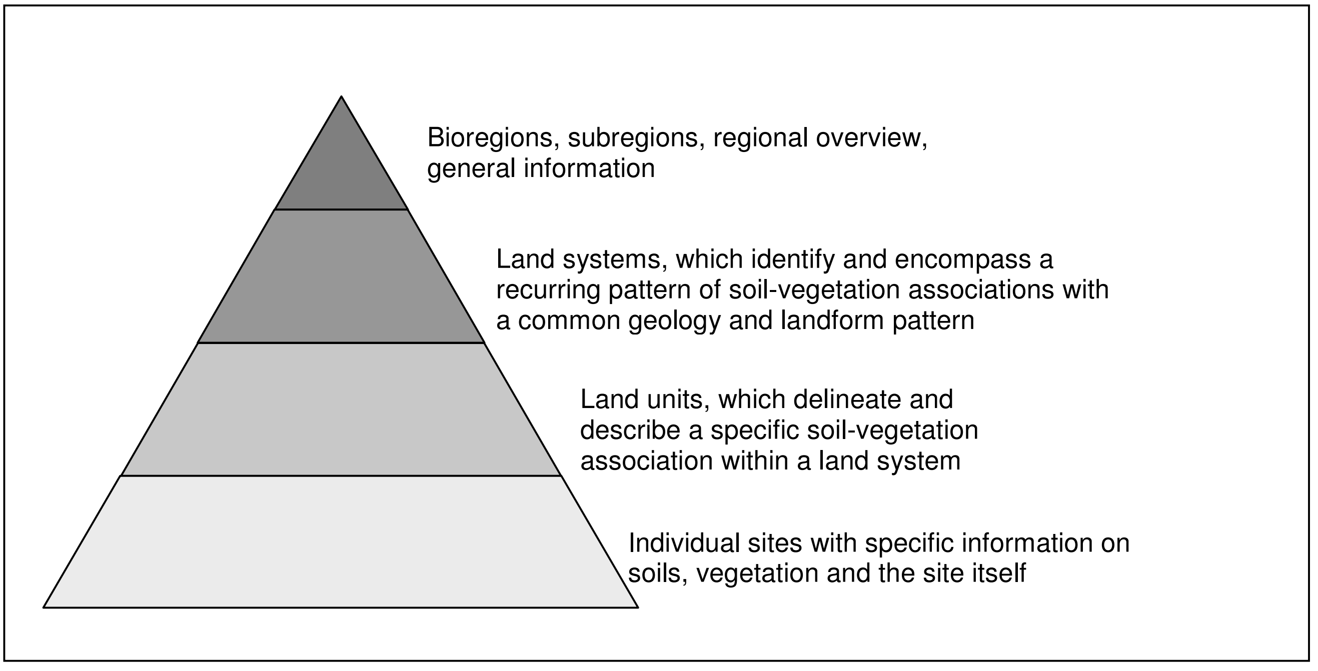

Figure 1.2 A framework depicting the hierarchical order of information in the Desert Uplands resource database

1.4.2 Preparations prior to fieldwork

Because the study area is so large (approximately 85,101sq.km) and driving time to the study sites could be up to nine hours, fieldwork was conducted in five-day periods. This required careful planning and appropriate equipment for fieldwork, camping and communication. Also, high capacity computer software was necessary for the anticipated vast quantity of land resource information to be collected over a three-year period and for the retrieval of data from a geographic information system database in the form of maps and associated spatial and descriptive information.

Topographic map sheets for the study area at a scale of 1:100,000 were not available at the time. Satellite images were prepared for the first three years of the project by CSIRO, as half sheets of the 1:100,000 series using Thematic Mapper (TM) bands 1, 5, and 7, which gave a clear definition of soil-vegetation associations. This was a convenient size to use in a vehicle and navigating or identifying specific locations simply required marking the reading from a global positioning system (GPS) in the vehicle directly onto the half sheets, which had the Australian Map Grid (AMG) printed at one kilometre intervals.

Black and white aerial photographs taken from a height of 25,000 feet (7620m) were available for the whole study area and approximated to a scale of 1:68,000. In combination with geological maps at a scale of 1:250,000 for the whole area and radiometric maps at a scale of 1:300,000 for the northern and south-eastern portion of the study area, the broad geomorphic features were identified and given an initial land system code. Within each land system, the different tones, indicating possible changes in vegetation or landscape position, were delineated on the aerial photos and given a specific number for that unit within the land system.

The linework on the aerial photos was copied onto 1:100,000 base maps using an artiscope and then digitised into the EPA geographic information system. Preliminary maps with property boundaries and homesteads were then printed as 1:100,000 half sheets to coincide with the satellite images, and provide a basis for planning the route and possible transects for the next field trip. The objective for each field trip was to concentrate on an area of approximately 30km x 30km and identify suitable transects, such as roads, fence lines, power lines etc, that would cut across as many different land units as possible. The primary function of the field work was to collect soil, vegetation and landscape information that would verify or modify the preliminary land system and land unit boundaries established by remote sensing, and provide the detail to adequately describe each landform pattern and soil-vegetation association.

Once the transects and potential sampling sites were marked on the field sheets as a possible field trip, the relevant property owners were contacted by telephone to request permission to enter the property, to enquire about the condition of tracks, possible access to specific areas of interest and for any information about the soils and vegetation in the area.

The field team was self-sufficient with a large 4WD vehicle and a purpose-built, enclosed trailer, which carried all the fuel, water, food, field equipment and camping equipment, together with enough space for all soil samples and plant specimens collected during a five-day field trip. Field trips usually took place every second week during the dry season (April-November) with the in-between weeks spent entering soil and vegetation data into the computer database, preparing soil samples for chemical analyses, identifying and mounting plant specimens, processing and annotating photos with date and site number, and planning the route and contacting landholders for the next field trip.

1.4.3 Field data collection

Three levels of data (primary, secondary and tertiary) were collected and recorded during fieldwork for the first part of the project, covering 65 percent of the study area. The codes and values for site and soil criteria followed the standards of the *Australian Soil and Land Survey Field Handbook* (McDonald *et al*. 1990).

Primary sites

These sites represent the most detailed site information available. A total of 381 primary sites were described and recorded on standard field sheets (see Appendix 2) under the following headings:

Standard site data

- date
- site number
- AMG (from GPS)
- runoff
- permeability
- drainage
- slope category
- morphological type
- element type
- landform pattern
- erosion/modal slope class
- aspect
- slope value
- surface micro-relief
- type of erosion
- degree of erosion
- inundation
- surface coarse fragments
- rock outcrop
- slope profile
- slope plan
- solum depth
- regolith depth

Soil profile details

From soil samples extracted with a hand-auger, down to two metres where possible, the following characteristics were recorded on the standard field sheet for each horizon:

- horizon code
- upper and lower depth of horizon boundaries
- abundance, size, colour and contrast of mottles
- texture
- abundance, size, shape, lithology and strength of coarse fragments
- grade, size and type of structure
- consistence
- abundance, nature, form, size and effervescence of segregations
- field pH

The soil profile was classified on site using two methods: *The Factual Key to Australian Soils* (Northcote 1979) together with the New South Wales extension (Charman 1978) to provide information on the topsoil (see Section 4 for a full explanation); and *The Australian Soil Classification* (Isbell 1996). However the classification was not finalised until values for the base status, sodicity, exchangeable sodium percentage, calcium:magnesium ratio and free ferric oxide content were available from subsequent laboratory analysis.

A 1kg sample (approximately) was bagged and labelled for later analyses. From these, a total of 1176 samples of approximately 200g each were sent to 'Incitec Ltd' for analyses. The analyses and methods used are listed in Appendix 3. Additional measurements included:

- a gravel content analysis, where the whole sample was air-dried, crushed and the gravel collected in a 2.0mm sieve. The weight of gravel was recorded and calculated as a percentage of the total weight of the sample. The sieved portion was recorded, after a sample was taken for chemical analyses, and stored in an airtight container for future reference.
- a slaking-dispersion test to measure the stability of soil aggregates in water Details of the method and definitions of slaking and dispersion are in Appendix 3 and the glossary respectively.

Vegetation details

Details of vegetation were recorded on a standard site sheet (Appendix 4), including:

- date
- site number
- AMG reference

- distance and bearing to nearest township
- land condition assessment (see below)
- any disturbance as a result of clearing, fire, grazing, weeds or feral animals
- landform element
- vegetation community
- notes on grazing pressure
- notes on weeds

At five metre intervals along a fifty metre transect, selected as representative of the site, a rectangular grid equal to one square metre and subdivided into ten equal areas (deciles) was thrown at random and the following information estimated and recorded (Appendix 5):

- plant species within the grid
- basal area of grasses
- basal area of other species
- cryptophyte
- rock, stones and gravel
- litter (dead, detached plant material)
- bare ground.

All plant species occurring within a 5m x 20m rectangle (1000sq.m) were recorded. Specimens of unknown plants were labelled with the site number and kept in a plant press for identification back at the office. Each plant species was recorded with a percentage occurrence and height category (Appendix 4). The stem count and height category for each tree and shrub species that registered with the Bitterlich Stick (Grosenbaugh 1952) were recorded. An estimate of total crown cover was derived from the average height, diameter and number of crowns of all the trees within the 1000sq.m area (Appendix 6).

Photographs were taken to capture the typical density and composition of the vegetation, and the photo number recorded. Any additional plant species, not recorded within the 1000sq.m sampled area, but in close proximity, were noted.

Land condition assessment

Land condition was assessed for each site using a methodology that was developed over the first twelve months of the project, with various criteria added during that time to fine tune the assessments. Further details can be found in Appendix 7. The resultant method is iterative – other criteria might be appropriate or the individual scores for each criterion might be 'weighted' to indicate a greater or lesser importance than the other criteria. However, the final scores, which appear on the site information sheets, give a good comparative assessment of the condition of that site at the time of sampling.

NB. Land condition assessment scores only apply to an area within a 50-metre radius of the AMG reference point. They do not represent the condition of the whole land unit or general district, as insufficient sites were recorded to make such a statement.

Secondary sites

Twenty-three secondary sites were described. These unplanned sites were recorded because they possessed some feature that would assist in producing a more accurate description of the land unit, or the location of its boundaries. Soil profile exposures in gullies or borrow pits were particularly useful as the landscape throughout the study area is generally flat to gently sloping and exposures are extremely rare. Changes in vegetation communities or the sighting of unusual plant species were equally important items of information.

The location was recorded from the GPS, photos taken and the relevant details of the site recorded.

Tertiary sites

Soil type, slope and vegetation changed continually with distance travelled. These changes and their GPS locations were noted on a hand-held tape recorder, and a visual assessment of the land condition also recorded, together with any information or observation that might:

- enhance the land unit description
- define more accurately the boundary and extent of the soil-vegetation association
- create a better understanding of the capability of the land to withstand current land management practices
- recognise features that impart a limitation to diversification or increases in production.

Some 1305 tertiary sites were recorded, providing the additional information necessary to more accurately describe the variability of soil and vegetation within the extent of each land unit, and the positioning of land unit and land system boundaries.

1.4.4 Compiling the data

The Soil and Land Information (SALI) system owned and managed by DNRM was adopted at the beginning of the project for the storage and retrieval of all landform, site, soil, and land degradation information collected in the study area. The system has since been upgraded, but at the time of interpreting the data, it could not incorporate the large quantity of data in this study relating to soil analyses or vegetation. Also, the system could only provide a standard report, which only included soil and site information relevant to a specific site. This was not appropriate for the layout and content of the final report for this study, and the program was abandoned.

Consequently, the data were kept in EXCEL files, where they could be sorted and filtered to provide rapid summaries for the interpretation of site and land unit variability. However, there is a limit to the number of criteria that can be accommodated in one file before it becomes cumbersome to read, manipulate or print.

The ACCESS program was adopted because it provides a superior ability to interpret land resource data. Any number of files, provided they have a common item of information, can be linked, codes can be converted to full text, and pivot tables can be created to do calculations, remove repetition and sort the data in alphabetical or numeric order. All the land resource data is now situated in ACCESS tables with a comprehensive, interactive interface designed to allow a complete range of reports, summaries and interpretations to be extracted and printed from the database.

From these ACCESS tables, information reports were developed that collate all the field data for land systems, land units and individual sites. In addition, maps at a scale of 1:100,000 can be retrieved and printed.

A wide variety of geographically-referenced resource data was compiled from other sources for the project, including:

- data about the natural environment, such as soils, hydrology, climate, geology, geomorphology, land systems and land units, biogeographical regions and subregions, and regional ecosystems
- data about the human environment such as land tenure, regional legislative and administrative boundaries, airstrips and roads.

A detailed description of GIS techniques can be found in Appendix 8.

The true worth of the system is the ability to easily access and review data at varying scales down to a property level, which greatly assists in the provision of practical on-ground management information.

In total, 47 x 1:100,000 map sheets, 524 property maps, 79 land system information sheets and 335 land unit information sheets have been prepared. The data from approximately 4,135 field sites was extracted from six different land resource studies*, which covered different sections of the Desert uplands and different amounts of relevant information. Of these, the data from 3,218 sites have been presented in site information sheets, which can be found in the land resource information section within this CD-ROM.

The reader is referred to Appendix 10, which provides a cross reference between the dedicated site number shown on the DUSLARA maps and the actual site number used in the original study. Several of these studies used the same numbering system for field sites, hence the need to differentiate, and at the same time acknowledge, the input from different datasets and projects.

* The Western Arid Region Land Use Study IV (Turner *et al*. 1978)
  The Western Arid Region Land Use Study V (Turner *et al*. 1993)
  CORVEG – The EPA Herbarium database
  Land Resources of the Dalrymple Shire (Rogers *et al*. 1999)
  Catchment management in the Desert Uplands Part 2 (Lorimer 1998)
  The Desert Uplands Strategic Land Resource Assessment Project (Lorimer 2003)

2. Climate

2.1 Introduction

This section has been prepared from data made available especially for this project by the Bureau of Meteorology in 2003. Summary tables and charts have been collated from the data to provide a comparison between several locations within the study area.

The climate of the Desert Uplands varies from semi-arid in the southern portion, through to intermediate arid-tropical in the north. Since the majority of the bioregion lies to the north of the Tropic of Capricorn and to the west of the Great Dividing Range, the climatic zone is often referred to as the dry tropics or northern savannas. However, the erratic and often low rainfall, combined with the high rates of evaporation, indicate the word 'desert' is quite appropriate when discussing the availability of surface water.

From the detailed description of the Australian climate by Gentilli (1971), the Desert Uplands appears to be situated on the margin of four major climatic zones, often missing out on the rain accompanying each of these weather patterns. For example:

- The monsoonal influence coming from the Gulf of Carpentaria can bring prolonged heavy downpours to the 'Downs' country (the Mitchell Grass Downs) when cyclones develop in the Gulf and turn into rain depressions as they cross the coast. Such depressions have been known to move south right through outback Queensland, down the border of New South Wales and South Australia to the southern coast. Rarely do these rains extend further east of a line joining Hughenden through Aramac to Barcaldine.
- Cyclones that develop in the Coral Sea move along the Queensland coast and bring torrential rain to the coastal plains if they come close to, or cross the coastline. However, only occasionally does the rain extend southwest into the Desert Uplands.
- If the low-pressure systems that form in the southern ocean and the Great Australian Bight extend into south-western Queensland, the southern portion of the Desert Uplands around Jericho and Alpha can receive some useful winter rain. However the majority of the Desert Uplands is too far north to benefit from this weather pattern.
- The southeast trade winds bring moisture in from the Tasman Sea to the Australian coastline between central New South Wales and northern Queensland, but the majority of the rain falls on the seaward side of the Great Dividing Range, and a rain shadow extends across the Desert Uplands.

2.2 Rainfall

Figure 2.1 shows annual rainfall over the last century. The average annual rainfall for the whole region is 543mm, but this figure has little value, because of the extreme variation in rainfall across the region in any year, except to provide a comparison between years, and to identify any long-term trends in the regional rainfall pattern.

The lowest recording over the last 100-year period was 184mm in 1902. The two years before and after were also below average, making it an extremely dry period, and one of the worst droughts on record. The highest recording was in 1950 with 1265mm, however the preceding seven years and the following three years had average or below average rainfall. Another record wet year was 1956, with 1086mm of rain, which may have been more effective than the 1265mm in 1950 because the preceding two years were also well above average and ground cover would have, most likely, still been present to slow runoff and increase infiltration of water into the soil.

The ten-year running average for the early to mid 1900s appears to have a strong cycle of 18-20 years, with above average rainfall 1907 - 1921, below average rainfall 1921 - 1949, above average rainfall 1949 - 1961, below average rainfall 1961 - 1969, and above average rainfall 1969 -1980. But then the pattern changes to eight years of average rainfall 1980 - 1988 and then a further fifteen years of average to below average rainfall.

Similarly the 20-year running average for the first 60 years shows a strong cycle with intervals of approximately 20 years between the above and below average values. However, after 1970 the cycle disappears. Had the cycle continued, 1990 - 2000 should have been above average rainfall but 1992 - 1996 were well below average, and now the period 2000 - 2010 may return to the below average cycle.

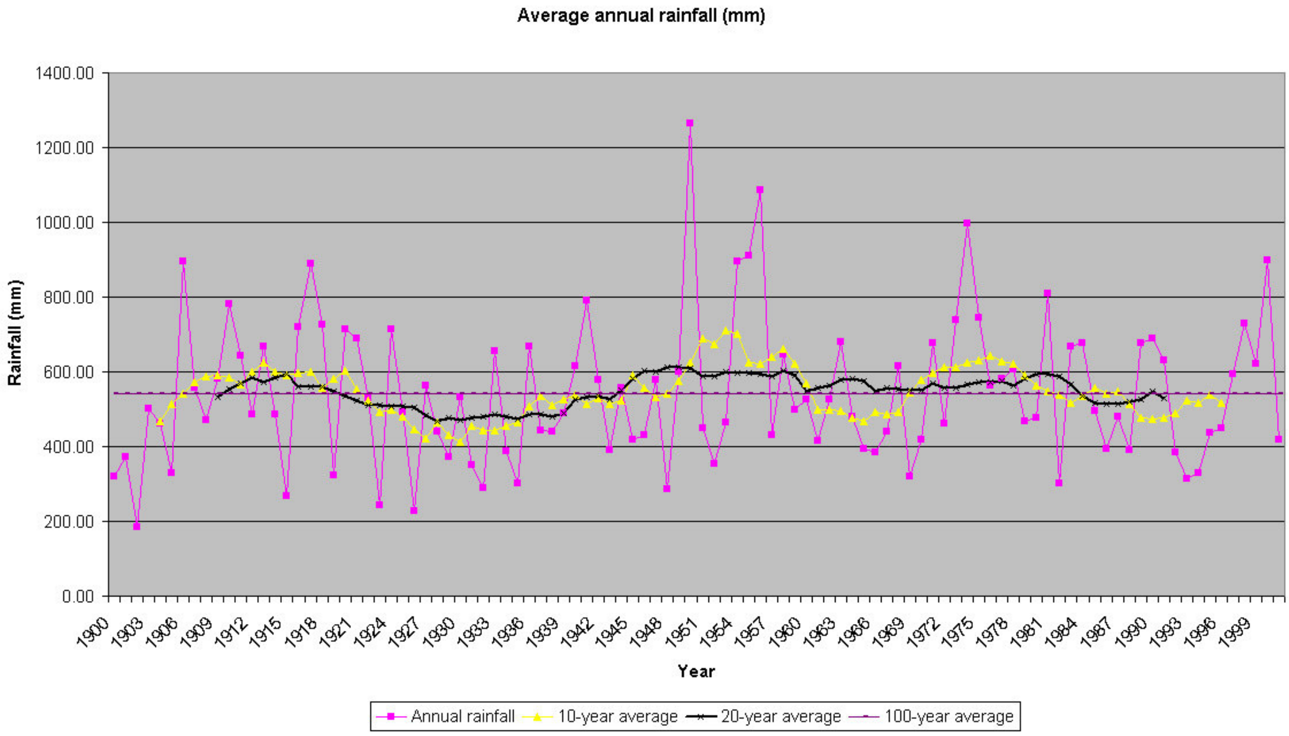

Figure 2.1 **Average annual rainfall for the Desert Uplands bioregion from 1900 to 2002**

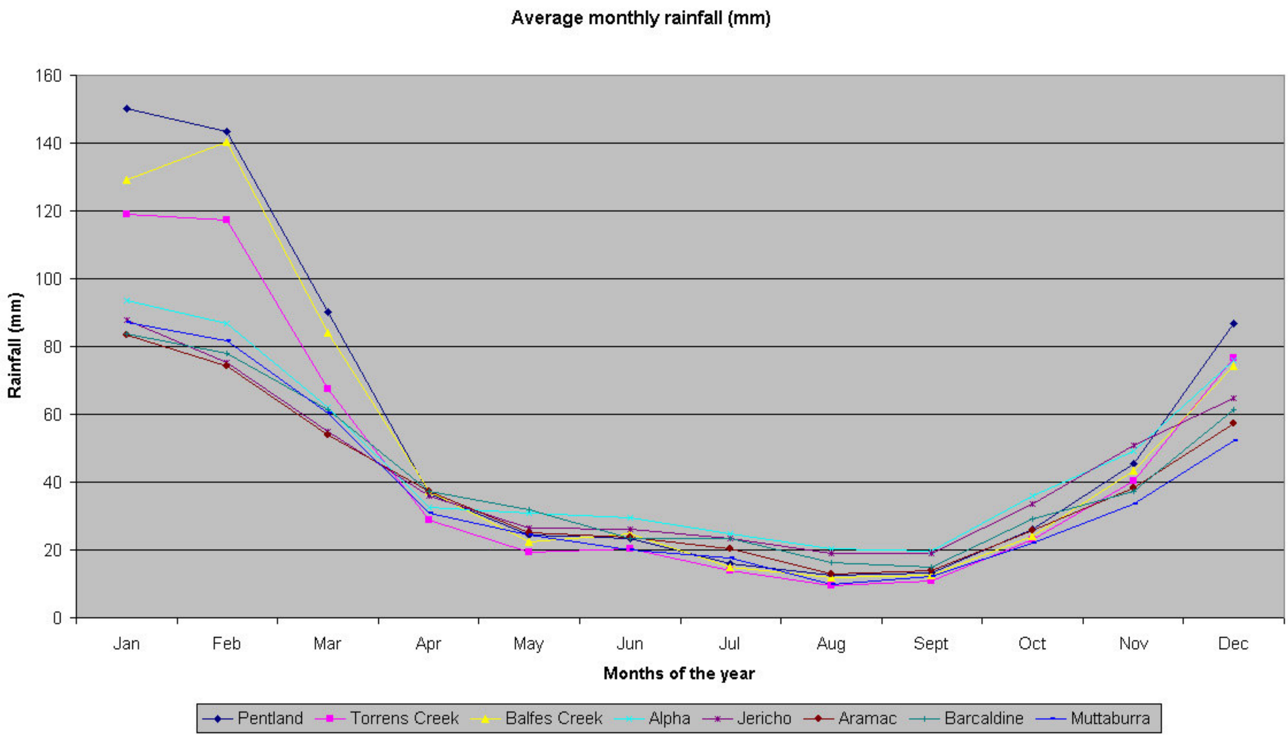

Figure 2.2 **Average monthly rainfall for towns within the Desert Uplands bioregion**

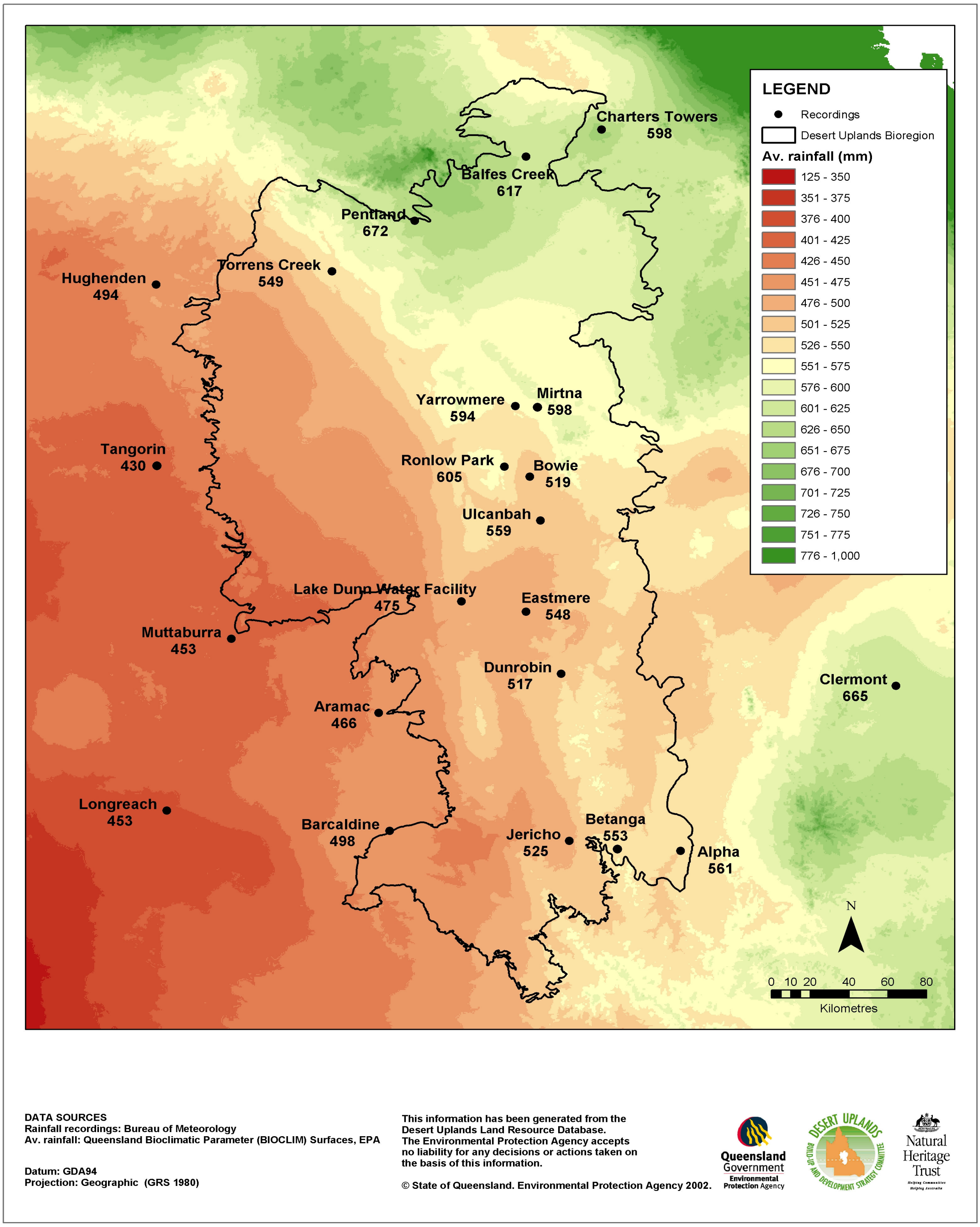

Figure 2.3 **Average annual rainfall summary for the Desert Uplands bioregion**

The average monthly rainfall for towns within the Desert Uplands is shown in Figure 2.2. Two trends are noticeable:

- January and February are the two wettest months while August and September are the two driest months of the year.
- The northern area (Balfes Creek, Pentland and Torrens Creek) has a markedly higher summer rainfall than the other towns and the southern area (Alpha, Jericho and Barcaldine) has a slightly higher winter rainfall than the other towns.

In Figure 2.3, two sets of data have been combined. Average annual rainfall values for the last 100 years up to 2003 are shown for specific towns and properties, whereas the different shades of colour, each representing a narrow range of average annual rainfall, have been generated from a computer model (ANUSPLIN) developed by the Centre for Resource and Environmental Studies, Australian National University. Data used in the computer model includes the monthly rainfall figures for the period January 1921 to December 1995, together with the elevation differences of the land surface. Standard relative errors in the charts derived from the computer model are approximately 10 percent, which accounts for most of the discrepancy between the rainfall values represented by a band of colour and the actual average rainfall recorded at specific locations.

The crescent-shaped rainfall zone extending from Pentland and Charters Towers in the north, around the eastern boundary through the property ‘Mirtna’ to Clermont and down to Alpha, represents a zone where the average annual rainfall is above that of the whole Desert Uplands region. Rainfall diminishes to the west such that Hughenden, Tangorin, Aramac and Barcaldine are well below the average annual rainfall for the region. The driest area appears to be westwards between Aramac and Muttaburra.

Interestingly, the average annual rainfall figures are higher than the median annual rainfall figures for all centres, except Balfes Creek (Figure 2.4). This suggests that a greater proportion of years have less rainfall than the average value, whereas a lower proportion of years with above average rainfall have excessive quantities of rain.

2.3 Temperature

The average monthly maximum and minimum temperatures are shown in Figure 2.5. The temperatures follow the expected trend of maximum values during summer and minimum values during the winter.

The summer maximums are consistently higher and the winter minimums are consistently lower on the Downs country. During January and February the highest maximum temperatures occur at Longreach, Hughenden and Barcaldine, that is, along the western margin of the bioregion. Clermont is consistently the coolest of the five locations, summer and winter, whereas Charters Towers has cooler maximum summer temperatures and relatively mild winter temperatures.

July is the coldest month with average minimum temperatures dropping down to 7 deg. at Clermont and 8 deg. at Barcaldine. Hughenden and Charters Towers are marginally warmer with 10 deg. and 11 deg. respectively.

2.4 Evaporation

The evaporation figures from a Class A pan (evaporimeter) presented in Figure 2.6 approximate to the potential water loss from a soil by evapotranspiration. Only three centres (Longreach, Hughenden and Clermont) record this data and they occur on the margins, but well outside, of the bioregion.

Longreach, with fewer wet days and low levels of humidity each month, has significantly higher evaporation rates than Hughenden or Clermont. Without any figures on evaporation from within the Desert Uplands region it is difficult to say just what the monthly rates and annual totals would be. Given that the region is predominantly under native woodland vegetation, the humidity levels are more likely to be somewhere between those of Clermont and Longreach, with resultant evaporation rates approximately 300 millimetres per month during the summer and approximately 120 millimetres per month during the winter.

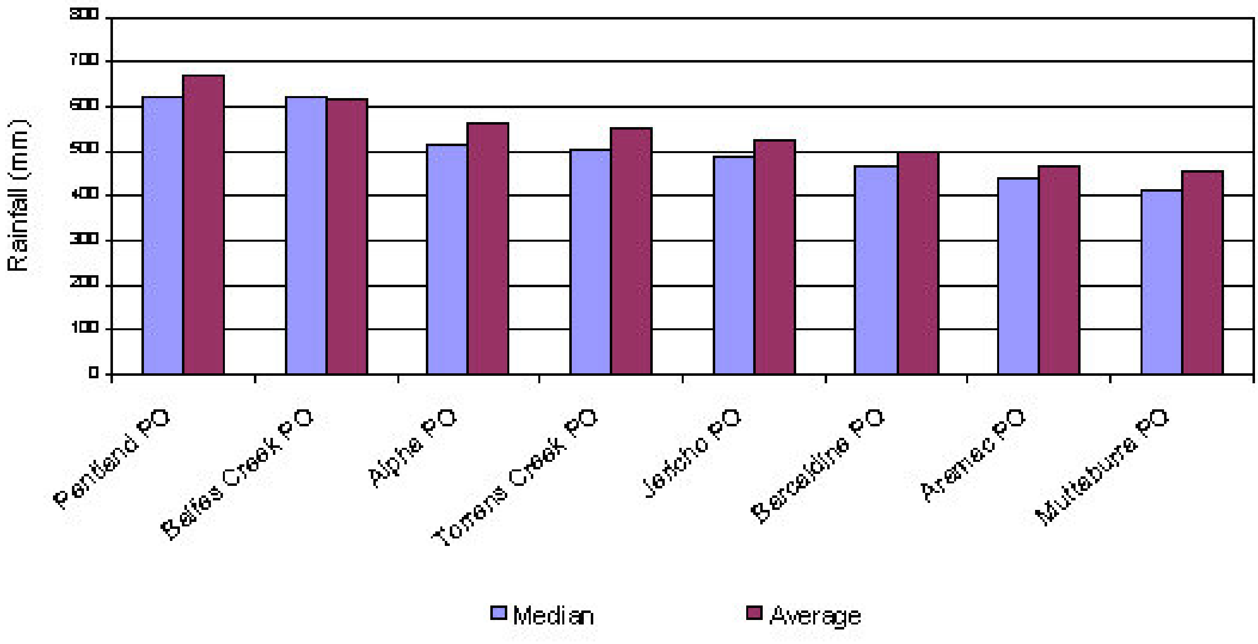

Figure 2.4 **A comparison of average and median annual rainfall for towns within the Desert Uplands bioregion**

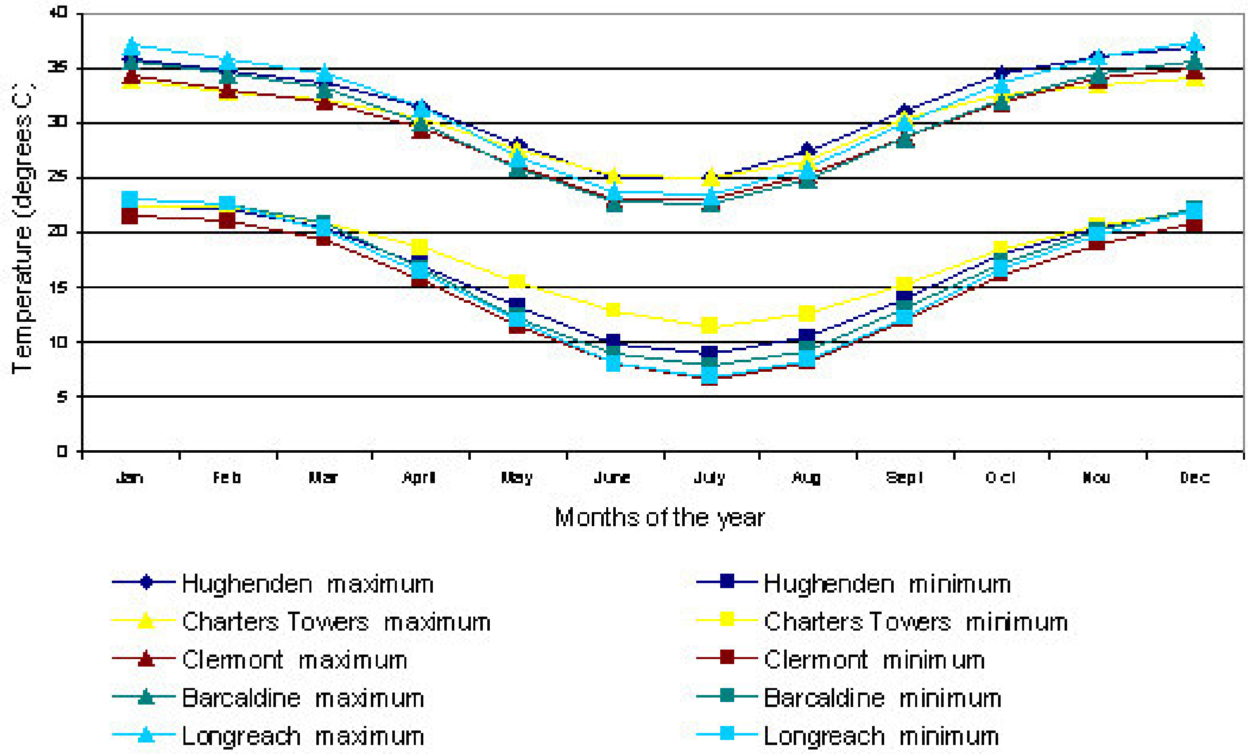

Figure 2.5 **Monthly maximum and minimum temperatures for towns adjacent to the Desert Uplands bioregion**

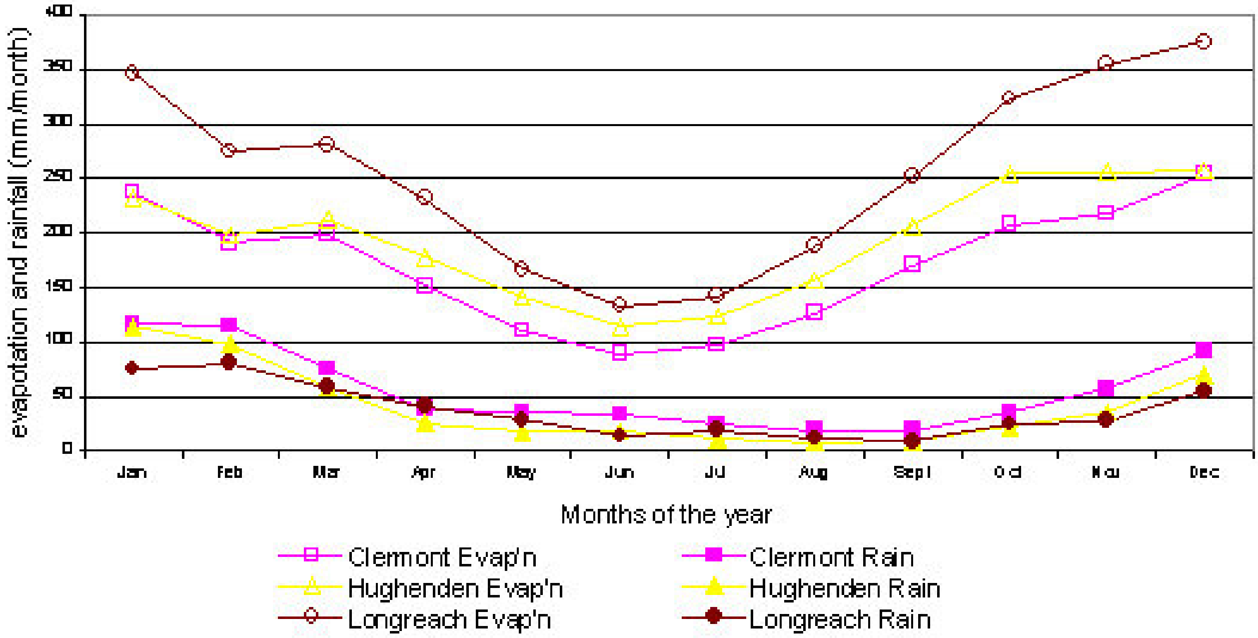

Figure 2.6 Average monthly evaporation and rainfall for towns adjacent to the Desert Uplands bioregion

2.5 Climate and plant growth

Low temperatures and lack of moisture are the two most important factors that restrict plant growth.

Limiting temperatures

It has been established that plant growth is severely retarded when the average monthly temperature falls below 10 degrees, and effectively ceases at temperatures below 7 deg. (Trumble 1939). Figure 2.5 indicates that plant growth is retarded for approximately one month (July) in Hughenden and three months (June-August) in Longreach, Clermont and Barcaldine. Longreach and Clermont have a colder July than other centres.

Limiting moisture

There are two different methods conventionally used to estimate the period in which plant growth is restricted because of insufficient soil moisture:

- The probability of receiving effective rainfall. Effective rain is defined as the minimum amount of rain necessary to start and maintain plant growth, and it corresponds to the amount of rainfall in excess of that lost through evapotranspiration. The length of a growing season relates to the number of months in which the probability of receiving effective rainfall exceeds 50 percent. This involves going through the rainfall records and counting the number of times effective rain fell and expressing those values for each month as a percentage of the number of years of records. Using this method on the climatic data from the three recording stations representing the Desert Uplands bioregion, the probability of receiving effective rainfall is less than 50 precent for every month of the year, thus drawing the conclusion that moisture is a limiting factor for plant growth for the whole year.
- The number of months in which rainfall is less than potential evapotranspiration. This method identifies a period when plant growth is restricted by lack of moisture and can be done simply by plotting the average evapotranspiration and rainfall figures for each month for each recording station (Figure 2.6). These results also clearly show that for each location moisture is a limiting factor for plant growth throughout the whole year.

Those who live in the Desert Uplands and witness the vigorous growth of vegetation after a wet season would consider the above conclusions incorrect and misleading. It would appear that neither method is sensitive enough, or is able to take into account the intensity and short-lived nature of wet-season storms, to identify the length of the growing season in the Desert Uplands. Pasture production after the wet-season is usually vigorous and can continue for a month or two without any indication of wilting. The native species have adapted to the short growing season and growth is opportunistic and dependent on rain. Other factors beyond climate also play an important role in determining how much rainwater enters the soil profile to provide plants with moisture over the following weeks or months. These factors include soil type, slope, infiltration rate, ground cover, intensity of rainfall and number of wet days/month, and are briefly described below.

Soil water storage

The amount of water that can be stored in the soil and the proportion that is available to plants has a direct influence on the length of the growing season. It depends on the amount of rainfall in excess of evapotranspiration, the depth of the rooting zone, the capacity of the soil profile to accept and store water, and site drainage, which in turn, is affected by other factors such as slope and subsurface pans.

Not all the moisture in the root zone of a soil profile is available to plants. As the size of the pores in the soil decreases and the proportion of very fine pores increases, plants find it more difficult to extract the moisture. This all relates to the term ‘available soil water’, which is the amount of water plants can extract from the soil. Soil pores greater than 30μm (1 micrometre = one thousandth of a millimetre) drain within a day or two under gravitational forces and allow gas exchange with the atmosphere, whereas pores less than 0.2μm bind moisture so tightly that it is unavailable to most plants.

As a general guide, the maximum available soil water of a profile can be calculated if the textures and depths of each soil horizon are known, using the values in Table 1 (Lorimer 1987).

Table 1 The relationship between soil texture and available water holding capacity

Soil texture	Available soil water (mm water/cm of soil)	Rating
sand	0.6	low
loamy sand	0.8	low
clayey sand sandy loam loam	1.3	moderate
sandy clay silty clay	1.4	moderate
clay silty loam silt	1.5	moderate
silty clay loam clay loam sandy clay loam	1.6	high

Organic matter in the soil has the ability to hold four to five times more moisture than an equivalent percentage of clay in the soil. Hence the importance of high organic matter levels in topsoils, not only as a source of nutrients and an aggregating agent of soil particles, but as a substance with a high water holding capacity. Unfortunately, the hot dry conditions experienced by most soils in the Desert Uplands bioregion result in a rapid breakdown and loss of any organic matter that accumulates in the topsoil.

Vegetation type

Native plant species have adapted in several ways to the high temperature and low rainfall pattern of the bioregion, one of which is the ability to extract moisture from the soil at levels well below the wilting point of many introduced species. Topsoils dry out very quickly and annual species, with shallow root systems, germinate, mature, set seed and die within a short period of time, because moisture becomes limiting and the probability of follow-up rain is low, that is, they have adapted to a very short growing season. Trees and deep-rooted perennial shrubs and grasses however are able to tap into the subsoil reserves of moisture and extend their growing season. For example, the availability of moisture in the deep subsoil of the cracking clays on the Downs and old lakebeds within the Desert Uplands allows Mitchell grass, after a winter dormancy induced by low temperatures and reduced photoperiod, to produce new growth in the spring months despite the lack of rain, because it has a deep primary root system.

2.6 Climate and erosion

The climate of the Desert Uplands has a major influence on erosion rates. Many individual factors play a role and if several combine together the resultant effect can be quite devastating. For example:

- Prolonged dry seasons cause most ground cover species to go into a dormant state, triggered by lack of moisture.
- Annual species wither and die to leave areas of bare soil exposed to the elements.
- The grazing pressure of native animals alone can reduce ground cover, but the addition of sheep or cattle reduces topsoil protection even further.
- The physical pressure by grazing animals, particularly at high stocking rates, can lead to topsoil compaction, increased runoff and subsequent erosion after heavy rainfall.
- Storm activity prior to the wet season, with high winds and lightning strikes, initiates wildfires that sweep across the country while there is fuel to burn, leaving the land surface exposed to the high intensity rainfall so often associated with the start of a wet season.
- Heavy rainfall, unprotected topsoils and channelisation of runoff water results in soil erosion.
- The loss of topsoil also means the loss of any accumulation of seed, organic matter or nutrients, which although scarce in many Desert Uplands topsoils, are none-the-less essential for maintaining plant growth and ground cover.

Information on wind velocity and direction during the year is scarce. However, light sandy soils that have been deposited by wind action, namely the dunes, lunettes and beach ridges associated with some of the larger lakes in the region, are also susceptible to further erosion by wind. The risk of erosion occurring is increased if the loose topsoils are dry, disturbed or lack any protective vegetative cover (Lorimer 1985).

3. Geomorphology

3.1 Introduction

To understand why there are so many different land types (each with their own limitations and capabilities for land use) and such a diverse array of soil-vegetation associations in the bioregion, it is necessary to study the geomorphology of the region, and to recognise the significance of the landscape-forming events that have taken place over a long period of time. Geomorphology takes into account the landforms and geological history of an area, the processes that have shaped the landscape, and the time period over which these processes occur. In other words, geomorphology can be used to explain the complex evolution of the landscape as we see it today. In Queensland the broad pattern of landscapes and the associated plants and animals are described as bioregions.

3.2 Bioregions of the study area

The Desert Uplands is one of thirteen bioregions described in *The Conservation Status of Queensland's Bioregional Ecosystems* (Sattler and Williams 1999). With an area of approximately 68,827 square kilometres (6.9 million hectares) the Desert Uplands bioregion, which straddles the Great Dividing Range between Blackall and Pentland and covers the major portion of the study area, represents approximately four percent of the State.

In setting the boundary of the study area, the Desert Uplands Committee determined that if at least 10% of a property occurred within the Desert Uplands bioregion, then the whole property should be included. Consequently, significant areas of adjacent bioregions are included in the study area:

- The Mitchell Grass Downs bioregion extends along the western margin of the study area. Extensive, undulating plains of Mitchell Grass tussock grasslands on heavy, grey and brown clay soils are predominant.
- The Einasleigh Uplands bioregion impinges into the northern and north-eastern sectors of the study area, and largely consists of a series of plateaus and ranges involving a complex geology of granites, basalts and Palaeozoic sediments.
- The Brigalow Belt bioregion extends along the eastern and south-eastern margin of the study area. It includes, steep hills on folded sediments, soils derived from basalt and brigalow vegetation on clay soils.

3.3 Subregions of the Desert Uplands

To obtain a broad overview, the Desert Uplands bioregion has been divided into four subregions (Morgan *et al*. 2002) according to general landform patterns and suites of land systems. These subregions are shown in Figure 3.1 and are described below:

Subregion 1: Prairie – Torrens Creeks Alluvials

The central portion of this subregion has an extensive area of Quaternary alluvial sands and clay plains, formed on the distributary flood plains of the ancestral Flinders River and the modern Prairie, Towerhill and Torrens Creeks. In the south an extensive, partly stripped, lateritic plain, with numerous shallow seasonal wetlands, merges into the clay plains of the Mitchell Grass Downs bioregion, which has formed on Cretaceous shales and mudstones. Along the western margin a silcrete formation is responsible for the shallow soils and low stony hills.

With the exception of Torrens and Bullock Creeks, which have the headwaters of their catchments in the White Mountains area of subregion 2, watercourses draining this subregion originate within it. All are tributaries of the Thomson River and form part of the Lake Eyre catchment.

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Subregion 2: Alice Tableland

This is the largest of the four subregions. It is dominated by deep, sandy, red soils on an extensive plateau, with scarps of exposed laterite around its margins. It includes smaller areas of skeletal soils on sandstone ranges, and sandy alluvial fans derived from them. There are also small areas of Mesozoic calcareous sandstone outcropping in valleys in the southeast, dunes associated with Lakes Buchanan and Galilee, and relict lake deposits of cracking clay soils. The subregion also contains some of the best freshwater wetlands of the bioregion (Lake Moocha, Caukingburra Swamp, Lake Galilee (parts of), Webb Lakes, Lake Huffer, Lake Thirlestone, and Lake Dunn), extensive saline wetlands, (Lake Buchanan, Lake Galilee, Lake Barcoorah), and a number of artesian mound springs and sandstone seeps.

The subregion includes two large internal drainage basins that are catchments for Lake Galilee and Lake Buchanan; otherwise drainage is westward into the Thomson River and the Lake Eyre Basin, and eastward into the Belyando River.

Subregion 3: Cape – Campaspe Plains

This subregion is in the northeast sector, between the Great Basalt Wall and the Cape River. It consists of an undulating, partly stripped land surface in its northern part, and alluvial plains in the south. There are also significant areas of relict lake deposits in the east and southeast.

Small areas of Palaeozoic granodiorite and folded sediments occur across the northern and down the eastern margins of the subregion, and there is a small outlier of the Alice Tableland subregion sandstones in the central east. The climate and vegetation of the Cape – Campaspe Plains have similarities with those of the Einasleigh Upland and Brigalow Belt bioregions, respectively.

Most watercourses originate outside the subregion. Just north of the Flinders Highway the land drains into the Burdekin River, but south of the highway drainage is into the Cape and Campaspe Rivers, the Belyando River, and then into the Burdekin River.

Subregion 4: Jericho Plains

This subregion is dominated by deep sandy deposits, which include Tertiary sand plains and Quaternary alluvial fans. Clay plains and sandy alluvial terraces are predominant in the valley bottoms. The gently dipping, Mesozoic sandstones outcrop to form an escarpment with a north-south alignment, giving rise to sandy red Kandosols of variable depth. The much older, strongly folded, Palaeozoic sediments (Permian) outcropping to form a ridge in the southeast are, in fact, part of the Brigalow Belt bioregion, but have been included in this study because property boundaries extend beyond bioregional boundaries. Gently dipping, Mesozoic shales and mudstones underlie the clay plains in the south and southwest.

Drainage is predominantly westward into the Lake Eyre basin, although the eastern slopes of the subregion drain into the Belyando River and the Burdekin catchment.

3.4 Significant geomorphic features of the region

The bioregion has many distinctive and characteristic landforms across its subregions. Some of the most notable ones are discussed below.

3.4.1 Laterite

Common to a large proportion of the Desert Uplands is the presence of a laterite at variable depths within the soil profile, or exposed at the soil surface and in cliff faces of the escarpment that occur along the margins and within the bioregion. When the landscape was one continuous, extensive land surface experiencing a warm, humid climate with a high rainfall, deep weathering of the bedrock and mobilisation of minerals, such as iron, silica and calcium, occurred in different locations according to specific pH, temperature and rainfall conditions. A fluctuating watertable containing small quantities of soluble iron would, over a long period of time (several million years), alternately saturate and drain the lower regolith. With each drying-out phase small quantities of iron would coat the soil or rock particles and harden, leading eventually to a massive concentration of iron

Figure 3.1 **Subregions of the Desert Uplands bioregion**

within the soil profile and weathered bedrock. These old weathering features are characterised by the presence of up to five specific horizons at any site. A typical sequence might be as follows:

- An unconsolidated soil profile (uppermost layer).
- A ferruginous zone, marked by an accumulation of iron, silicon, and/or aluminium in the weathering profile (Figures 3.2, 3.3).
- A mottled zone, marked by the variable accumulation of resistant elements as in the ferruginous zone in bleached, kaolinised, strongly weathered, parent material.
- A pallid zone of completely bleached, kaolinised, strongly weathered rock (Figure 3.4).
- Partially weathered or unweathered bedrock.

At any particular site these layers may have been differentially removed or exposed by subsequent erosion.

3.4.2 Sand sheets in the Alice Tableland and Jericho Plains subregions

Perhaps the most identifiable feature of the Desert Uplands bioregion is the red sandy soil in association with yellowjacket and spinifex vegetation (Figure 3.5). These soils are some of the oldest in the bioregion, as they have formed on a sand sheet, which once blanketed the whole landscape, filling valleys to depths in excess of 30 metres (Figure 3.6), changing the physiography from one of rolling rises and low hills to one of gently undulating sand plains. These areas, with their own characteristic vegetation communities, act as important recharge zones for the Great Artesian Basin. Erosion over the past millennia has removed vast quantities of soil from the sand sheet, forming alluvial fans, alluvial plains and terraces adjacent to sandy creek beds, but the original sand sheet is still a prominent landform extending from Pentland to Barcaldine.

3.4.3 Escarpments

The Desert Uplands plateau is bounded on the eastern and western sides by escarpments**,** which “erode regressively and consume uplands”. This rather dramatic description of an erosion process by Twidale (1973) is quite true, when considered in a geological timeframe – the Badlands (BD), Colorado (CO), Cudmore (CE), Doncaster (DR), Vacquera (VA) and Waterview (WV) land systems all represent particularly active scarps, which are eroding back into the plateau.

The western escarpment (Figure 3.7) is in a relatively slow retreat because of the low erosion potential of Torrens, Cornish and Aramac Creeks, and their inability to remove eroded material from the scarp. In comparison, the eastern escarpment is showing a rapid retreat (Figure 3.8) because of the extensive catchment, huge flood volumes of water, and the erosive potential of the Belyando River. Tributaries such as Amelia, Dyllingo–Carmichael, Dunda and Pine Creeks are making significant incursions into the Desert Upland plateau with Dyllingo–Carmichael creeks capturing some of the Lake Buchanan and Lake Galilee catchments.

3.4.4 Alluvial fans

Vast alluvial fans and aprons, built up over the millennia, extend out onto the Belyando floodplain from the eastern escarpment. During very wet periods, creeks and streams pour off the plateau onto an almost level plain and the transported sediments are deposited as the water velocity decreases. Alluvial fans with a similar process of formation occur within the catchments of Lake Buchanan, Lake Galilee (Figure 3.9) and Lake Dunn, and where the sediments from Amelia Creek, Reedy Creek, Torrens Creek (Figure 3.10), and Alice River spill out onto the adjacent clay plains. The most extensive alluvial fan in the study area is represented by the Corea (CA) land system. Vast quantities of sediment eroded from the Lolworth Range spread out to form an alluvial apron with gently sloping plains extending 130 kilometres in a southeast direction across the Cape-Campaspe Plains subregion.

The nutrient status of alluvial deposits depends on the source of the alluvium. Torrens Creek originates in the highly dissected, quartzose sandstones of Triassic and Jurassic age, which are described as ‘White Mountains’ because of the white cliffs and the strongly dissected terrain. These sandstones are devoid of nutrients, themselves a washed deposit of sand, which explains the low fertility of the Torrens Creek fan. A climate with intense, prolonged periods of rainfall prevailed to produce huge volumes of runoff water and suspended sediment loads to produce the extensive Torrens Creek Fan (TF) land system. Similarly, the soils of the Corea (CA) land system have a very low nutrient status, even though the source of material (granite) has a slightly better range of minerals than the White Mountains sandstones. Lateritisation and leaching processes over the

Figure 3.2 **A thin ferruginous layer characterised by abundant iron-manganese gravel is underlain by a mottled hardpan at shallow depths throughout the bioregion, particularly in the Northern Plateau (NP) land system and across the Cape-Campaspe Plains subregion**

Figure 3.3 **A massive ferruginous capping sits upon the mottled zone of a lateritic weathering profile formed on sandstone bedrock, which itself has been impregnated with iron, but to a lesser extent (Badlands (BD) land system)**

Figure 3.4 **The sandstone bedrock in the White Mountains (WM) land system shows differential erosion because iron has impregnated and hardened the upper layers, making them more resistant to the abrasive forces of the wind. The bleached lower part of the exposure is the pallid zone of a lateritic weathering profile**

Figure 3.5 **Spinifex, heaths, wattles and yellowjacket represent an extremely diverse vegetation community on the very deep, red sandy, gradational soil profiles that predominate in the Desert (DT) land system**

Figure 3.6 **A railway cutting near Pentland provides a good depth indicator for the sandy Red Kandosols on the sandsheet that characterises the Desert (DT) and Grant (GT) land systems extending south to Barcaldine**

Figure 3.7 **Looking northwards along the western escarpment from the Aramac-Lake Dunn road – the Badlands (BD) land system**

last 10 – 20 million years have removed most of the nutrients remaining after deposition and reworking by floodwaters that transported the alluvium.

3.4.5 Ancestral lakes

The Desert Uplands must have experienced a very wet climate in the distant past since there are several extensive areas of clay plains that were once the bed of a freshwater lake. Most of these now have a present-day drainage system eroding into the old lakebed. The Alice Clays (AC), Aberfoyle (AL), Bogunda (BA), Maynard (MD), Slogan Downs (SD), Teewarrina (TA) and Willandspey (WY) land systems are prime examples, whereas Balfes Creek (BF), Lake Buchanan (LB), Lake Dunn (LD) and Lake Galilee (LG) land systems still have a portion of the original lake remaining.

3.4.6 Internally drained lakes

Lake Buchanan

The current lakebed of Lake Buchanan is a flat salt playa approximately 28km long and 8km wide at its widest point, with a surface area of about 117sq.km (Figure 3.11). In an average wet season, provided the rainfall is intense and the runoff is high, the lake will fill to a depth of 1.5 – 2.0 metres, creating a temporary paradise for a wide variety of water birds. By mid-year, however, the lake is usually dry. The catchment area of 2766sq.km is of extremely low relief with the lakebed at 289 metres above sea level (ASL), and the highest points on the eastern and western catchment boundaries are only 510 metres and 450 metres ASL respectively.

Wetter climates have prevailed in the past and maintained much higher water levels with drainage out through 'Thirlestone' into Torrens Creek, and finally into the inland sea of Lake Eyre. There are a number of features associated with the lake which are discussed below:

- Lakebed fossils

  Lake Buchanan is different from all other salt lakes in Australia because it occurs at a high elevation - on the Great Dividing Range - on a remnant of a very old landscape surface. It is also the northernmost salt lake in eastern Australia. The species of microfossils and the thickness of shells have been used by Chivas (1986) to determine the salinity levels, and the depth and the chemistry of the lake water at the time each sediment layer was being formed; soil cores taken from the lakebed down to 15 metres indicate a very low sedimentation rate of approximately 8mm per 1000 years for the last 1.6 million years. The living organisms and the chemistry of the water have remained virtually unchanged. At least four long wet phases are known to have occurred during the last 730,000 years, that is, the lake had water deeper than five to six metres in it for periods of several hundred years, at least on four separate occasions (Chivas 1986).

- Beach ridges

  Although beach ridges are quite common along the coastline, examples associated with Australian lakes are rare (Timms 1992). The parallel ridges along the western margin of Lake Buchanan (Figure 3.12) represent long periods of time when the water level was fairly constant, water currents were weak or non-existent and the sediment supply was sufficient for sandy sediments to accumulate in the wave zone. The wave-built terrace would then be exposed when the water level dropped during drier periods. The oldest and highest ridge, approximately six metres high, is now 1.5km from the present shoreline and is separated from the lake by four younger ridges.

- Stockyard Creek delta

When rivers or streams carrying sediment in suspension flow into a lake, the velocity of the water decreases and the transported material is deposited on the lakebed. If the water level of the lake remains constant the sediments will increase in depth and fan out from the river mouth. Should the water level of the lake recede for a long period of time, the stream will erode through the fan deposits as it flows down to the new shoreline, below which another fan begins to form. If old fan deposits are sufficiently deep and extensive, remnants or lobes of them may survive subsequent stream erosion and wave action, providing a source of information on the age of the fan and the soils being eroded at the time.

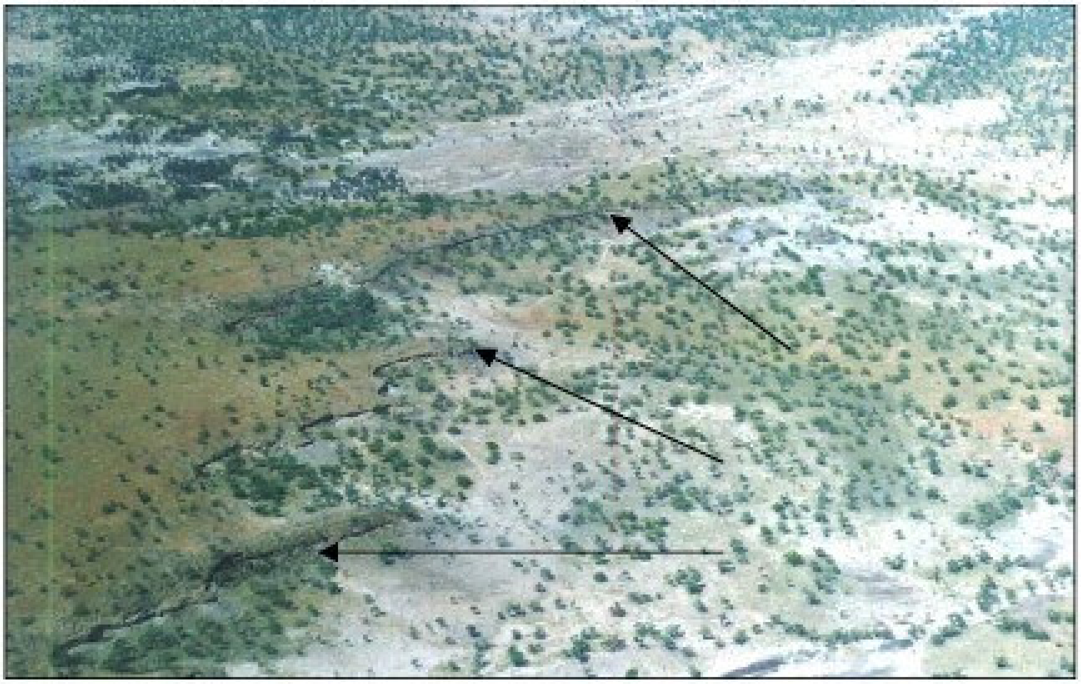


Figure 3.8 **This aerial photograph shows a particularly active section of the Badlands (BD) land system along the eastern escarpment, eroding back into the Desert Uplands plateau, with the arrows depicting the ferruginous cap of the scarp (also shown in more detail in Figure 3.4)**

Figure 3.9 **Lake Galilee – several alluvial fans emanate from a ridge to the west and coalesce to form an extensive alluvial apron**

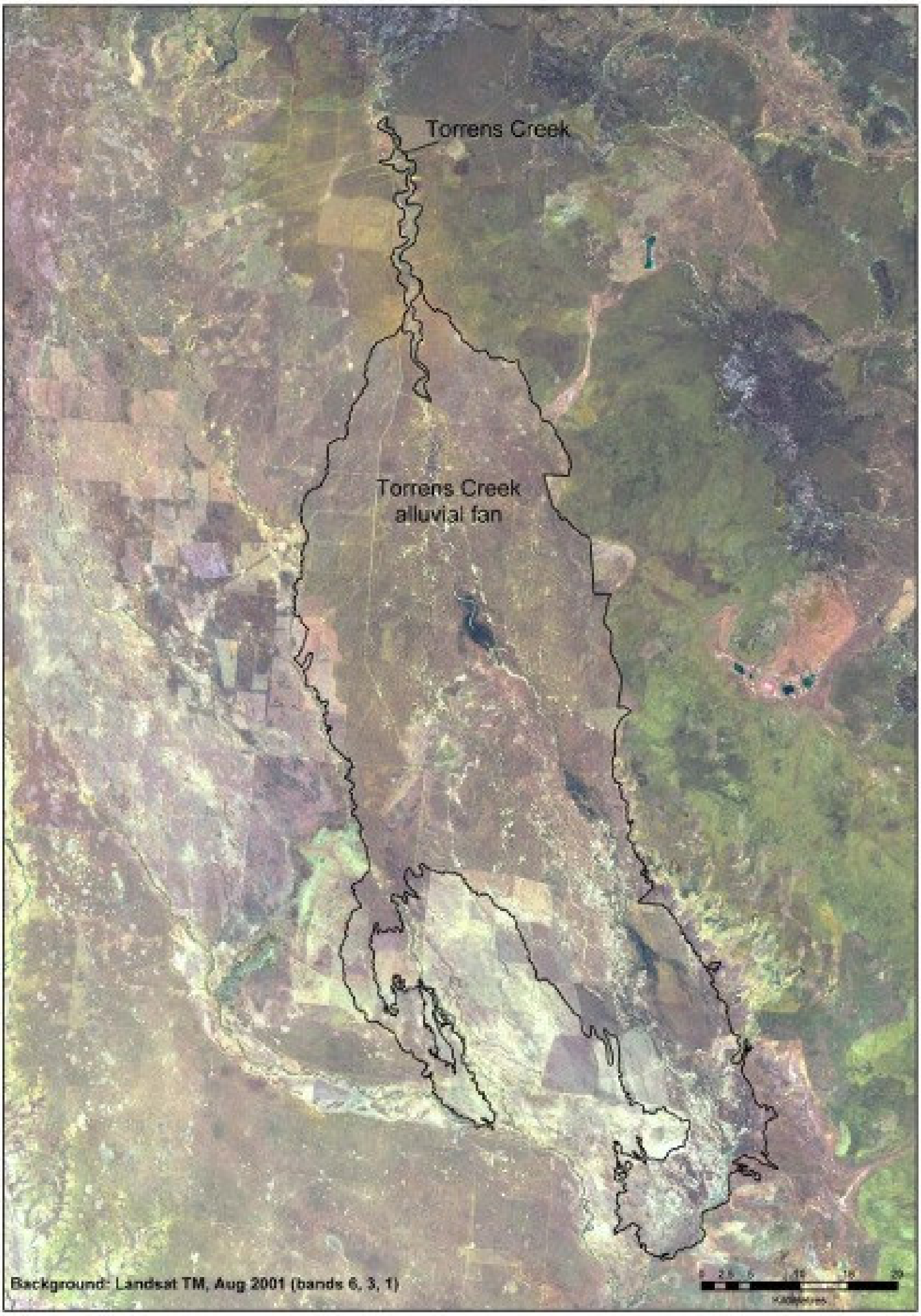


Figure 3.10 **The Torrens Creek alluvial fan spreads out onto the extensive clay plains of the Moondah (MH) and Bogunda (BA) land systems**

Stockyard Creek enters the lake from the northeast sector of the catchment and the delta formation at the mouth of the creek indicates that it carries a substantial quantity of sediment. Watson (1984) identified three different ages in the delta deposits - 25,000 years old, 13,000 years old and the present delta material, all of which have been deposited since the last full period described by Chivas (1986) - and correlated these ages with periods when the water level was higher than the present shoreline for extended periods. The presence of specific minerals and aquatic organisms in the sediment provided a fingerprint to identify sediments of the same origin and the same age. Studies of sedimentation in closed lake systems, such as Lake Buchanan, is one way of identifying how the climate has changed and might continue to change with time.

- Water chemistry

Lake Buchanan is a unique salt lake because it has brine that is chemically different from that of seawater and other Australian salt lakes (Chivas 1986) as a consequence of the weathering and leaching of the salts from the local bedrock. In brief, the proportion of calcium and magnesium ions are about equal, whereas in sea water there is much more magnesium than calcium. Strontium and fluoride contents are unusually high and the bromide content is extremely low. There is no chemically precipitated carbonate or gypsum in the sediments, only a low-magnesium calcite in the form of shells and nodules. Due to its position on the continental divide, Lake Buchanan probably escaped the intense, acid-weathering regimes, and the resultant gypsum formation, that occurred across most of inland Australia.

- Fauna of Lake Buchanan

Lake Buchanan is considered by Timms (1987) to have a relatively high diversity of endemic fauna in its mud and water, which ranges from brackish to hypersaline each year. He identified 28 species of insect, one rotiferal species, 21 species of crustacean, two species of water mite, and one snail species in a comprehensive study of the lake complex. He also explained why many halobiont and halophilic species are missing, and why the lake fauna of Lake Buchanan differs from those in the salt lakes of southern Australia:

- Some species have been unable to adapt to the tropical conditions of Lake Buchanan.
- The isolation of Lake Buchanan from other salt lakes has prevented a regular influx of common species from the south.
- The arid zone separating Lake Buchanan from its ultimate drainage sink and possible source of species (Lake Eyre) would eliminate those species requiring permanent, or seasonally reliable waters.
- Lake Eyre is a poor source of lake fauna species.

- Caukingburra Swamp

Caukingburra Swamp occupies a natural depression at the northern end of Lake Buchanan and is separated from the lake by a low lateritic outcrop. Runoff water from the northeast segment of the catchment drains into Caukingburra Swamp (Figure 3.13). The waters are fresh and may persist through to the next wet season if good rains and high runoff occur. The swamp and the associated stand of red gum (*Eucalyptus camaldulensis)* and Reid River box (*E. brownii*) provide an important haven and watering hole for local and migratory birds and local fauna (Blackman *et al*. 1999). Dry Swamp in the north and Moonoomoo Swamp in the southeast of the catchment are similar areas, but they do not retain water for as long as Caukingburra Swamp.

- Western outlet

A series of shallow, fresh-water swamps (usually dry) situated on the western catchment boundary only 15km from, and approximately 15m above the present shoreline of Lake Buchanan, represent the original lake outlet through the property of 'Thirlestone' into the Torrens Creek - Thomson River system. It is not known when the lake last flowed through this outlet, but from the salt concentration on the lake floor and the age of delta deposits (35,000 years – Watson, 1984) near the present shoreline of Lake Buchanan, it must be hundreds of thousands of years. In 1974, which was an extremely wet year for the whole east coast of Australia, the water in Lake Buchanan was four to five metres deep and extended only 4.5km westwards of the present shoreline (Chivas 1986)

Figure 3.11 **Lake Buchanan – a dry saline playa for most of the year. Photograph taken from a point about three quarters of the way down the eastern shore, facing southwest**

Figure 3.12 **Sandy beach ridges separated by clay-rich, lakebed sediments occur on the western shore of Lake Buchanan**

Lake Galilee

The lake is approximately 29km long but the width varies between 3km and 15km (Figure 3.14). The lake floor is 275m ASL and has a surface area of approximately 220sq.km. The lowest points on the catchment boundary occur at the north-western and southern ends of the catchment, and are approximately 290m and 280m ASL respectively. Several features are described below:

- Recent outlet

  An outlet occurring in the southwest corner lies approximately 8m above the present-day shoreline. This is consistent with a water level necessary to form the lacustrine clay deposits at the northern end of the lake (see *Ancestral lakebed* below) and in low-lying areas throughout the Oakvale (OE) land system to the east. The relatively low elevation of the outl*et al*so helps explain why Lake Galilee is not as saline as Lake Buchanan. Although Lake Galilee has not overflowed since European settlement, its low outlet means that it could have been flushed out more frequently than Lake Buchanan, and relatively recently (i.e. over the last thousand years or so). Salts brought in at the northern and south-eastern ends of the lake have been transported to the south-western corner during very wet periods, where they have concentrated to form the current saline ponds.

- Lakebed vegetation

  Although the lakebed soils are saline and the watertable lies at, or very close to the surface, a salt-tolerant bush (*Halosarcia* spp.) covers all but the southwest corner, where a bare, hyper-saline playa exists.

- Ancestral lakebed

  Extending approximately 12km beyond the present northern shoreline there is an extensive area of gilgaied grey and red-brown clay soils, which represent the floor of an older, much larger lake system. Numerous small occurrences of clay soils can be found in the southern and eastern parts of the catchment and may represent remnants of this stranded lakebed. The natural vegetation consists of gidgee (*Acacia cambagei)* and brigalow (*A. harpophylla*), together with some small stands of belah (*Casuarina cristata*).

- Beach dunes

  The dunes that occur around Lake Galilee have been formed by wind action alone (unlike the beach ridges on the western side of Lake Buchanan), and there are major differences in the material that has been deposited, the soils that have developed, and the natural vegetation that grows on them, such that three different soil-vegetation associations (Qd2, Qd3 and Qd4) have been described by Lorimer (1998).

3.4.7 The Lake Galilee catchment

A small dune system some 13-14km north-northeast of the current northern shoreline, with a level clay plain in between, is a relict shoreline of the original Lake Galilee (Figure 3.15). This raises a number of questions, but also helps explain some interesting landscape and soil features in adjacent areas and further downstream. For example:

- Water supply

  Where did all the water come from to maintain this huge lake? Certainly not from the current catchment area as the catchment boundary to the east is only a kilometre away from the relict shoreline. Similarly, the high nutrient status of the old lakebed clays indicates the source of sediments must have come from much further a field than the impoverished sandstones and sand she*et al*ong the western side of the catchment. A more likely source of the water and catchment is the basalt and granite country to the west of Charters Towers.

  The drainage pattern to the north and north east of Lake Galilee shows the Cape, Campaspe and Burdekin Rivers, all with a south-easterly trend, joining up before making a sudden and dramatic change of direction through the Great Dividing Range to drain out towards the coast and into the Coral Sea. It is quite possible that the Burdekin River once flowed south forming a huge lake – relict lakebed clays occur on the properties of ‘Natal Downs’ and ‘Willandspey’, and the Belyando floodplain - with an overflow into Lake Galilee and Lake Dunn. Lakebed clays link these two lakes on a common catchment boundary with low-elevation (on ‘Eastmere’). However, some event, possibly tectonic uplift, changed the course of the

Figure 3.13 **Caukingburra Swamp – an ephemeral wetland with high conservation values**

Figure 3.14 **Lake Galilee, looking northwards across the saline water and saltpans of the southwest sector of the lake. The outlet is to the bottom left**

Burdekin River and cut off the water supply to Lake Galilee and the southwest. Taylor (1911) in his discussion on the origin of 'boathook bends' in rivers suggested that active down cutting of the coastline captured the Burdekin river and turned it northwards. Cannon and Coventry (1989) also speculated about a southern inland trend in the Burdekin River.

- Diminishing area of Lake Dunn

The current shoreline of Lake Dunn represents only a small area of the original lakebed, which extends southeast into the property 'Clare'. The original, elevated water level produced a continuous sheet of water into Lake Galilee. When the major source of water entering Lake Galilee from the north suddenly stopped, the high water level fell and two separate lakes were formed. During dry periods, fine sand and silt were blown out of the lakebed by the prevailing south-easterly winds to form a sandy dune along the northern and western shoreline of Lake Dunn, building up a catchment boundary between the two lakes. Similar dunes occur along the northern and western shoreline of Lake Galilee. Even in today's climate, two major creeks from the south supply Lake Dunn with a large volume of sandy sediments, further decreasing its water storage capacity.

- Permanent water supply in Lake Dunn

When every other lake in the Desert Uplands is dry, Lake Dunn continues to have a relatively high water level (Figure 3.16). A rocky bar of ferruginised sandstone at the outlet acts like a subsurface dam wall and is a major influence preventing subsurface drainage, thereby maintaining a high water table upstream of the bar. Lake Dunn lies in a shallow depression, and the lakebed dips below the level of the water table allowing free water to fill the depression to the level of the water table. It is most likely that the ferruginised sandstones underlie the clay sediments and prevent deep drainage. Floodwaters flush the system of any salt accumulation almost every wet season.

A similar system of old lakebed clays and rock bars impeding subsurface drainage occurs in the Alice Clays (AC) land system, however permanent lakes do not exist, although an open woodland of coolabah (*Eucalyptus coolabah*) suggests the area may be inundated with water from time to time. Even if the groundwater table is only slightly saline, the combination of evaporation from bare soil surfaces and infrequent flooding results in a high salinity risk.

- Isolated pockets of clay soils on properties 'Oakvale' and 'Eastmere'

Although the precise elevations of all these clay pockets are unknown, they may coincide and relate to the former lakebed and relict shoreline of the original lake system. Confirmation of this theory would explain the presence of these clay pockets in the low-lying areas of ironbark country to the east of Lake Galilee (land unit Ql2 – Lorimer 1998).

- Outflow from Lake Dunn and Lake Galilee into Reedy Creek

The main outlet from the combined lake system was probably through Lake Dunn as it is significantly lower than the other potential outlet for Lake Galilee past the 'Swanlea' homestead. Perhaps both outlets functioned during periods of high discharge. If so, the volume of water moving down Reedy Creek must have been sufficiently high to be responsible for the huge sandy deposits leading into Sandy Creek (on 'Barcoorah') and the large alluvial fan (Lake Huffer land system) spreading out onto the clay plains at 'Adelong'.

3.4.8 Diversion of the Flinders River

The Flinders River in the far northwest of the bioregion once swept south through Prairie to join up with Torrens and Cornish creeks. Coventry *et al*. (1985) showed that two separate basalt flows, which occurred approximately 5.6 and 3.3 million years ago, have played a major role in forming the present day landscape in the Prairie-Torrens Creek Alluvials subregion. Remnants of the older basalt flow on the Denna Plain indicate a southern-flowing drainage pattern existed at the time, resulting in the extensive river flood plains around Prairie and further south. The younger basalt flow occupied ancestral channels in the northern portion of this plain, before veering westwards towards Hughenden. Coventry *et al*. (1985) suggest that the Flinders Gorge has formed since the younger basalt flow, when the ancestral Flinders River cut back and captured the headwaters of the Prairie Plains river system, taking the river flow to the west then north to the Gulf of Carpentaria.

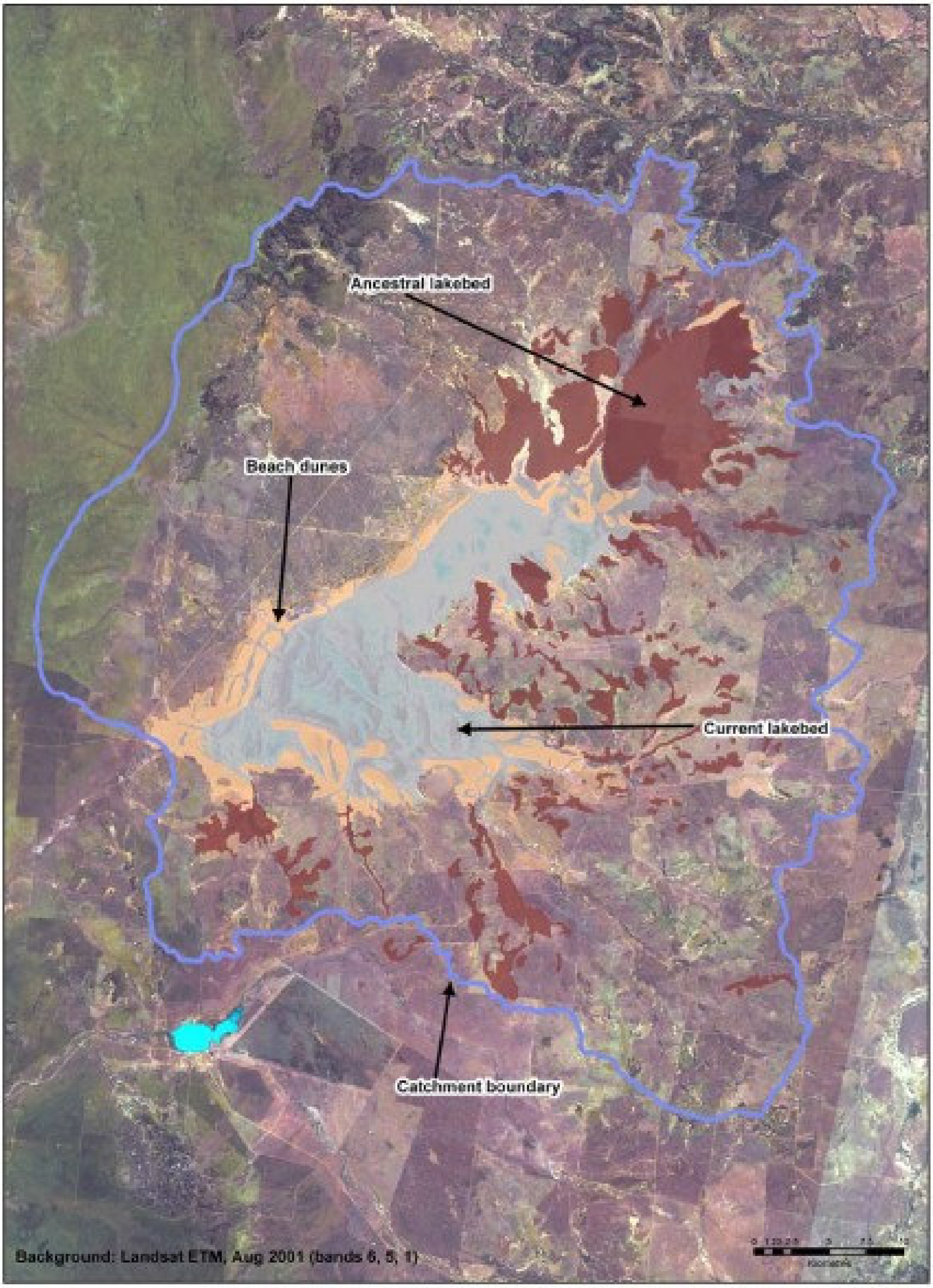


Figure 3.15 **The internally drained Lake Galilee catchment, showing ancestral and current lakebeds, and associated beach dunes**

Figure 3.16 **The water level in Lake Dunn is relatively constant, unless several dry years occur in succession**

Figure 3.17 **This small lake is a permanent wetland fed by several seepage areas in the Moses Springs complex on the property 'Doongmabulla'**

There are a number of landscape features that support this theory:

- A series of sandy 'islands' elongated and orientated in a north-south direction alternate with clay plains in the Prairie district and show a distinctive flood plain appearance – the Prairie Plains (PP) land system.
- Extensive deposits of water-worn ironstone gravel indicate large volumes and high velocities of water must have been operating to move and deposit gravels over a large area in the northwest of the Prairie-Torrens Creek subregion in the Ludgate (LE) land system. Subsequent lateritisation has cemented the gravels to form pisolitic ironstone, which indicates the area was low-lying and experienced a long period of fluctuating watertable levels. Many of the cemented gravels now occupy elevated positions in the present landscape. Further studies would be required to explain the presence of numerous shallow depressions often with cracking clay soils, particularly in the north of the Ludgate land system. They may be relict lakes or billabongs from the ancient Flinders River system, although no drainage pattern links them to each other. Alternatively, the soils may have formed *in situ* on Cretaceous mudstones or younger lacustrine clays, which underlie the area, but were not covered by the gravel deposits.
- An ironstone ridge forming a barrier across the flow that was deflected to the southeast caused a constriction in the broad valley and drainage pattern in the 'Moorrinya-Uanda' locality. It could have been responsible for damming the waters of an ancient south-flowing Flinders River to form a huge lake and allow fine sediments to settle. When the headwaters of this ancient Flinders River were captured and diverted westwards, then north-westwards into the Gulf of Carpentaria by the current Flinders River, the lake would have dried up, leaving the extensive and intermittent clay plains of the ancient lakebed now recognised as the Bogunda (BA) and Prairie Plains (PP) land systems, respectively.
- Another restriction to water flow may have happened further south, in the 'Prairie Vale'-'Rainsby' area, which helps explain two other features. Firstly, it would mean the Torrens Creek fan post-dates the formation and draining of the lake, with clay soils in low-lying areas of the fan representing exposures of the underlying lakebed clays. Secondly, the incidence of salinity in the Aberfoyle (AL) land system may have been caused by a high saline water table at the southern end of the ancestral lake, where the restriction that slowed down surface flow may still constrain sub-surface flow, similar to that of the Lake Dunn (LD) and Alice Clays (AC) land systems.

3.4.9 Artesian springs

Three groundwater systems are known to occur under the southern half of the Desert Uplands bioregion (Linda Foster, DNRM – personal communication):

- The Doncaster System consists of a shallow layer of Lower Cretaceous marine mudstone, siltstone, minor sandstone and limestone containing water with a high carbonate content, a salt content closer to that of seawater than fresh water, and a high pH. This system feeds a western line of springs, which includes the springs on 'Edgbaston' and 'Lake Huffer' properties.
- The Ronlow Beds consist of Jurassic to lower Cretaceous fluviatile sandstone with some siltstone and minor mudstone. This system has water of good quality from a deep aquifer and feeds a central line of springs extending from 'Kyong' to 'Ightham' properties
- A Tertiary deposit of fluviatile sandstone, sandy mudstone with thin beds of conglomerate in places, at considerable depth, feeds a line of springs along the eastern escarpment and includes Moses Springs on 'Doongmabulla' property (Figures 3.17 and 3.18).

3.4.10 Links to the Great Artesian Basin

The Great Artesian Basin is one huge basin made up of three sections: Carpentaria, Eromanga and Surat basins. The Eromanga Basin underlies a large proportion of the Desert Uplands bioregion (subregions 1, 2 & 4) and the deep red sandy soil profiles, so common in the Alice Tableland and Jericho subregions, act as major recharge areas for the Great Artesian Basin. Williams and Coventry (1980) were able to account for all Great Artesian Basin recharge from two percent of current rainfall becoming deep drainage.

Most of the water in the Great Artesian Basin probably entered when there was a more tropical, and generally wetter climate, at least one million years ago (Torgersen *et al*. 1991). Following an intensive campaign over the last decade to cap artesian bores and control the outflow of water from the artesian basin, it is estimated that the quantity of water being extracted at the present time (approximately one and a half million cubic metres a day) is about the same as the quantity of water entering the system from the recharge areas along the Great Dividing Range (Habermehl 1980). However, the pressure is considerably less than when the first bores were drilled at Bourke in 1878, and Barcaldine and Cunnamulla in 1887. A resource study by the Great Artesian Basin Consultative Council (1998) estimated that there were about 3000 free-flowing artesian bores and about 35,000 sub-artesian bores tapping into the water reserves of the Great Artesian Basin.

It is of national importance that this valuable resource is maintained, since without it there would be no primary production or townships in most of western Queensland. Priority actions require that:

- The quantity of water extracted and the rate of draw-down is constantly monitored.
- The bore-capping program is continued, thereby controlling outflow and minimising wastage.
- Water is used efficiently and responsibly.
- The importance of restoring the water supply and pressure of the Great Artesian Basin is publicised, so that management practices can be adapted to enhance the recharge potential of the intake areas.
- Studies relating to the quantity of water entering the ground water table under different regimes of rainfall intensity and duration are needed, with particular attention to the runoff, infiltration, vegetative ground cover and condition of the soil at the time.

Figure 3.18 **A tall dense forest of paperbarks (*Melaleuca leucadendra*) clearly identifies the location of a seepage area in the Moses Springs complex on the property 'Doongmabulla'**

3.4.11 The Cape and Campaspe River catchments

These two rivers originate within the Lolworth Igneous Complex (Barrington (BN) land system) on the north-western boundary of the study area, and then flow in a south-easterly direction to join on the property of 'Nosnillor' on the eastern boundary of the study area. The deeply weathered landscape and erodible soils of the granitic Lolworth Range, and the sandy plains of the Corea land system provide a constant supply of sediment.

Apart from the excessive flows of water during the wet season and transporting a considerable bed load of sediment, the two rivers, in the process of draining and lowering the general landscape, have been responsible for dissecting and removing a major portion of an extensive lakebed that once existed in this south-eastern corner of subregion 3. The clay plains of the Teewarrina (TA) and Slogan Downs (SD) land systems represent the remaining portions of the relict lakebed.

3.4.12 The Nulla and Toomba basalts

The Nulla basalt, which consists of several flows between 4.5 and 1 million years old, created an extensive plain of approximately 5,000 square kilometres to the north of the study area - only a very small portion is represented in the Toomba (TM) land system of the study area. However, the Toomba Basalt (10,000 - 12,000 years old) is one of the youngest basalt flows in Queensland, and it flowed out over the Nulla basalt as a viscous mass, cooling rapidly and solidifying as it moved slowly in a north-easterly direction. Some particularly interesting features include a wall 3-5 metres high (Great Basalt Wall) where the Toomba Basalt sits on top of the Nulla basalt, as well as lava tubes, caves and, because of its young age, flow structures that are still visible and a rocky surface devoid of soil development. This 'new' extrusion of relatively low volume was confined to one or two small drainage depressions and did not spread out to form a flat plain as the Nulla Basalt had done.

Landscapes formed on basalt are not normally considered to be part of the Desert Uplands bioregion but have been included in this report for the reasons outlined in the first paragraph of Section 3.3.14 below.

3.4.13 The Charters Towers Metamorphics

The sediments that were laid down during the Cambrian, approximately 550 million years ago, have experienced some dramatic changes. Apart from the compaction brought about by the weight of several thousand metres of sediments deposited in subsequent geological Periods, and the regional metamorphism caused by the folding of the sedimentary layers as the earth's crust adjusted to cooling and shrinkage, another major factor influencing the present-day landscape was the intrusion of the Ravenswood Granodiorite Complex into these folded Cambrian sediments. The prolonged, extreme heat of the magma, in contact with the sediments deep beneath the land surface, created a band of hardened rock known as the Charters Towers Metamorphics. Subsequent uplift has exposed these hardened sediments, most of which have been removed over a long period of time despite their resistance to weathering and erosion. Only isolated areas of steep hills are left to indicate the zone of metamorphosed sediments along the boundary of the Ravenswood - Lolworth granitic intrusion, with perhaps the best example being the prominent parallel ridges occurring between the Barrington (BN) and White Mountains (WM) land systems.

3.4.14 The Ravenswood Granodiorite Complex and Lolworth Igneous Complex

The study area includes the whole of any property provided at least 10 percent of the land lies within the Desert Uplands bioregion. Consequently, some lithologies and landscapes, not normally considered to be part of the Desert Uplands bioregion, have been included. The landscapes formed on granitic and basaltic substrates in the Dalrymple Shire belong, in fact, to the Einasleigh bioregion.

During the Silurian, 400 – 440 million years ago, magma intruded the Palaeozoic sediments deep below the land surface of that time. With slow cooling the Ravenswood Granodiorite Complex was formed. Subsequent uplift and erosion have removed the overburden of sediments and broken through the metamorphic aureole enclosing the granodiorite. The coarse crystalline structure of the granodiorite allowed moisture to penetrate and initiate rapid chemical weathering. Subsequent erosion has lowered the landscape to below that of the Desert Uplands plateau and formed a landscape of rolling rises.

In contrast, the Lolworth Igneous Complex exists as a prominent mountain range. It has been dated at 390 – 400 million years. Since then the massif has been exposed, deeply weathered and eroded. Considering the intrusion cooled while several thousand feet below the land surface, it is hard to imagine the erosive forces and time required to remove such a vast quantity of material and sculpture the present-day landscape. One small area high up among the peaks represents the only residual of a high-level plateau – an ancient land surface, all but gone. Since tectonic uplift, the region has experienced extrusive volcanism and diverse climates ranging from wet tropical to dry arid and glaciation, with the Lolworth Range in a constant state of weathering and erosion. One product of this erosion is the extensive Campaspe Beds, which underlie the Corea (CA) land system and consist mainly of quartz, feldspar and muscovite, and extend from Lolworth Creek in the north to the confluence of the Cape and Campaspe Rivers at the property 'Nosnillor', approximately 130 kilometres to the southeast.

4. Soils

4.1 Introduction

The soils of the Desert Uplands region are remarkably variable; some profiles are five to six million years old and more than 36 metres deep (Coventry *et al*. 1985), while others are so young they have not had time to develop any soil profile features, such as horizon layers. The formation and development of a soil is a dynamic process influenced by the lithology of the parent material, past and present climates, flora and fauna, position in the landscape, and time. Consequently, the variability found in soils, particularly when all the physical, chemical, biological, and hydrological properties of a soil profile are considered, is enormous.

The texture, structure and nutritional status of a soil depend primarily on the nature of the substrate from which it is derived. In general, the soils within the study area have a low base status because the underlying bedrock consists of Mesozoic sandstones and mudstones that are products of erosion, deposition, weathering and leaching over a long period of time. During the Tertiary, eroded material was deposited across extensive areas of the landscape and subjected to a long period of weathering, leaching, and further redistribution of any minerals that remained.

Moisture and temperature are important prerequisites for mineral weathering, leaching and subsequent soil formation. The rate of weathering and secondary mineral formation varies with temperature, composition of the surrounding solution, and resistance of the primary minerals to weathering. For example, quartz and iron oxides are very resistant whereas amphiboles, pyroxines, and calcic feldspars weather rapidly. During weathering, the more mobile cations (calcium, magnesium, sodium and potassium) are released and are leached out of the weathering zone by percolating water. Iron can exist in two forms: the immobile ferric (oxidised) condition and the slightly soluble ferrous (reduced) condition. From the amount of iron in the laterite cliffs throughout the study area it is obvious that the region has been subjected to prolonged and intense weathering, mobilisation and concentration of iron and silica, under a climate different from the present. The great depth of weathering evident in the area suggests that the former climates were effectively wetter than at present. The present-day, unreliable and short wet season for the Desert Uplands is not conducive to the weathering of substrate material or soil formation.

The flora and fauna living in and above the soil contribute to the complex processes of aeration, infiltration, nutrient storage, structural improvement, and drainage of a soil profile. For example, respiration by plant roots and the decomposition of organic matter within the soil produce carbon dioxide and organic acids, which can increase the rate of mineral weathering. In addition, the growth and decay of plant roots provides passageways for gaseous exchange (aeration) and water movement. Any increase in the organic matter content and general turnover of biomass helps to maintain soil structure, nutrient levels, infiltration rates, and water holding capacities. Groundcover, whether in the form of leaf area or as a litter layer, protects the soil surface from wind, evaporation, and the erosive forces of raindrop impact and runoff water.

Burrowing animals such ants, termites and earthworms also improve the aeration and drainage of soils. The role of earthworms may be limited because of the dry, compacted topsoils throughout the study area, but ants and termites have a significant influence on soil profiles throughout the tropical and sub-tropical areas. Lee and Wood (1971) and Holt *et al*. (1980) have described some of the specific effects termites have on the distribution of organic matter and the modifications they can make to the soil profile.

The position in the landscape also influences the drainage, the degree of leaching, and the rate of erosion or deposition. Steep slopes are usually well drained and prone to erosion, whereas the lower slopes and depressions accumulate sediments and moisture. Although drainage is usually poor in the lower landscape positions, there is a better moisture supply, which extends the growing season for plant growth and allows deeper soil profiles to develop.

4.2 Soil classification systems

Minor variations in the land surface influence the site drainage, permeability of the soil profile, and the presence of gravels or hardpans, which in turn influence the colour, depth, base status and sodicity of the soil profile. So, it is not surprising to find a range of soil profiles in the same land unit or similar soil profiles in different land units. However, given sufficient sites to assess soil variability, each land unit usually has a dominant soil type accompanied by a number of minor variants.

Two classification systems have been used throughout this report. The Factual Key for the recognition of Australian Soils (Northcote 1979) has been used to enable readers to relate information in this report to the mass of data available in the Atlas of Australian Soils (Northcote *et al*. 1968). The new Australian Soil Classification (Isbell 1996) has also been used, as this is now the official classification system for Australian soils. Little comparative data, or cross-linking with previous classification systems is available yet for this new classification system.

The Factual Key has been in use for more than 20 years and provides a useful comparison of soil morphology on the basis of textural changes down the soil profile. Soils can be separated initially into three primary profile forms:

- Uniform soils (U) – soil profiles with little, if any, textural change with depth. If the general texture is sand or sandy loam the profile is classified as Uc (coarse texture). Uniform loam and clay loam profiles are designated by the symbol Um (medium texture), and uniform clay profiles are subdivided into non-cracking clays (Uf) and cracking clays (Ug).
- Gradational soils (G) – soil profiles that become increasingly finer-textured (more clayey) with depth. The major subdivision within this group distinguishes calcareous profiles (Gc) from non-calcareous profiles (Gn).
- Duplex soils (D) – soil profiles that have a clearly defined contrast in texture between the topsoil and the subsoil. This group is subdivided on the basis of the subsoil colour: red subsoils (Dr), yellow subsoils (Dy), brown subsoils (Db), dark subsoils (Dd), and gleyed subsoils (Dg).

Characteristics such as structure, consistence, bleaching, mottles, and soil reaction trend (pH) are used to complete the code, which describes the soil profile.

Charman (1978) added an extension to the Factual Key code to provide additional information on the topsoil. This consists of a figure to represent one of the six texture groups described by Northcote (1979) (1: sand, 2: sandy loam, 3: loam, 4: clay loam, 5: light clay, 6: medium-heavy clay), a second figure to represent the strength of aggregate structure (0: no structure, 1: weak structure, 2: moderate structure, 3: strong structure) and a third value to indicate the depth in centimetres of the topsoil, (for example 025: 25cm). Thus a full soil description could be obtained, for example, from the code Dy3.43-2/0/015, which represents a yellow mottled duplex profile with a bleached A2 horizon, hard setting topsoil and an alkaline soil reaction trend. The topsoil is a sandy loam that is massive (structureless) and approximately 15cm deep.

The Australian Soil Classification (Isbell 1996) is a new system that has been adopted across Australia and will eventually replace all previous systems. It is a hierarchical system designed to identify the most important characteristics of the profile at the highest level of the classification, followed by the next most important features at lower levels. There are five levels in the classification: Order, Sub-order, Great Groups, Subgroups and Families.

4.3 Soils of the study area

The different soils occurring in the study area are briefly described below in terms of the Australian Soil Classification, starting with the most common soil Orders. Photographs of typical soil profiles within the relevant Soil Orders were obtained, with permission, from the publication by McKenzie *et al*. (2004), and the GIS Unit of EPA (Townsville) prepared the distribution patterns of the soil Orders.

A spade and hand auger (and at times, a crowbar) were used for the vast majority of the sites where soil information was collected. At a number of sites the boundary between the A and B horizons was difficult to ascertain because of the mixing effect of the soil auger. Consequently some profiles classified as Chromosols may have been Kandosols, and vice versa. The various Soil Orders are discussed in order of importance, starting with the Chromosols.

4.3.1 Chromosols (CH)

The distribution and characteristics of Chromosols are illustrated in Figure 4.1.

The dominant feature of Chromosols is the strong texture contrast between the topsoil (A horizon) and subsoil (B horizon). If thick topsoils are present, the lower portion may be bleached (an A_2 horizon) and the degree of bleaching relates directly to the difference in permeability between the A and B horizons. The B horizon can be neutral to alkaline (pH >5.5) but the upper B horizon must not be sodic (Exchangeable Sodium Percentage, ESP <6). Chromosols described during fieldwork often required the results of a chemical analysis to verify that the ESP was indeed less than 6; those soils with ESP >6 are classified as Sodosols.

Chromosols have a very close relationship with the profiles classified by Northcote (1979) as ‘duplex’, since all duplex profiles fit into the Chromosol Order, except those with a bleached A2 horizon and an upper B horizon with an ESP >6 (Sodosols) or a pH <5.5 (Kurosols). The Suborder, which is based on the colour of the upper B horizon, varies according to the position in the landscape, the site drainage and the permeability of the soil profile. Chromosols occur in every landscape position, from ridge crests and upper slopes to lower slopes, plains and drainage depressions. Parent material ranges from alluvial and aeolian sediments to the coarse-textured sedimentary rocks.

Thin sandy loam topsoils are most common in the Chromosols of the Desert Uplands and unless a good ground cover is maintained, particularly prior to and during the wet season, the risk of sheet and rill erosion, even on gentle slopes, is high. When little or no topsoil remains the all-important characteristics for pasture production (good seedbed, nutrient level, seed supply, water storage, aeration and rainfall infiltration) are lost. Exposed B horizons tend to be bare, unproductive and generate high runoff after rain.

In other areas of Queensland and Australia, Chromosols are widely used for the production of crops, such as cereal grains, oil seeds and quality hay, because of their favourable seedbed characteristics. However, in the dry tropics, where the summer wet season is short and unreliable, and the soils have a low nutrient status, beef cattle production on native pastures is the predominant land use.

At least 25% of the land units in the Desert Uplands have the dominant soil profile classified as a Chromosol and of the 63 profiles examined the well-drained, red or brown Chromosols are the most common. The numbers of profiles occurring in the various categories of Chromosol are as follows:

Suborder	Great group	Subgroup
Red B horizon (AA): 22	Hardpan in solum (BJ/EA): 23	No features (CD): 28
Brown B horizon (AB): 22	High base status (AH): 18	Sodic lower B (EO): 17
Yellow B horizon (AC): 15	Moderate base status (AG): 12	Other mixed features: 11
Grey B horizon (AD): 4	Other mixed features: 10	Mottled B horizon (DQ): 7

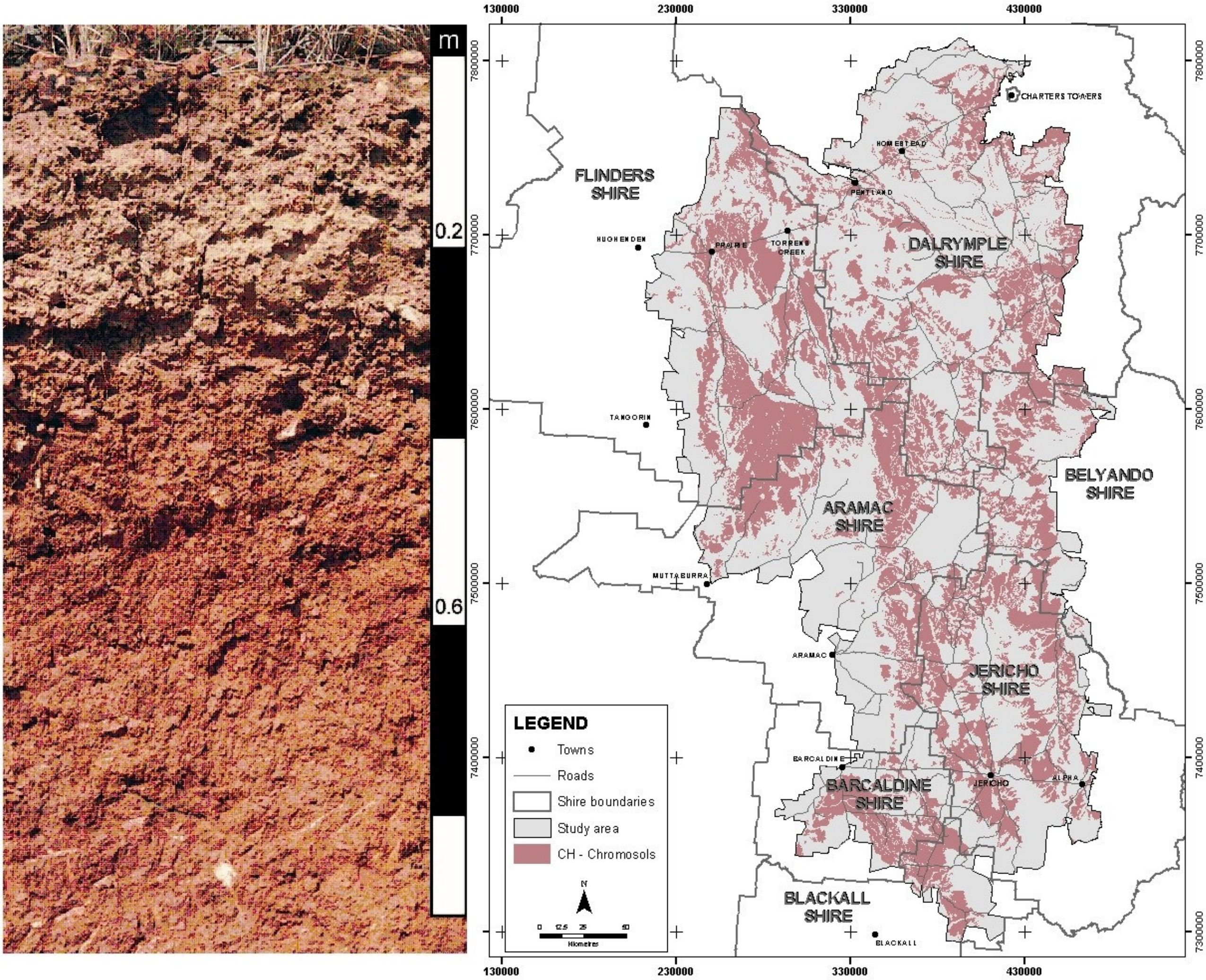


Photo: CSIRO, Land and Water

The distribution of Chromosols as the dominant soil
(approximate area: 29,385 sq.km, 34.53% of study area)

A Haplic, Mesotrophic, Red Chromosol (Isbell 1996):
A texture-contrast profile with a red clayey subsoil, which has no other distinguishing features apart from a base status of between 5 and 15 cmol. per kg clay.

Dr2.52 - 2/0/027 (Northcote 1979, Charman 1978):
A duplex profile with a neutral soil reaction trend and a massive sandy loam topsoil of medium depth, devoid of any bleached layer, overlying a whole-coloured, red, structureless clay subsoil.

Figure 4.1 Characteristics and distribution of Chromosols

4.3.2 Vertosols (VE)

The distribution and characteristics of Vertosols are illustrated in Figure 4.2.

The Vertosols have several clearly developed features:

- A uniform clay texture throughout the profile
- Shrink-swell properties that cause the soil to shrink and develop large cracks when dry, but swell and close up to form a tight impermeable mass when wet
- Slickensides (smooth surfaces on the faces of 'peds' or soil aggregates indicating that blocks of soil have moved past one another) and large lenticular structures at depth that provide evidence of the shrink-swell process.

Two surface features commonly associated with these soils are self-mulching topsoil and gilgai micro-relief, although the latter 'phenomenon is not restricted to Vertosols, nor is it universal to these soils.' (Isbell *et al.* 1997).

In the Factual Key some of the Uf and all of the Ug profiles fit into the Vertosol Order. The Uf designation arises because the key relies on an expression of cracking at the surface to distinguish Uf soils from Ug soils, whereas the Australian Soil Classification recognises a Vertosol as any uniform clay profile that cracks at or near the surface, and has slickensides or lenticular structures at depth. It is possible for some Uf soils to display none of the shrink-swell characteristics that are essential to their recognition as Vertosols; such soils might be classified as Dermosols.

The study area includes several land systems not normally associated with the Desert Uplands bioregion. For example, the Aramac (AR) and Dunrossie (DE) land systems represent Downs country to the west and the Willandspey (WY) land system represents an old lakebed in the east - all three land systems have Vertosols as the predominant soil type. However, the Desert Uplands bioregion itself has a surprising number of land systems with uniform clay soils in one or more of their units, invariably associated with relict lake beds or exposures of buried clays underlying alluvial fans. Basalt outliers from the Brigalow Belt bioregion (Surbiton (SN) land system), and from the Einasleigh bioregion (Clyde Park (CP) and Toomba (TM) land system) also contain Vertosols.

Land use on Vertosols throughout Australia is quite varied and includes a wide variety of crops reliant on irrigation (such as rice, sugar cane and cotton), whereas cereal, oilseed and some cotton crops use natural rainfall and stored soil moisture. The grazing of native and introduced pastures is usually confined to areas of low rainfall, and it is unlikely that the Vertosols in the Desert Uplands will ever realise their potential productivity, because of four limiting factors:

- **Low rainfall.**

  The summer wet season is often short, with below average rainfall. The best rains (for these crackingclays, but not the rest of the bioregion) are heavy downpours at the start of the wet season, thus allowing maximum quantities of water to pour down the cracks and fill up the subsoil before the clays swell and the cracks close up. Deep-rooted perennials, particularly Mitchell grass, survive during the dry season and come to life again in the spring with a surge of growth driven by the deep subsoil moisture, despite the lack of rain. Shallow rooted annuals have adapted to short growing seasons and complete their life cycles in several weeks.

- **High ambient temperatures and evaporation rates.**

  The topsoils dry out rapidly as plant growth and high temperatures during the summer growing season extract moisture; the process is exacerbated by the clay soils cracking and exposing the moist subsoil. The fine-textured clays hold any remaining moisture so tightly that plant roots are unable to extract it and they 'shut down' or die. Vertosols characteristically have a narrow moisture range between field capacity and wilting point. Hence, it is important that graziers maintain a high proportion of deep-rooted perennial pasture species, which can tap into the deep moisture reserves throughout the dry season.

- **High salt contents in the soil profile.**

  Under natural conditions soil salinity is not a problem since the dense ground cover of perennial tussock grasses prevents evaporation from the soil surface and, through transpiration, dries the soil out so that subsequent rains can leach or carry any salts on the soil surface down to lower depths. Problems are most likely to develop if the structure and composition of the vegetation is changed or the natural hydromorphic equilibrium of the soil profile is upset by tree clearing, drainage or irrigation. Changes in land management that attempt to supplement the natural rainfall with irrigation or replace the native plant species with 'more-productive' species, which may not be able to adapt to, or survive, this soil-climate environment, are fraught with danger because of the inherent salinity hazard.

- **Lack of supplementary irrigation water.**

  Attempts to store sufficient runoff water and extend the growing season of pastures or to grow fodder crops are met with expensive operations in excavation and/or the building of dam walls. The gently undulating topography is not conducive to deep, water storages. Limitations also exist in the use of artesian and sub-artesian bore water for irrigation purposes. All bores must be licensed, subject to the provision of the *Water Act 2000*, and the mandatory permit allowing a proportion of the bore water to be used for irrigation will only be issued if the operation is sustainable and does not affect the output of neighbouring bores.

At least 22% of the land units in the Desert Uplands have the dominant soil profile classified as a Vertosol and of the 55 profiles examined the grey Vertosols with self-mulching topsoils are the most common. The numbers of profiles occurring in the various categories of Vertosol are as follows:

Suborder	Great group	Subgroup
Grey B horizon (AD): 33	Self-mulching (EI): 34	Epihypersodic (BR): 10
Brown B horizon (AB): 15	Epipedal (GS): 12	Haplic (CD): 9
Black B horizon (AE): 4	Massive (DF): 3	Endohypersodic (BP): 8
Red B horizon (AA): 2	Crusty (BH): 4	Epicalcareous (FY): 4
Yellow B horizon (AC): 1	Others: 2	Gypsic (BZ): 4
		Episodic (BN): 3
		Others: 17

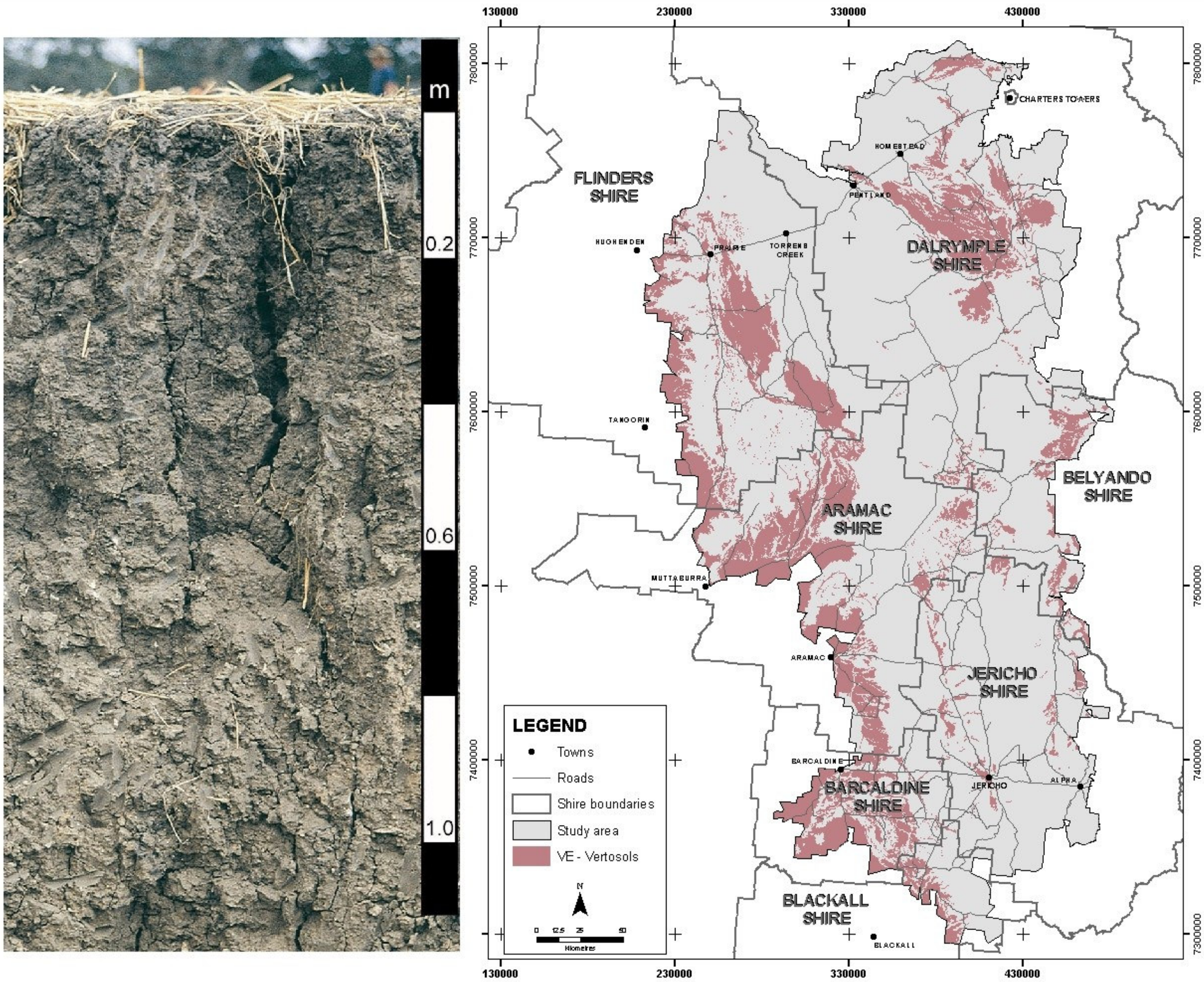


Photo: CSIRO, Land and Water

The distribution of Vertosols as the dominant soil
(approximate area: 16,834 sq.km, 19.78% of study area)

An Epicalcareous-Endohypersodic, Self-mulching, Grey Vertosol (Isbell 1996):
A uniform-textured, cracking clay profile with a fine, strongly-structured topsoil and a grey subsoil, in which the major part of the upper 0.5 m is calcareous and an exchangeable sodium percentage of 15 or greater occurs at a lower depth.

Ug5.24 - 5/3/003 (Northcote 1979, Charman 1978):
A uniform-textured profile of medium to heavy clay that shows seasonal cracking, with a thin self-mulching topsoil and a grey clay subsoil.

Figure 4.2 Characteristics and distribution of Vertosols

4.3.3 Kandosols (KA)

The distribution and characteristics of Kandosols are illustrated in Figure 4.3.

Kandosols lack a strong texture contrast between horizons, usually showing gradual increases in texture in gradational-textured profiles, and have massive or only weakly structured B horizons with a clay content exceeding 15 percent. They do not have tenic (well-defined) B horizons and are not calcareous throughout. These soils cover approximately 37 percent, or 34 million hectares of tropical Queensland (Isbell and Smith 1976) and are often referred to as the red, yellow, or grey earths because of their general earthy appearance down the profile, without showing any soil structure (pedality) or horizon differentiation. The mineralogy is dominated by quartz, kaolin, and iron oxides and hydroxides, and the natural fertility is low. In the Factual Key (Northcote 1979), these soils are represented mainly by the following codes: Gn2, Um5.2, Um5.3, Um5.4, and Um5.5.

Isbell *et al*. (1997) suggest that the red Kandosols are mainly relict soils because their widespread distribution throughout Australia bears little relationship to the present conditions of low rainfall and dry climate. The red Kandosols of the Desert Uplands, particularly the very deep profiles of the Desert (DT) and Grant (GT) land systems, conform to this theory.

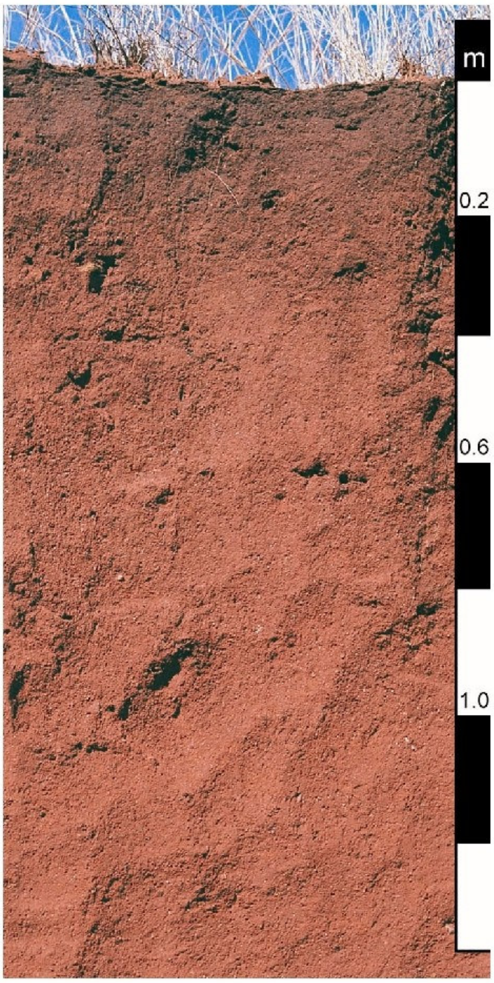
The deep sandy red Kandosols extend along the spine of the Desert Uplands plateau from Barcaldine to Pentland. This ‘red desert country’, because of its inherent characteristics of rapid infiltration rate, high permeability and very deep soil, is now recognised as an important intake area for the Great Artesian Basin.

Land use is predominantly beef-cattle production, but these red Kandosols are very sensitive to over-grazing. The sandy, rapidly drained topsoil lacks the organic matter content that imparts structure and stability to the soil surface. Removal of vegetation, particularly the low ground cover, which provides surface litter and shade for the soil and the soil organisms within, will most likely result in erosion of the topsoil and exposure of the underlying, more clayey, material to the sun. A hard, relatively impermeable surface is likely to develop, inhibiting pasture establishment and growth, and promoting runoff after rain.

Lack of surface water and soil moisture, low soil fertility and the presence of *Gastrolobium grandiflorum* (Heartleaf poison bush) have, up to the present time, restricted the number of cattle and the introduction of exotic pasture species in this type of country, but with advances in technology likely to overcome these restrictions, the challenge will be to achieve sustainable, viable levels of production without adversely affecting the ability of these soils to recharge the Great Artesian Basin.

At least 17% of the land units in the Desert Uplands have the dominant soil profile classified as a Kandosol and of the 23 profiles examined the well-drained, red Kandosols are the most common. The numbers of profiles occurring in the various categories of Kandosol are as follows:

Suborder	Great group	Subgroup
Red B horizon (AA): 14	Hardpan in solum (BJ/EA): 8	No features (CD): 11
Brown B horizon (AB): 7	Moderate base status (AG): 8	Sodic lower B (EO): 6
Yellow B horizon (AC): 2	High base status (AH): 3	Ferric layer (DQ): 4
	Others: 4	Others: 2



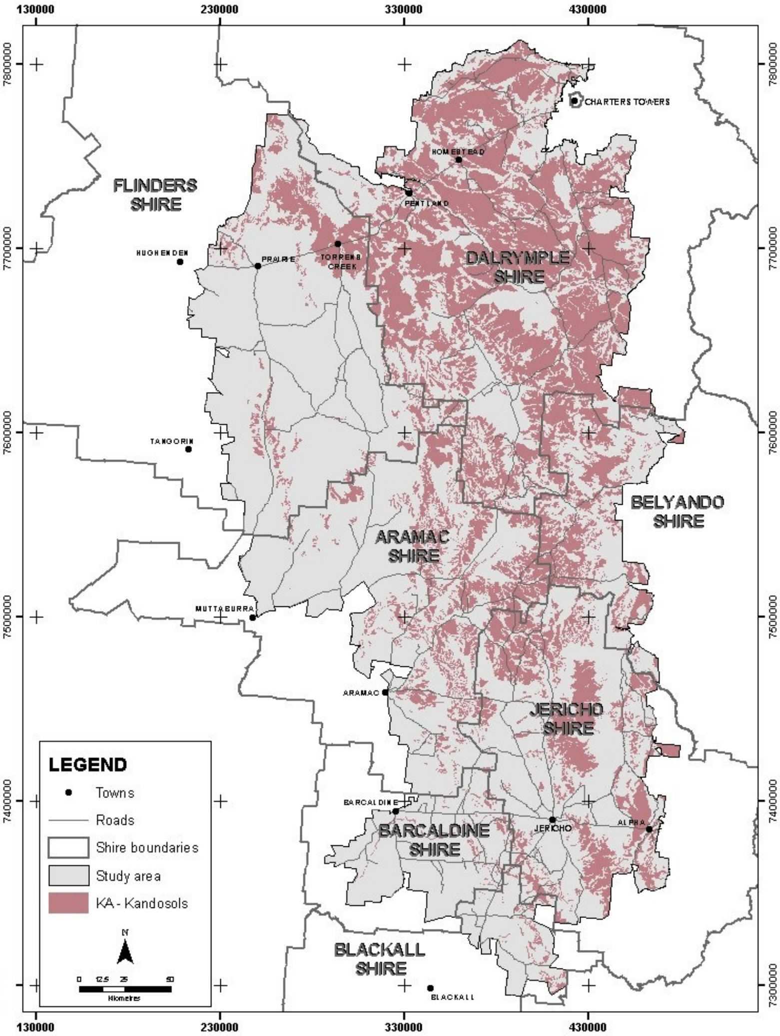


Photo: CSIRO, Land and Water

The distribution of Kandosols as the dominant soil
(approximate area: 26,424 sq.km, 31.05% of study area)

A Haplic, Mesotrophic Red Kandosol (Isbell 1996):
A gradational-textured profile with a red, structureless subsoil, which has a base status of between 5 and 15 cmol. per kg clay.

Gn 2.11 - 2/0/010 (Northcote 1979, Charman 1978):
A red gradational-textured profile with a thin, massive sandy loam topsoil, devoid of bleached layer, grading into a more clayey, whole-coloured, structureless red subsoil with an acidic soil reaction trend.

Figure 4.3 Characteristics and distribution of Kandosols

4.3.4 Tenosols (TE)

The distribution and characteristics of Tenosols are illustrated in Figure 4.4.

The Tenosols include a rather diverse range of soils found throughout the Desert Uplands and elsewhere in Australia, especially in Western Australia and the Northern Territory. By definition Tenosols may have:

- a weakly structured A1 horizon directly over-lying weathered, unweathered or unconsolidated parent material,
- an A2 horizon, which may be bleached, directly overlying the parent material,
- a tenic (weakly expressed) B horizon, or
- a B2 horizon with < 15% clay (a texture of light sandy loam).

These soils fit between the Rudosols, which have little or no profile development, and the Kandosols, which have a more obvious profile development. In the field, it is often difficult to decide if there is sufficient evidence of profile development to warrant classification as a Tenosol.

The Factual Key incorporates the Uc2, Uc3, Uc4, Uc5, Uc6 and some Um classes into the Tenosol Order.

Land use on these soils is usually restricted to light grazing because they occur in areas of Australia with low and erratic rainfall. In the Desert Uplands Tenosols tend to occur on young alluvial floodplains, where the soil profile can be quite deep, although variable, and able to retain sufficient soil moisture to extend the growing season, or on land at a higher elevation where bedrock or a hardpan is present at a shallow depth, thereby restricting the water storage capacity of the soil profile and the growing season. (Tenosols are also present on the granitic hill slopes in the northern segment of the study area - but outside the Desert Uplands bioregion – where a higher annual rainfall extends the length of the growing season).

The fertility of a Tenosol depends on the lithology of the substrate material where the soil has developed *in situ*, or the source of the material if the soil has developed on alluvium. The majority of Tenosols in the Desert Uplands have low fertility, which places introduced species with potentially high levels of productivity at a severe disadvantage. However, the major limitation to pasture growth is the short growing season caused by lack of moisture in the rapid-draining, often shallow, sandy profile.

Approximately 11% of the land units in the Desert Uplands have the dominant soil profile classified as a Tenosol and of the 25 profiles examined the sandy profiles that are neither calcareous nor strongly acid are the most common. The numbers of profiles occurring in the various categories of Tenosol are as follows:

Suborder	Great group	Subgroup
Orthic (DS): 23	Arenic (AO): 18	Basic (AR): 21
Bleached-Leptic (AW): 1	Regolithic (GF): 3	Acidic (AI): 3
Bleached-Orthic (GZ): 1	Hardpan (BJ): 2	Others: 1
	Others: 2	

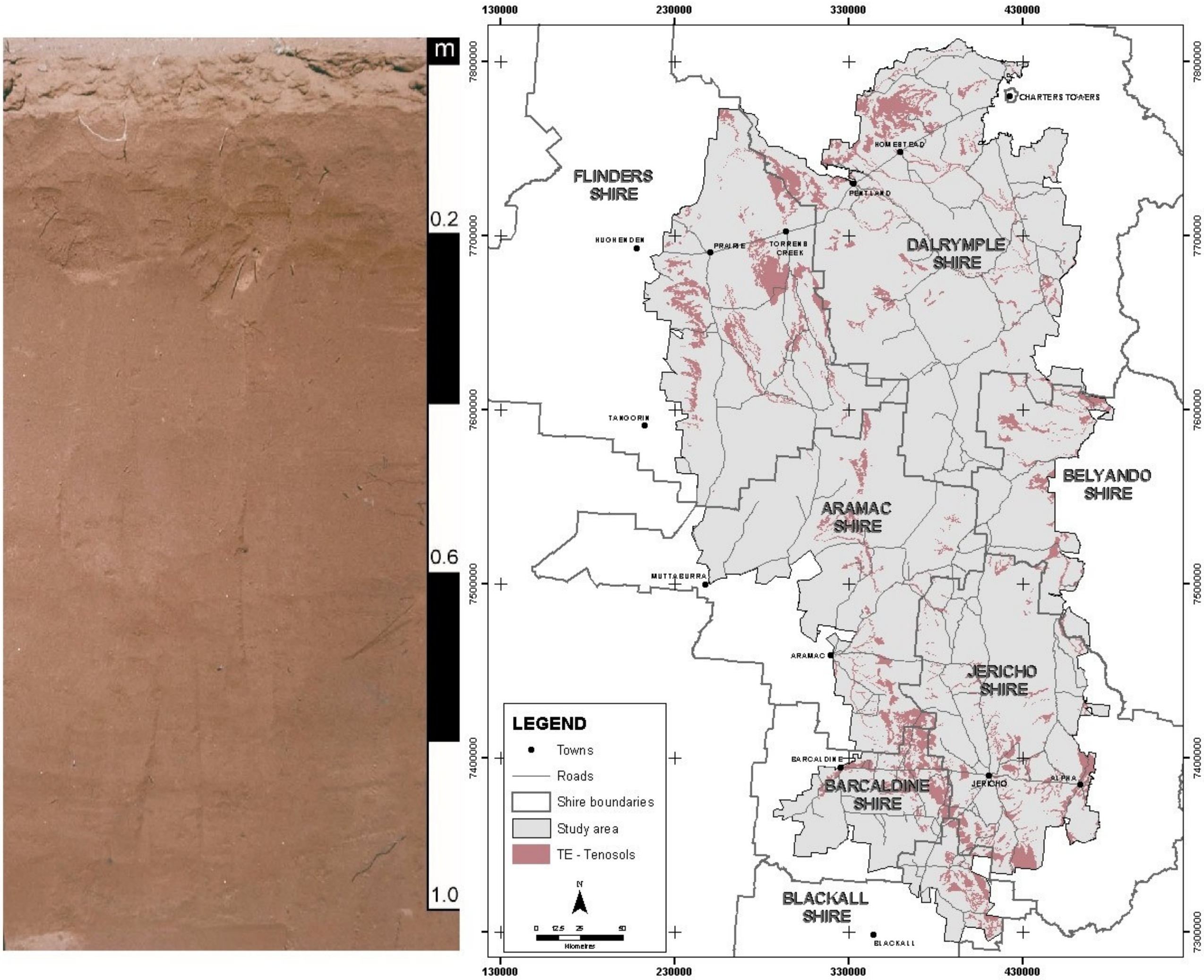


Photo: CSIRO, Land and Water

The distribution of Tenosols as the dominant soil
(approximate area: 7,805 sq.km, 9.17% of study area)

A Basic Arenic, Red-Orthic Tenosol (Isbell 1996):
A red, sandy, uniform-textured profile that has little development other than a weakly differentiated topsoil and the subsoil is neither strongly acid or calcareous.

Uc1.23 - 1/0/008 (Northcote 1979, Charman 1978):
A red, non-calcareous uniform sand that is only weakly coherent in the moderately moist state.

Figure 4.4 Characteristics and distribution of Tenosols

4.3.5 Sodosols (SO)

The distribution and characteristics of Sodosols are illustrated in Figure 4.5.

Sodosols are characterised by a strong texture contrast between the A horizon and B horizon. Invariably the A2 horizon is bleached and the B horizon is sodic (an ESP of 6 or greater) and often mottled, indicating a major change in permeability between the A2 and B2t horizons, caused primarily by the dispersive nature of the sodic clay.

Sodicity was not used in the Factual Key and other criteria, such as the presence of a bleached A2 horizon, neutral or alkaline subsoils and columnar structure, help provide a correlation to Sodosols in the Australian Soil Classification. For example Dr3.43, Db2.43, Dy3.43 and Dd2.43 all have conspicuously bleached A2 horizons and alkaline soil reaction trends and would most likely be Sodosols – an ESP of 6 or greater in the upper B horizon would confirm the classification.

Sodosols have a number of inherent problems for land use:

- The relatively impermeable subsoils restrict water and root penetration.
- The sodic clays are very dispersible, making them susceptible to gully and tunnel erosion.
- The sandy topsoils become waterlogged and 'boggy' during wet periods and 'droughty' during extended dry periods.
- The topsoils are usually hard setting or crusty, and have a very low nutrient status.

The persistence of ground cover, particularly perennial pasture species, is dependant on minimal topsoil disturbance, the retention of litter and the accumulation of organic matter in the A1 horizon. The droughty nature and low fertility of the topsoil translates into a high sheet erosion hazard and the risk of erosion occurring is increased by overgrazing or clearing the native vegetation. If the topsoil is lost the relatively impermeable, impenetrable surface of the B horizon presents an inhospitable seedbed that is likely to remain bare and promote runoff during heavy rainfall.

Approximately 10% of the land units in the Desert Uplands have the dominant soil classified as a Sodosol, and of the 23 profiles examined those with brown clay subsoils and a high base status are the most common. The majority of these profiles occur on alluvial fans, flood plains and broad drainage depressions. The numbers of profiles occurring in the various categories of Sodosol are as follows:

Suborder	Great group	Subgroup
Brown B horizon (AB): 11	Subnatric (ES): 10	Moderate base status (AG): 3
Grey B horizon (AD): 6	Mottled-Mesonatric (FO): 3	High base status (AH): 12
Red B horizon (AA): 4	Hypernatric (CR): 3	Hypercalcic (CQ): 3
Yellow B horizon (AC): 2	Petrocalcic (DZ): 2	Calcic (BD): 2
	Hardpan in solum (EA): 2	Others: 3
	Others: 3	

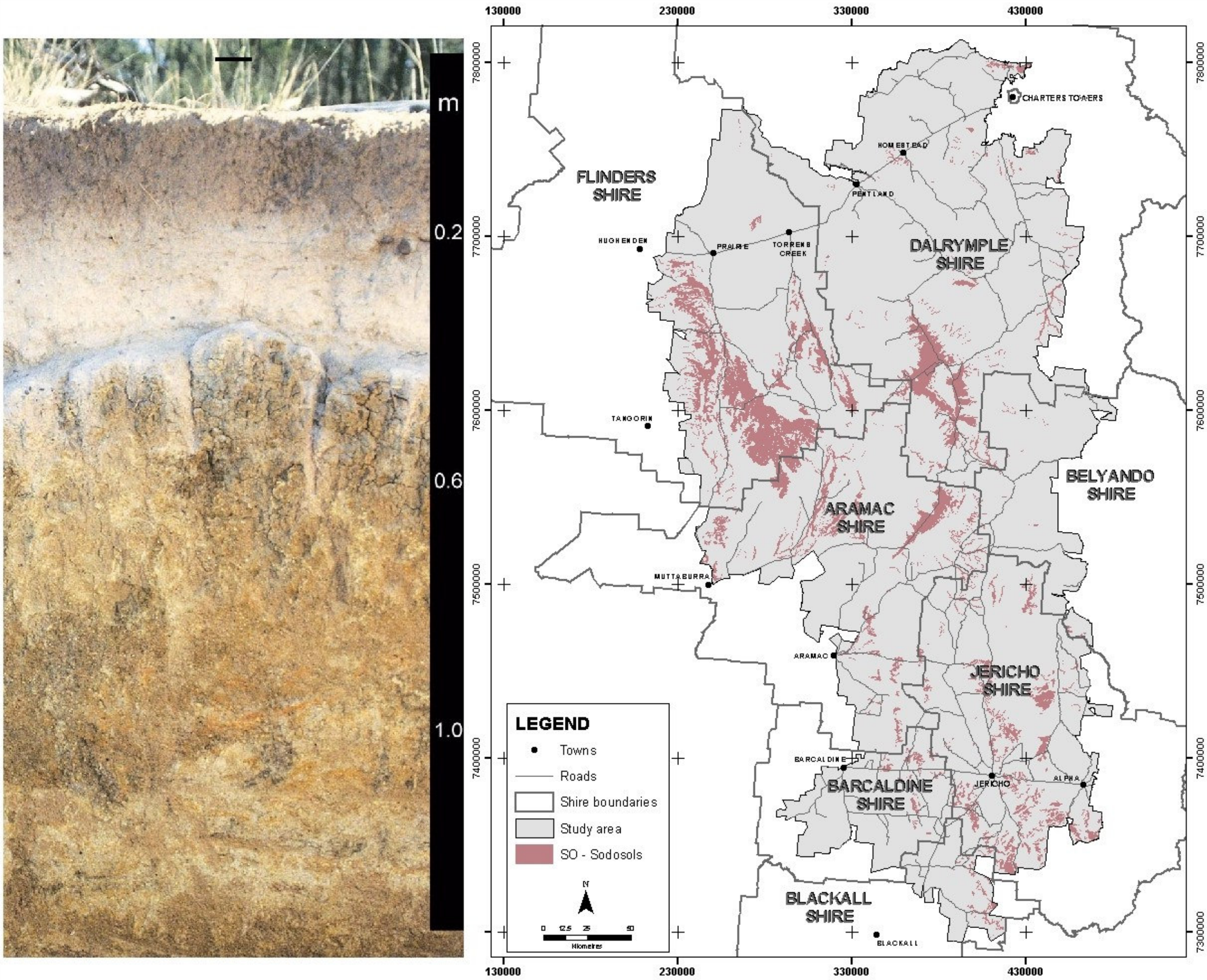


Photo: CSIRO, Land and Water

The distribution of Sodosols as the dominant soil
(approximate area: 7,274 sq.km, 8.55% of study area)

A Mesotrophic, Mottled-Mesonatric, Grey Sodosol (Isbell 1996):
A texture-contrast profile in which the grey mottled subsoil has an exchangeable sodium percentage of between 5 and 25 and a base status of between 5 and 15 cmol. per kg clay.

Dy3.43 – 2/0/040 (Northcote 1979, Charman 1978):
A duplex profile with a thick, massive, conspicuously bleached sandy loam topsoil overlying a structured, mottled, yellowish brown clay with an alkaline soil reaction trend.

Figure 4.5 Characteristics and distribution of Sodosols

4.3.6 Rudosols (RU)

The distribution and characteristics of Rudosols are illustrated in Figure 4.6.

The Rudosols are distinguished from other soils by the complete lack of horizon development, other than the accumulation of organic matter in the A1 horizon. The soils are so young, or conditions have been such, that soil-forming factors have not significantly modified the colour, texture, or structure of the parent material. If the profile is calcareous it is because the parent material is calcareous, not because pedogenesis has concentrated carbonate in any specific horizons.

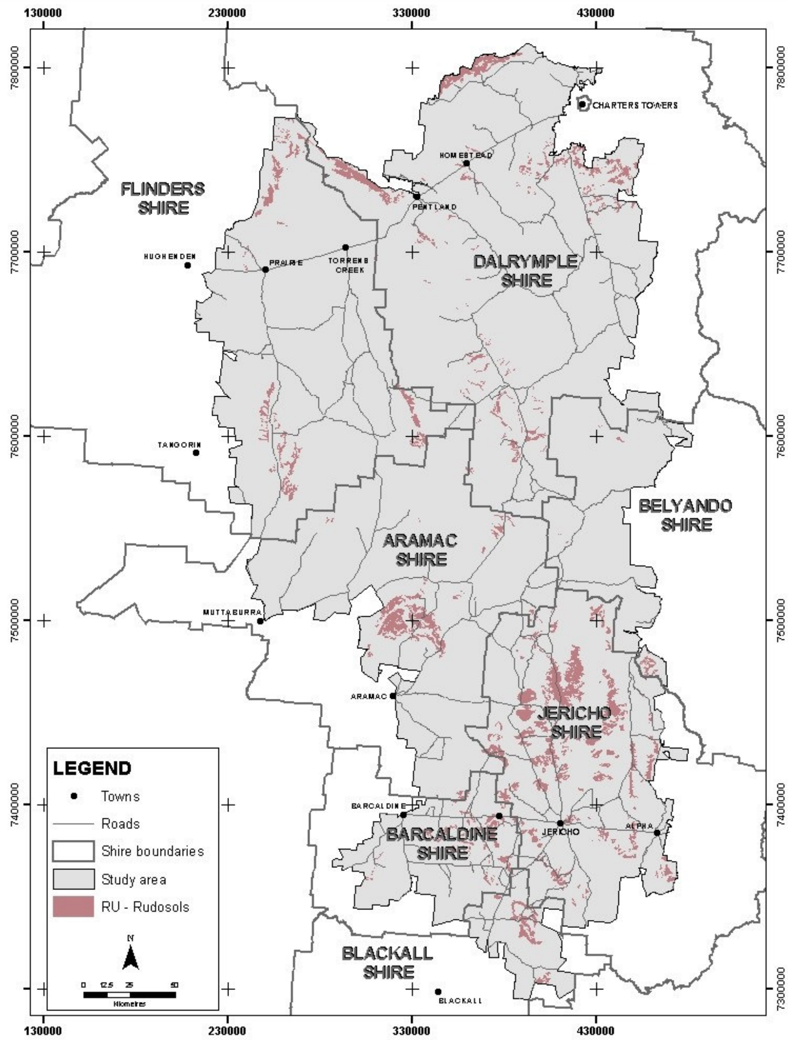
In the Factual Key soil classes Uc1, Uc4.1, Um, and Uf are classified in the Australian Soil Classification as Rudosols.

Where shallow Rudosols occur on bedrock or hardpan land use is very limited, whereas the deep sandy alluvial profiles, even though nutrient levels are still low, have a better water-holding capacity and a longer growing season for deep-rooted pastures. If perennial pasture species have been removed and replaced with annual species as a result of overgrazing, productivity will be reduced dramatically since the shallow-rooted annual plant species germinate, set seed and die within a short period while moisture remains in the topsoil and dry matter production is very low.

Less than 4% of the land units in the Desert Uplands have the dominant soil classified as a Rudosol and of the 10 profiles examined the sandy Rudosols are the most common. Half these sites occur as relatively shallow profiles overlying sandstone bedrock or lateritic hardpans (land systems: Charters Towers Metamorphics (CM1), Southern Plateau (SP1), Cudmore (CE1) and Gordonbrook (GK1)), whereas the other half are deeper profiles on alluvium that have not developed marked soil horizon characteristics (land systems: Joe Joe (JJ1), Alice River (AE2), Buchanan-Galilee Fan (BE2), Badlands (BD4), Lake Buchanan (LB1) and Ludgate (LE5)). The numbers of profiles occurring in the various categories of Rudosol are as follows:

Suborder	Great group	Subgroup
Arenic (AO): 5	Ferric (BU): 2	Basic (AR): 8
Leptic (CY): 3	No appropriate class (ZZ): 4	Acidic (AI): 1
Clastic (HH): 2	Paralithic (DU): 2, Other: 2	Other: 1

Photo: CSIRO, Land and Water



The distribution of Rudosols as the dominant soil
(approximate area: 3,880 sq.km, 4.56% of study area)

A Basic Arenic Rudosol (Isbell 1996):
A uniform-textured, sandy profile that is loose or only weakly coherent in a moist condition and shows little or no colour change or texture change with depth and is neither strongly acidic or calcareous.

Uc5.22 - 1/0/007 (Northcote 1979, Charman 1978):
A structureless, but coherent, uniform brown sandy loam profile with a thin slightly darker topsoil.

Figure 4.6 **Characteristics and distribution of Rudosols**

4.3.7 Dermosols (DE)

The distribution and characteristics of Dermosols are illustrated in Figure 4.7.

The Dermosols lack a strong texture contrast between the A and B horizons, but they do have moderately to strongly structured B2 horizons. The profiles have less than five percent free ferric oxide and are not calcareous throughout, thereby distinguishing them from Ferrosols and Calcarosols, respectively.

In the Factual Key most of the Gn3, Gn4, Um4.4, Um6.3 and Uf6.3 soils fit into the Dermosol order. These soil profiles are not very common in the study area and there may have been instances where profiles have been classified as Dermosols, but in fact, are eroded gradational or texture-contrast profiles. Isbell *et al.* (1997) state that 'arid zone occurrences in Queensland mainly occur on low angle pediments, extending from lateritic mesas in varying degrees of denudation on to the surrounding Vertosol plains'. This is particularly true in the Desert Uplands study area where 6 of the 11 sites with Dermosols were located on the eroded, lower slopes of lateritic escarpments (Badlands (BD3), Britannia (BT4), Doncaster (DR3), Potosi (PT5), Stagmount Scarp (SS3) and Waterview (WV3) land systems). The remaining 5 sites occur on basalt or fine-grained sedimentary rock that are regarded as 'outliers' of the adjacent Brigalow and Einasleigh bioregions.

Land use on the Dermosols of the semi-arid tropics is confined to light grazing by cattle. The soils, although usually possessing a moderate-high nutrient status, are often well drained and carry only a light cover of native grasses. The lack of soil moisture, and the resulting short growing season associated with these soils, has inhibited the introduction of pasture species with a higher potential productivity than the native species.

Less than 6% of the land units in the Desert Uplands have the dominant soil classified as a Dermosol and of the 15 profiles examined the Brown Dermosols with a high base status are the most common. The numbers of profiles occurring in the various categories of Dermosol are as follows:

Suborder	Great group	Subgroup
Brown B horizon (AB): 9	High base status (AH): 11	No features (CD): 6
Red B horizon (AA): 3	Moderate base status (AG): 2	Sodic lower B (EO): 2
Grey B horizon (AD): 2	Other: 2	Acidic-sodic B (HO): 3
Yellow B horizon (AC): 1		Bleached A_2 horizon (AT): 2
		Other: 2

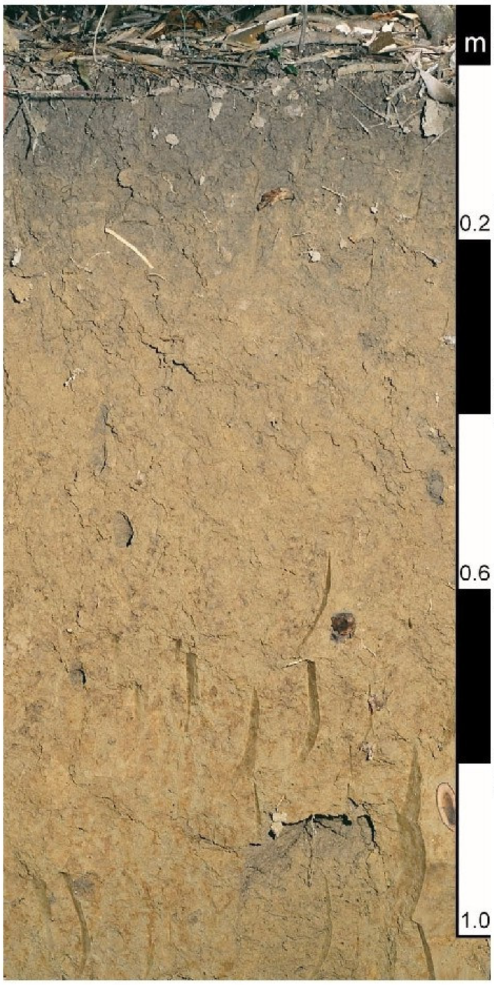
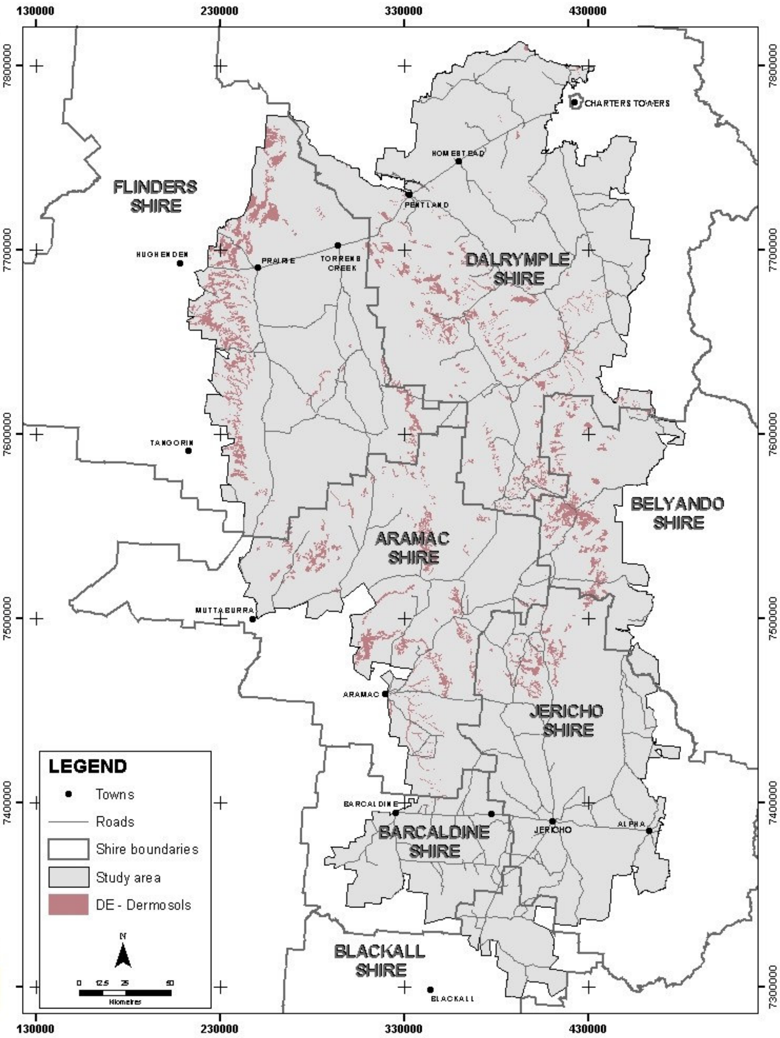


Photo: CSIRO, Land and Water



The distribution of Dermosols as the dominant soil
(approximate area: 3,903 sq.km, 4.59% of study area)

An Acidic Dystrophic Brown Dermosol (Isbell 1996):
A gradational-textured profile with a structured subsoil, which is rown, strongly acidic and has a base status of less than 5 cmol. per kg clay).

Um6.34 - 4/2/015 (Northcote 1979, Charman 1978):
A uniform clay loam profile with a moderately structured clay loam topsoil of medium depth overlying a yellowish-brown, moderately-structured subsoil showing distinct red mottles).

Figure 4.7 Characteristics and distribution of Dermosols

4.3.8 Hydrosols (HY)

The distribution and characteristics of Hydrosols are illustrated in Figure 4.8.

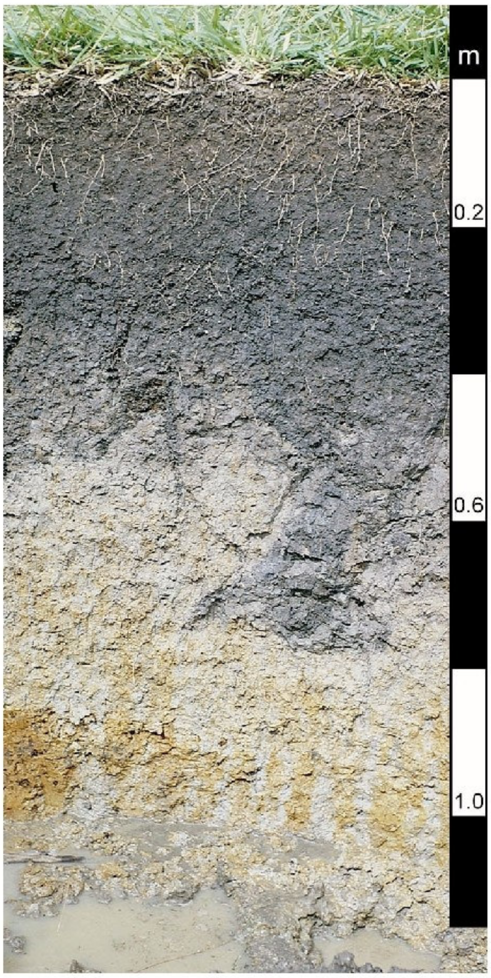
Hydrosols occur in seasonally or permanently wet areas. Exceptions to these criteria are the Organosols, Podosols and Vertosols, which can be seasonally waterlogged but also have other important characteristic features. The Factual Key does not identify 'Hydrosols' as such, but relies on characteristics such as gley colours and the degree of mottling to indicate regular waterlogged or anaerobic conditions. The Australian Soil Classification uses the rationale that seasonally (at least two months of the year) or permanently saturated soil profiles are severely restricted in their use and that other profile characteristics are less important. For a profile to be classified as a Hydrosol, it is not necessary for reducing conditions, gley colours, ochrous mottles, or other segregations to be present as these characteristics are often of a temporal nature and variable distribution, and not always indicative of a saturated condition.

Land use on Hydrosols is often restricted to light grazing by cattle during the dry season, or as soon as the soils are trafficable. However, during periods of inundation the ephemeral wetlands so formed, are havens for migratory and local bird life.

Numerous examples of seasonally wet soils, many of which are non-saline, occur throughout the Desert Uplands. Some are in small, localised wetlands associated with artesian springs; others have formed because of impediments to the surface or subsurface drainage. The most likely locations for wetlands and Hydrosols are in the following land units: Alice Clays (AC5), Desert (DT4), Edgbaston (EN3), Lake Buchanan (LB5), Lake Dunn (LD6), Lake Galilee (LG7 & LG8), Lake Huffer (LH7), Lolworth Creek (LW2), Ludgate (LE3), Reedy Creek (RC3), Ravenswood (RD3), Toomba (TM6) and Webb Lake (WL3).

Where the dominant soil in a land unit is classified as a Hydrosol, the most common feature in four of the five profiles examined is the salic or hypersalic condition of the soil. The numbers of profiles occurring in the various categories of Hydrosol are as follows:

Suborder	Great group	Subgroup
Hypersalic: >50dsm^{-1} (CS): 3	Dermosolic features (FQ): 1	Not applicable
Salic: 2-50 dsm^{-1} (EG): 1	Kandosolic (FR): 1	
Oxyaquic (DT): 1	Other: 3	



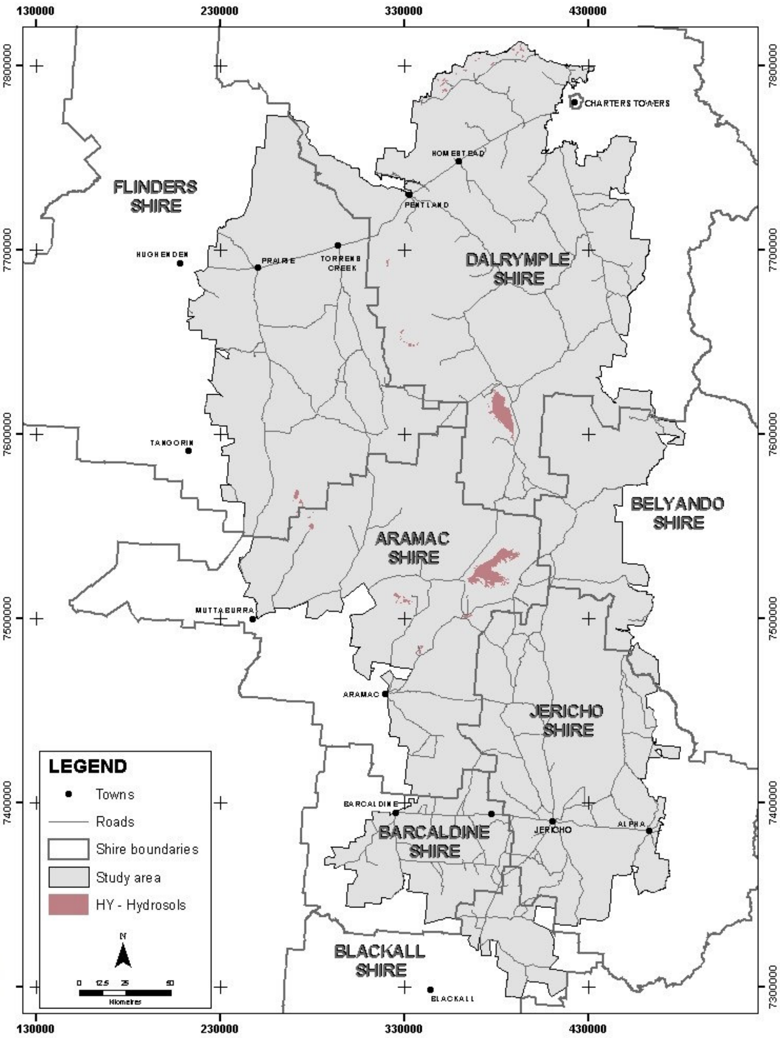


Photo: CSIRO, Land and Water

The distribution of Hydrosols as the dominant soil
(approximate area: 475 sq.km, 0.56% of study area)

An Humose Dermosolic Redoxic Hydrosol (Isbell 1996):
A gradational-textured profile, in which the major part is structured, mottled and saturated for 2-3 months in most years, and with a topsoil containing between 4 and 12% organic material.

Gn3.91 - 4/3/050 (Northcote 1979, Charman 1978):
A gradational-textured profile with a thick, strongly structured, clay loam topsoil overlying a mottled, yellow, light clay with an acidic soil reaction trend.

Figure 4.8 Characteristics and distribution of Hydrosols

4.3.9 Calcarosols (CA)

The distribution and characteristics of Calcarosols is illustrated in Figure 4.9.

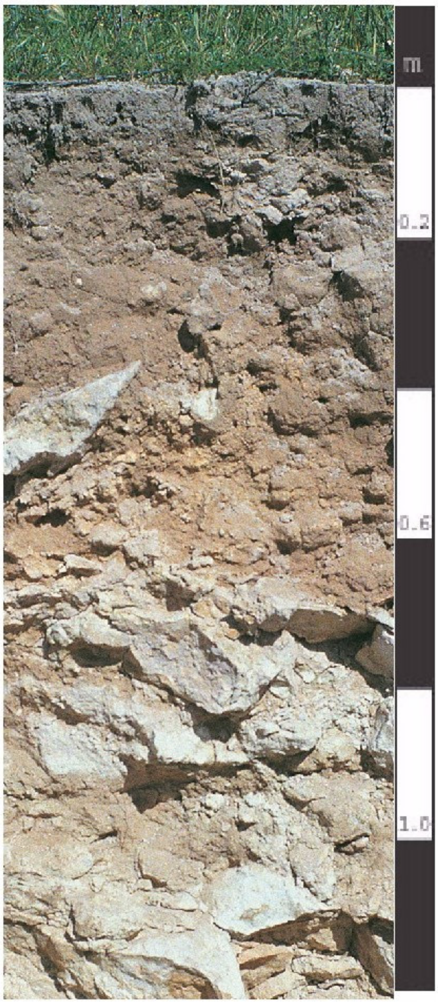
Calcarosols are common in the arid and semi-arid regions of Australia (200 – 350mm of rain per annum), where shallow soils are underlain by limestone. Calcarosols are also associated with aeolian sediments, usually in a landscape of low calcareous dunes, and with calcrete hardpans in palaeo-drainage valleys and old lakebeds. Unlike limestone, a calcrete hardpan may not be the parent material of the soil profile (Isbell *et al.* 1997), but a concentrated layer of calcareous material, once deposited as a fine dust on the soil surface and subsequently leached down into the existing soil profile. Ample evidence of this process is provided by Butler (1956), who describes the influence of ‘parna – an aeolian clay’ on the soils of the northern and western slopes of Victoria and New South Wales, respectively.

The Desert Uplands is a relict plateau underlain by Jurassic and Triassic sandstones that have undergone prolonged periods of intensive weathering and lateritisation – both processes preclude the formation of Calcarosols. However, a soil profile at one site located in a relict lakebed (land unit Teewarrina TA2) is classified as a Calcarosol. Other land units (Gainses (GS1), Lake Buchanan (LB4), Slogan Downs (SD1, SD2 & SD3), and Teewarrina (TA2 & TA4)), also associated with relict lakebeds, have concentrations of calcium carbonate or a calcrete hardpan in the soil profile, but not distributed throughout the entire profile to be classified as a Calcarosol. It suggests that a thin layer of calcareous dust may have blown in from the arid interior, only to be washed off the land surface and concentrated in the sediments of the lakes that existed at that time.

Calcarosols usually have major limitations for land use, namely, shallow depth of soil, low water storage capacity, high salt content, high alkalinity and possible boron toxicity for plant species

The only soil profile sampled (land system Teewarrina (TA4)) and classified in the study area as a Calcarosol contained more than 50 percent of hard calcrete fragments and nodules, and overlay a calcrete hardpan.

Suborder	Great group	Subgroup
Lithocalcic (DA): 1	Petrocalcic (DZ): 1	Melanic (DK): 1



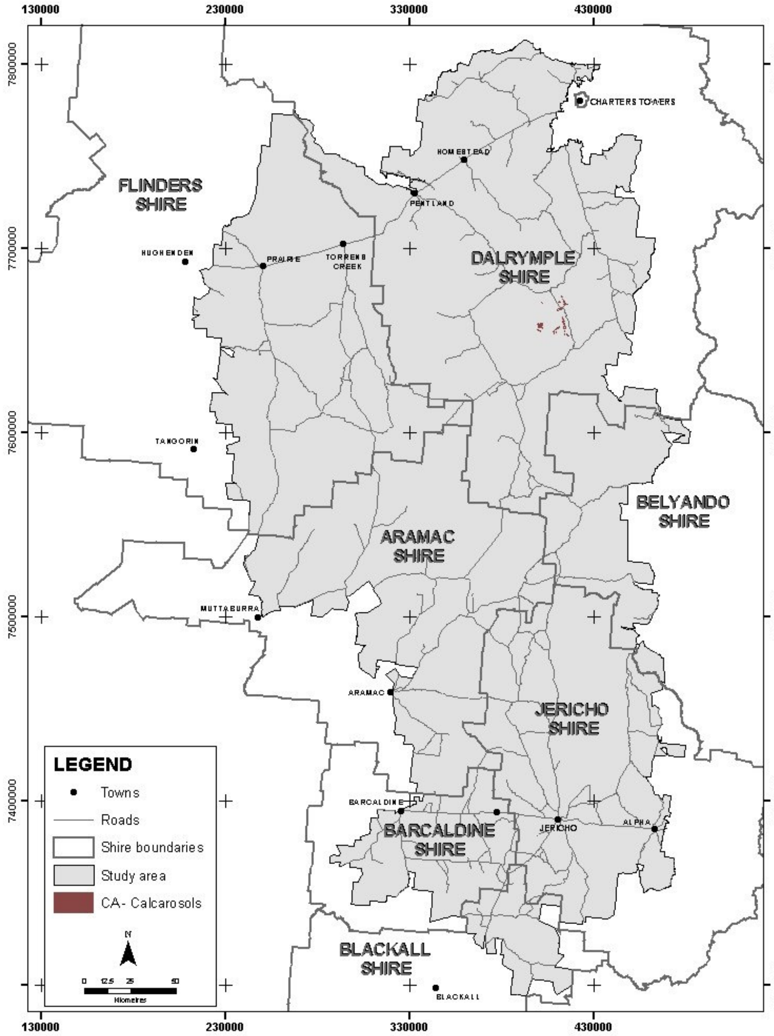


Photo: CSIRO, Land and Water

The distribution of Calcarosols as the dominant soil (approximate area: 37 sq.km, 0.04% of study area)

An Hypervescent, Petrocalcic, Supracalcic Calcarosol (Isbell 1996):
A uniform-textured profile, in which the moderately deep profile is calcareous, has a massive structure and a light sandy clay loam texture, throughout.

Um1.31 - 3/0/008 (Northcote 1979, Charman 1978):
A moderately deep profile with a topsoil containing at least 8% finely-divided carbonate, a subsoil containing 20-50% hard calcrete fragments or nodules, overlying a calcrete hardpan.

Figure 4.9 Characteristics and distribution of Calcarosols

4.3.10 Ferrosols (FE)

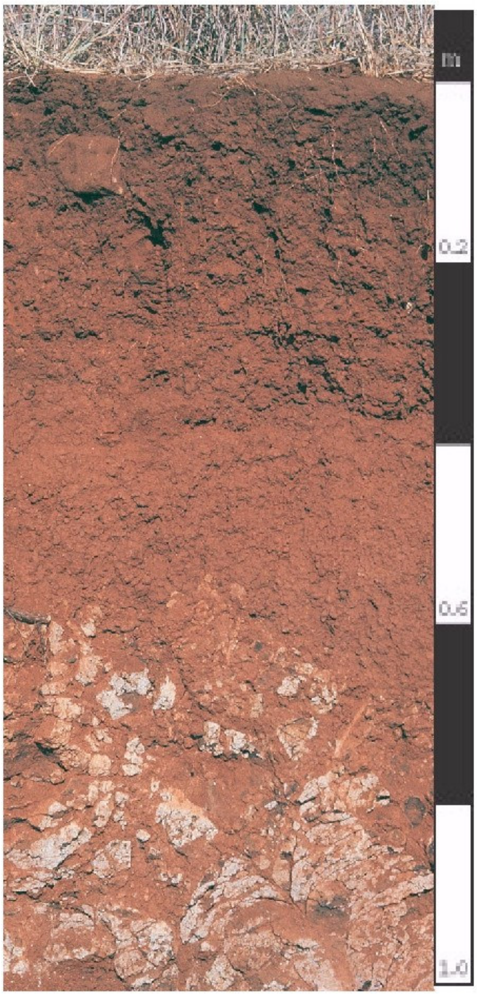
The most likely distribution of Ferrosols is illustrated in Figure 4.10.

The only areas in the study area likely to contain Ferrosols are the basaltic land systems of Clyde Park (CP), Toomba (TM) and Surbiton (SN) on the northern and south-eastern margins of the Desert Uplands bioregion. Unfortunately, chemical analysis on soil samples for free iron oxide, which is a diagnostic feature of this Soil Order, is not a regular procedure. Consequently, some soil profiles on basalt, classified as a Kandosol or Dermosol may be, in fact, a Ferrosol but this cannot be verified because the chemical data is not available.

Rather than the bright red, deep, friable clay profiles normally associated with intensive agriculture on the Atherton Tablelands, the basalt plains in the study area tend to have a leached profile with a hard-setting, clay loam topsoil grading into a weakly-structured, reddish-brown clay, often with significant quantities of ironstone gravel, and a land use restricted to extensive grazing.

One soil profile in the Toomba (TM2) land system is classified as a Ferrosol, but without data on the free iron oxide content, some doubt remains.

Suborder	Great group	Subgroup
Brown (AB): 1	Eutrophic (AH): 1	Manganic (DC): 1



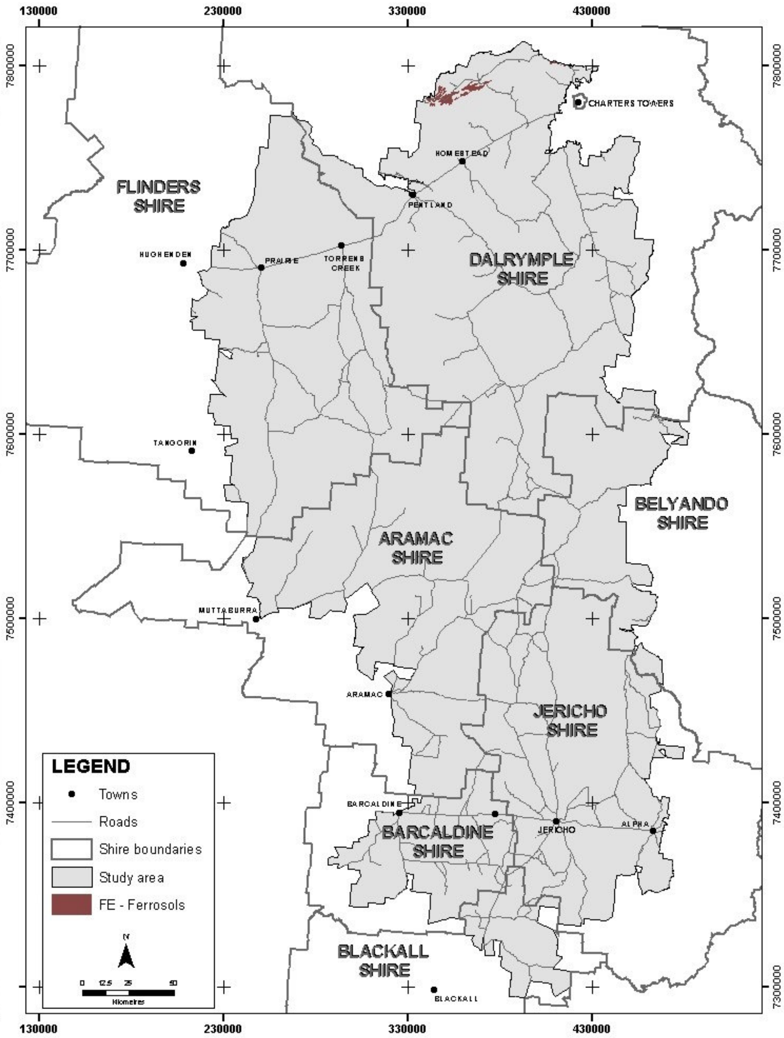


Photo: CSIRO, Land and Water

The distribution of Ferrosols as the dominant soil
(approximate area: 130 sq.km, 0.15% of study area)

An Haplic Eutrophic Red Ferrosol (Isbell 1996):
A strongly structured red soil profile with a moderately high base status and grading in texture from a heavy loam topsoil to a light medium clay subsoil.

Gn3.12 - 3/2/020 (Northcote 1979, Charman 1978):
A gradational-textured profile with a moderately-structured loamy topsoil and a dark red strongly-structured clay subsoil.

Figure 4.10 Characteristics and distribution of Ferrosols

5. Vegetation

5.1 Introduction

The Desert Uplands is part of the savanna woodlands, which extend across northern Australia from Queensland to Western Australia in a climatic zone known as the dry tropics. Diverse and colourful, spectacular and specifically adapted, much of the vegetation in the Desert Uplands bioregion has survived despite modern-day pressures to clear the land and increase productivity.

During the 1840s and 1850s explorers such as Sturt, Burke and Wills, Mitchell, Leichhardt and Kennedy were exploring and describing the productive potential of the land to the northwest, southwest and west of the Desert Uplands. Their quest to find open grasslands for grazing and land suitable for growing crops did not include the Desert Uplands because a major portion of the area was densely timbered and the availability of surface water, so necessary for the horses and bullock teams in the exploration party, was unreliable.

In 1859, the explorers Landsborough and Buchanan set out from Rockhampton to find good pastures for sheep and cattle. The expedition led to the establishment of Bowen Downs, just north of present-day Aramac, and the discovery of open, productive grasslands extending northwards to Torrens Creek. However, the journey nearly ended in tragedy when, desperately short of supplies, the party took a short cut back to Rockhampton through the Lake Buchanan district of the Desert Uplands. It was an area with sandy soils, saline flats, steep rocky cliffs and very little water. The return journey presented enormous challenges to the weakened party as they attempted to traverse the area as quickly as possible. As a result, the plant diversity and different vegetation communities were not fully described or recorded. It was another eighty years before Blake (1938) produced a summary of the vegetation in the bioregion.

Today, there is greater appreciation of the extraordinary diversity of plant species within the Desert Uplands bioregion, and it is this diversity that is highlighted in this section of the report. The number of plant species available and the presence of fertile material to assist identification are strongly influenced by field conditions and past land management practices. These include seasonality, (some plants only appear in certain seasons or years), fire (intensity and frequency), defoliation (domestic stock, wildlife, insect populations), seasonal rainfall and sampling methodology. Therefore, species lists presented here should be regarded as indicative rather than complete.

One thousand and fifty-eight different plant species were identified during the initial three-year period of fieldwork, however, with the inclusion of the Desert Uplands portion of the Dalrymple Shire in this final report (DUSLARA), and the data extracted from the CORVEG (Queensland Herbarium) database, the total number of plants recorded is approximately 1,474.

Within the diverse range of native plant species there are a number of morphological features that show an adaptation to a climate of erratic and unreliable rainfall and a generally low nutrient status of the common soil types. According to Brock (1993) while "the lack of obligately deciduous species and development of scleromorphy in the form of hard stiff foliage (*Grevillea* spp.), phyllodes (*Acacia* spp.), cladodes (*Pachynema* spp.) and highly reduced foliage (*Calytrix exstipulata)* …… would appear to be adaptations to arid climatic conditions, it is generally agreed that these plants have developed in response to nutrient-deficient soils".

Of the 112 families and 433 genera recorded in this study, eight families account for 44.5 percent of genera and 56 percent of species. These are summarised in Table 2.

Within the Desert Uplands bioregion, nine plant species are considered to be 'Rare', two plant species are considered 'Vulnerable' and require protection, and two plant species are 'Endangered. The plants in these categories are summarised in Table 3, where the site location and corresponding land unit code are provided. For more details refer to the specific Primary sites or CORVEG sites, which are listed on each land unit information sheet. Secondary and Tertiary sites from the earlier DUSLARA study, and sites from the Dalrymple Land Resource study, do not have detailed vegetation lists. Other plants of particular conservation significance in the Desert Uplands are discussed in Morgan *et al.* (2002).

Of the 1,474 different species identified during the study, 57 are exotics (Table 4). These have been introduced either intentionally, as a means of increasing production from sheep and cattle (for example, buffel grass (*Cenchrus ciliaris*)*,* Indian couch grass (*Bothriochloa pertusa*)*,* Rhodes grass (*Chloris inflata*)*,* feathertop Rhodes grass (*Chloris virgata*)*,* seca stylo (*Stylosanthes* scabra) and sabi grass (*Urochloa mosambicensis*)*,* or unintentionally as seed contamination in the following ways:

Table 2 Predominant plant families and genera in the desert uplands

Family	Number of genera	No of species	Most common genera	Number of species in the most common genera
Poaceae (Grasses)	68	296	*Aristida* *Digitaria* *Eragrostis* *Enneapogon* *Sporobolus* *Paspalidium*	34 17 27 14 12 11
Myrtaceae	16	106	*Eucalyptus* *Corymbia* *Melaleuca*	44 25 13
Mimosaceae (Wattles)	3	89	*Acacia*	95
Asteraceae (Daisy-like plants)	37	89	*Calotis* *Peripleura*	8 10
Cyperaceae	12	61	*Cyperus* *Fimbristylis*	28 15
Fabaceae (Legumes)	32	108	*Indigofera* *Glycine*	11 8
Chenopodiaceae	15	59	*Sclerolaena*	21
Malvaceae	8	50	*Sida* *Hibiscus* *Abutilon*	22 11 10
Sub-total	**191**	**858**		
Total for Desert Uplands bioregion	**433**	**1,474**		

- Soil adhering to stock or vehicles
- Stock fodder purchased and transported in from outside the region
- In the faeces excreted by stock brought back from agistment or purchased from outside the district.

Some of these species are so widespread that they are generally regarded as being ‘naturalised’. Their presence is taken for granted and they do not appear to be a cause of concern (for example white cypress pine (*Callitris glaucophylla*), spiked mallow (*Malvastrum americanum*), red natal grass (*Melinis repens*), prickly pear (*Opuntia stricta*) and hairy pigweed (*Portulaca pilosa*). Others are causing concern amongst land managers, government agencies and environmentalists because of the plants’ ability to spread rapidly, alter the ecological function, restrict access on the property or have adverse effects on animal health. Plants that fall into this category include mimosa bush (*Acacia farnesiana*), prickly acacia (*Acacia nilotica*), mother of millions (*Bryophyllum delagoense*), rubber vine (*Cryptostegia grandiflora*), parkinsonia (*Parkinsonia aculeata*), Noogoora burr (*Xanthium pungens*) and *Bathurst burr* (*Xanthium spinosum*).

Tarvine (*Boerhavia coccinea*) (sites 534, 528, 655 and 819) and tarvine (*Boerhavia diffusa*) (site 533) are regarded as agricultural pests, however it is uncertain if the two species have been introduced or are endemic to the area.

Table 3 The names and location of plant species with a rare or vulnerable conservation status

Plant species	Common name	Site number	Land unit	Number of sites
Rare plants				
Acacia spania	-	1014	BD2	1
Callistemon chisholmii	-	1492	TF4	1
Eucalyptus quadricostata	-	3510, 3511, 4895, 5926, 5928, 5929, 5984	WM2, WW2, WM1, CA1, BN4, BN4, CM2	7
Euphorbia sarcostemmoides	climbing caustic	2012	BE3	1
Fimbristylis vagans	-	3579, 3590, 3591, 4739, 4740, 4743, 4759, 4763, 4956	LB2, BE3, BE3, LB4, LB4, LB4, LB1, LB4, LB4	9
Pararistolochia praevenosa	Richmond birdwing vine	4797	CA3	1
Peripleura scabra	-	4774	BD2	1
Sclerolaena everistiana	-	1132	PT5	1
Sporobolus partimpatens	-	167, 168	BD3, UH2	2
Vulnerable plants (considered for protection)				
Lawrencia buchananensis	-	2030, 3578, 3579	LB1, LB5, LB2	3
Micromyrtus rotundifolia	-	4912	BD2	1
Endangered plants				
Nesaea robertsii	-	1076	TK3	1
Acacia ramiflora	-	4967, 4970, 4973, 4976, 4989, 4994	DR1, WM1, WM2, WM2, WW3, BD1	6

Table 4 The names and location of introduced plant species and those that have become environmental weeds

Plant species	Common name	Site number	Land unit	Number of sites
Introduced species				
Argemone ochraleuca	Mexican poppy	974, 1121	AR1, AR2	2
Introduced environmental weed species				
Acacia farnesiana	mimosa bush	numerous sites	numerous land units	192
Acacia nilotica	prickly acacia	numerous sites	numerous land units	25
Alternanthera pungens	khaki burr	122, 123, 2085, 2087, 2095, 4729	NP4, NP4, DT4, NP4, UH2, DT4	6
Bothriochloa pertusa	Indian couch grass	numerous sites	numerous land units	51
Bryophyllum delagoense	mother-of-millions	337, 533	JC2, JC3	2
Cardiospermum halicacabum	balloon vine	1133	TK3	1
Cenchrus ciliaris	buffel grass	numerous sites	numerous land units	577
Cenchrus setiger	birdwood grass	1615	WW2	1
Chenopodium ambrosoides	Mexican tea	1043, 1058, 1110, 1615	BD3, DT1, WV2, WW2	4
Chloris gayana	Rhodes grass	4794, 4857, 4928, 5395, 5843, 5848	BF2, CR5, SC3, PK3, GS1, GS1	6
Chloris inflata	purpletop chloris	numerous sites	numerous land units	10
Chloris virgata	feathertop Rhodes grass	numerous sites	numerous land units	12
Convolvulus arvensis	bindweed	3561	CA3	1
Crotalaria pallida	streaked rattlepod	3588	TA3	1
Cryptostegia grandiflora	rubber vine	numerous sites	numerous land units	110
Cucumis melo	-	3551, 3552, 4739, 4743	CM4, CA2, LB4, LB4	4
Cyperus tuberosus	sedge	numerous sites	numerous land units	14
Digitaria violascens	bastard summergrass	606, 649	CO3, SP2	2
Echinochloa colona	awnless barnyard grass	numerous sites	numerous land units	13
Eragrostis cilianensis	stinkgrass	4928	SC3	1
Eragrostis minor	smaller stinkgrass	2055	NP1	1
Eragrostis pilosa	soft lovegrass	4931	NP1	1

Plant species	Common name	Site number	Land unit	Number of sites
Eragrostis tenuifolia	elastic grass	1372	LE3	1
Gomphrena celosioides	gomphrena weed, soft khaki weed	642, 872, 1023, 1431, 3531, 3546, 4863	SP1, CO2, LH6, LE2, UH2, WW2, CA2	7
Harrisia martini	harrisia cactus	595, 5042, 5225, 5387, 5388, 6020	CC4, CM4, CR3, CM5, CM5, GS2,	6
Heliotropium indicum	Indian heliotrope	4804	BF3	1
Jatropha gossypiifolia	bellyache bush	5167, 5184, 5185, 5190, 5874	SC6, GS2, SC2, CR3, SC3	5
Lantana camara	lantana	4803, 4947, 4952, 5171, 5175, 5182, 5416	SC2, WW2, SC3, SC2, GS1, SC1, CA3	7
Macroptilium lathyroides	phasey bean	4827	CA2	1
Megathyrsus maximus	green panic, Guinea grass	495, 4779, 4928,	NP3, BE3, SC3	3
Malvastrum coromandelianum	prickly malvastrum	4718	BB4	1
Malvastrum americanum	spiked malvastrum	numerous sites	numerous land units	29
Melinis repens	red natal grass	numerous sites	numerous land units	137
Ocimum americanum	American basil	4858, 4860, 4866, 4867	CA3, CA2, CR2, CM5	4
Ocimum basilicum	sweet basil	4855, 4925	CR5, CR5	2
Opuntia monacantha	drooping tree pear	5042, 5184, 5314, 5356, 5843, 5848	CM4, GS2, CM7, SC5, GS1, GS1	6
Opuntia stricta	prickly pear	numerous sites	numerous land units	15
Opuntia tomentosa	velvety pear tree	numerous sites	numerous land units	14
Parkinsonia aculeata	parkinsonia, Jerusalem thorn	numerous sites	numerous land units	60
Parthenium hysterophorus	parthenium weed	49, 83, 122, 123, 4718, 4720, 4749, 4931	WY3, BB1, BD3, BD5, BB4, PK3, TA1, NP1	8
Pennisetum villosum	feathertop	1640	WM2	1
Richardia brasiliensis	white eye	4718	BB4	1
Scoparia dulcis	scoparia	4895, 4913	WM1, BD3	2
Senna obtusifolia	sicklepod	5323, 5325	CM5, CA3	2
Senna occidentalis	coffee senna	386, 392, 405	MD3, NP3, BD3	3
Sida cordifolia	flannel weed	numerous sites	numerous land units	12
Sida rhombifolia	common sida	1328, 4721, 4723, 4760	TF2, TA3, AA3, BE3	4
Sida spinosa	spiny sida	numerous sites	numerous land units	12
Sporobolus coromandelianus	-	715, 977, 1301, 4777, 4778	DS3, SS2, TF2, BD3, BD2	5

Plant species	Common name	Site number	Land unit	Number of sites
Stylosanthes guianensis	stylo	4772	NP2	1
Stylosanthes hamata	verano stylo	54	Outside study area	1
Stylosanthes humilis	Townsville stylo	1351, 4798	WV2, CA3	2
Stylosanthes scabra	shrubby stylo, seca stylo	numerous sites	numerous land units	78
Themeda quadrivalvus	grader grass	5312	CA2	1
Urochloa mosambicensis	sabi grass	numerous sites	numerous land units	18
Urochloa panicoides	liverseed	1328	TF2	1
Verbesina encelioides	crownbeard	788, 847	AE3, LR1	2
Xanthium occidentale	noogoora burr	874, 1023, 1382, 4718	RD2, LH6, TC3, BB4	4
Xanthium spinosum	Bathurst burr	874, 973, 974, 1020, 1133,	RD2, AR1, AR2, TK3,	5
Ziziphus mauritiana	chinee apple, Indian jujube	5028, 5163, 5190, 5222, 5874, 6024	CA2, SC3, CR3, CR3, SC3, GS2	6

5.2 Major vegetation communities of the Desert Uplands

In order to simplify the natural variability that occurs within and between vegetation communities throughout the bioregion, the following section presents the vegetation information under a series of headings. These signify the dominant and co-dominant plant species, as well as the general vegetation structure. That is, they provide the 'big picture' on the location of dominant or co-dominant tree species, open grasslands and heathlands. For example, Figure 5.1 shows several locations where spinifex is the dominant plant species in open grasslands, whereas Figure 5.2 shows the distribution of the spinifex genera as one of the many ground cover species throughout the whole study area. It is possible to extract from the database a similar map format with accompanying detailed information showing the distribution of any one of the 433 plant genera recorded.

It is not within the scope or timeframe of this project to interpret all the information collected during the study period, but the mechanism is there for anyone familiar with ACCESS to extract specific information for a wide range of issues, establish correlations between different data sets and initiate new projects or research.

5.2.1 Naturally open grasslands and heathlands

There are two dominant areas of natural grasslands in the study area (Figure 5.1).

The first is along the western margin of the study area, and is really the edge of the Mitchell Grass Downs bioregion. Hence, the land units of AR2, DE2, RD4 and TK1 represent the open grassland areas of the Aramac, Dunrossie, Ravenswood and Thistlebank land systems, respectively. Curley Mitchell grass (*Astrebla lappacea*) is predominant throughout with varying proportions of bull Mitchell grass (*A. squarrosa*), desert daisy (*Streptoglossa adscendens*), lovegrass (*Eragrostis* species), button grass (*Dactyloctenium radulans*), saltbush (*Atriplex* species) and Queensland blue bush (*Chenopodium auricomum*).

The second major grassland area extends through the clay plains of subregion 1 and 3, represented by the land systems and land units of Aberfoyle (AL1), Bogunda (BA1), Moondah (MH2), Prairie Plains (PP2), Teewarrina (TA3) and Towerhill Creek (TC2). In contrast to the Downs clays, which have formed on consolidated mudstones, these clays have developed on lakebed clays and the resulting composition of the native pastures is quite different. Curley and bull Mitchell grass (*Astrebla* species) and Queensland bluegrass (*Dicanthium sericeum*) are co-dominant throughout, although relative proportions vary from one locality to another. There is a diverse range of other grasses and herbs that are listed in the individual land unit descriptions, however the more common ones include red Flinders grass (*Iseilema vaginiflorum*), several wiregrasses (*Aristida* species), nutgrass (*Cyperus* species), purple lovegrass (*Eragrostis lacunaria*), wanderrie grass or neverfail (*Eriachne* spp.), finger rush (*Fimbristylis dichotoma*) and native sensitive plant (*Neptunia gracilis*).

There are several other areas, some too small to show in Figure 5.1, that represent open grass plains:

- Within the Ulcanbah (UH) land system, barley Mitchell grass (*Astrebla pectinata*) is predominant in several locations of land unit UH3 with showy foxtail (*Ptilotus exaltatus*), soft roly-poly (*Salsola kali*) and woolly copperburr (*Sclerolaena bicornis*) playing a minor role.
- On the basalt plains in the north-western corner of the study area within the Clyde Park (CP) land system, heavy black clay soils (land unit CP4) support grasslands of bluegrass (*Bothriochloa* species) and wiregrass (*Aristida* spp.) with accompanying *Chloris, Eulalia, Panicum, Paspalidium* and *Sporobolus* species.
- Within the Ludgate (LE) land system the open areas that are not inundated with water during the wet season (land unit LE3) have an open tussock grassland of curly Mitchell grass (*Astrebla lappacea*) and bull Mitchell grass (*A. squarrosa*) predominant, with bluegrass (*Bothriochloa* species), long-awned wanderrie (*Eriachne armitii*) and common native couch (*Brachyachne convergens*) in a supportive role.
- The land units EN2 and LR3 from the Edgbaston and Lochinvar land systems, respectively, are similar in that both have variable depths of aeolian or alluvial sand overlying sodic and saline clays. However a dominant feature is the open grassland of giant grey spinifex (*Triodia longiceps*).

Although the grasslands support a fauna assemblage of low species richness, the fauna is very specialised and almost entirely restricted to the micro-habitat features of these plains (for example, the deep cracking-clay soils and tussock-grass bases - Morgan *et al*. 2002).

Heathlands are commonly found on shallow sands that have a very low nutrient status and water storage capacity, and often overlie deep gravels or an ironstone hardpan. The soils are rapidly drained and droughty but the native plant species are well adapted to such conditions. Many of the plants that combine to form a heathland come from the genera of *Calytrix*, *Acacia*, *Grevillea*, and *Hakea*, and occur individually in a number of land systems, such as Northern Plateau (NP1), Southern Plateau (SP2), Grant (GT1) and Desert (DT2). However, relatively large areas of heathlands are common only in the land units of CE1 (Cudmore), CO1 (Colorado) and WW1 (Wishaw) land systems, where desert fringe myrtle (*Calytrix microcoma*), silver oak (*Grevillea parallela*), golden parrot tree (*G. pteridifolia*), slender wattle (*Acacia leptostachya*), catkin wattle (*A. julifera*), waxy wattle (*A. melleodora*), narrow-leaved wattle (*A. tenuissima*), soap tree (*Alphitonia excelsa*), woodland paperbark (*Melaleuca nervosa*), grasstree (*Xanthorrhoea johnsonii*) and geebung (*Persoonia falcata*) are most likely to occur.

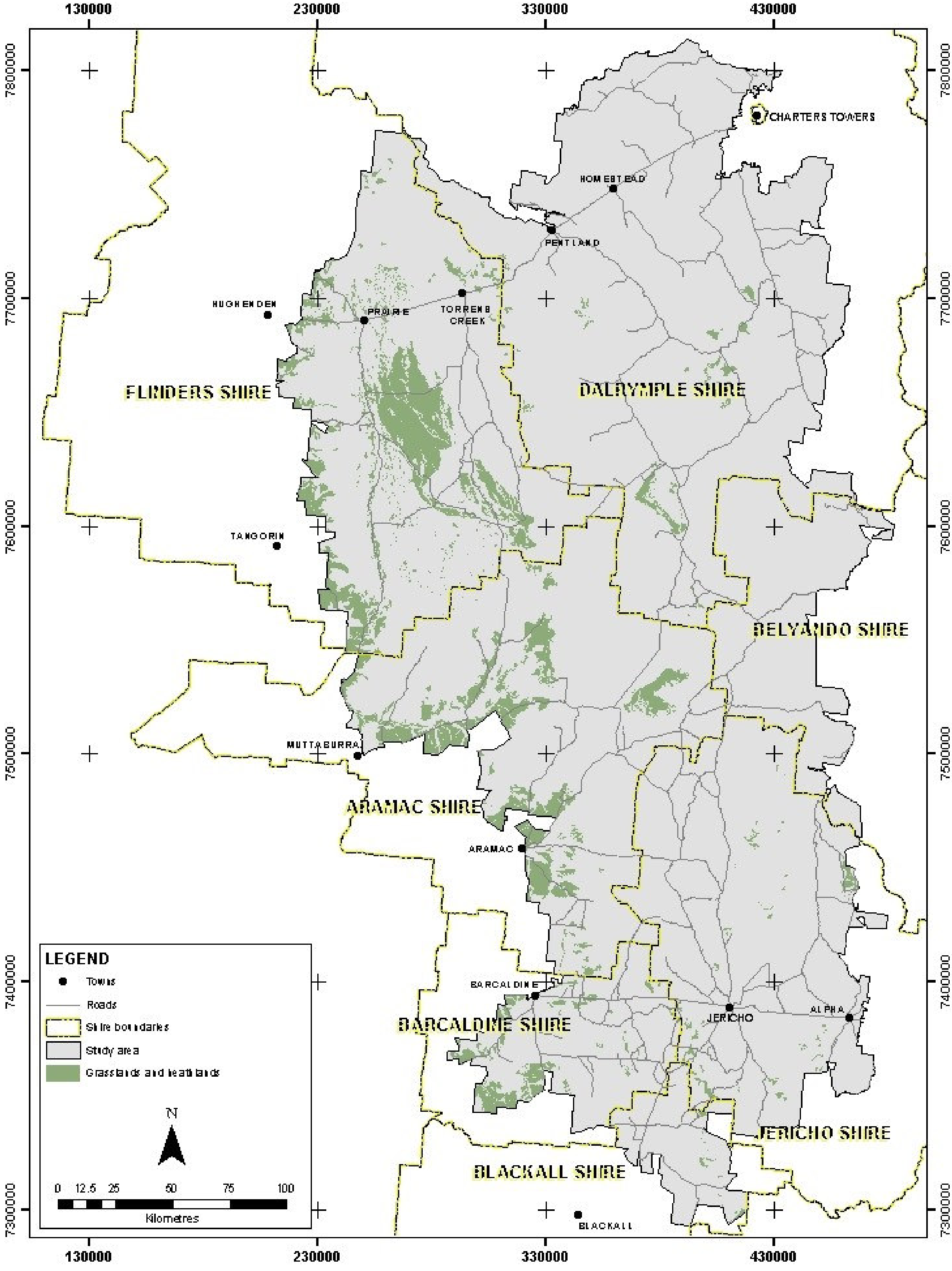


Figure 5.1 **The location of open grasslands and heathlands as dominant vegetation communities**

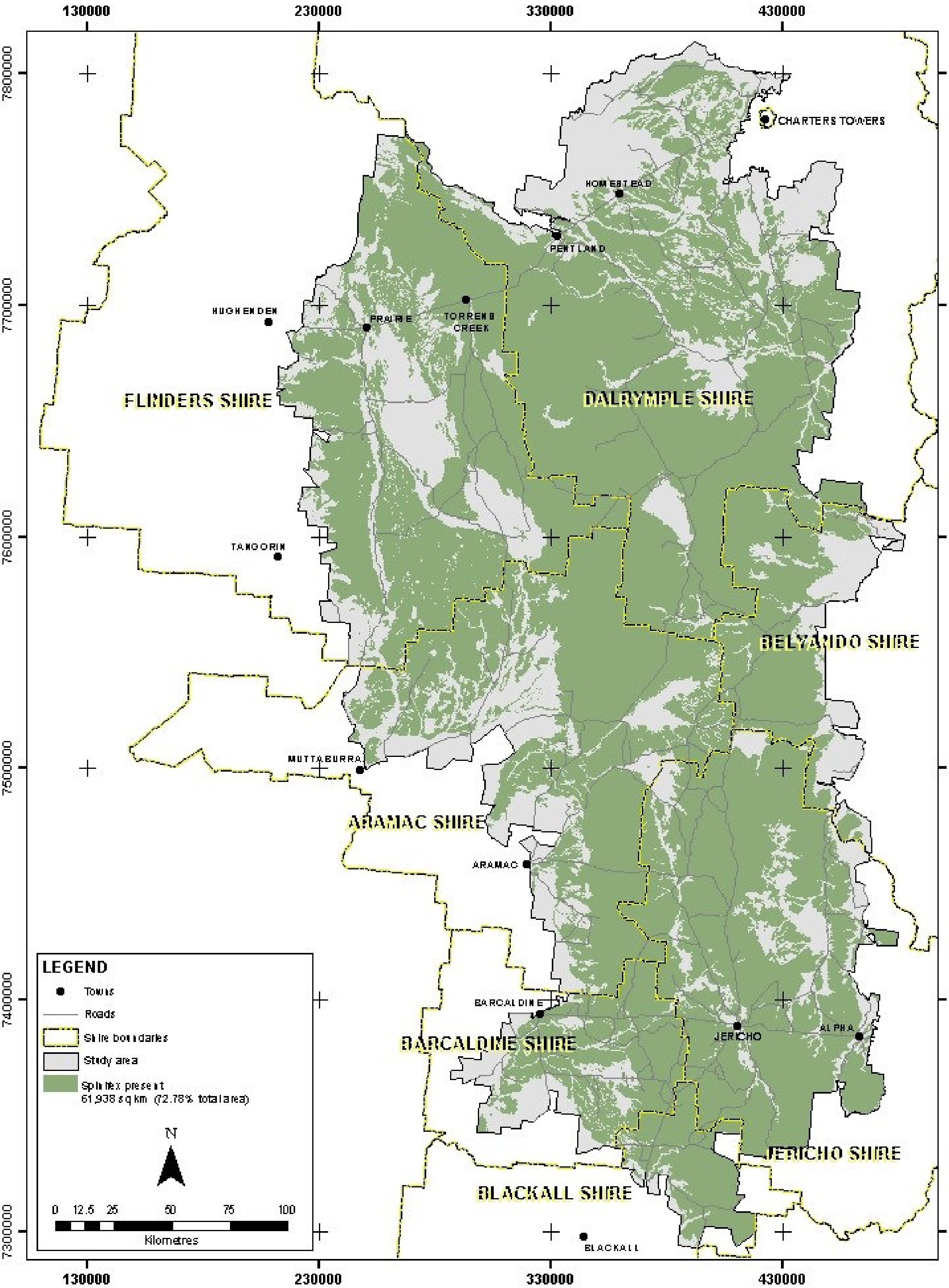


Figure 5.2 **The distribution of Spinifex (Triodia spp.)**

5.2.2 Acacia forests and woodlands

There are approximately 88different acacia species within the Desert Uplands bioregion. The location diagram (Figure 5.3) depicts the area where blackwood (*Acacia argyrodendron*), gidgee (*A. cambagei*), brigalow (*A. harpophylla*), lancewood (*A. shirleyi*) and bendee (*A. catenulata*) are the dominant tree species or co-dominant with other tree genera.

A definite pattern emerges if the location of individual species is considered, for example:

Blackwood: Areas dominated by blackwood are confined to the heavy sodic clay soils on the clay plains of the Aberfoyle (AL2), Plain Creek (PK4) and Thistlebank (TK2) land systems and in the drainage depressions of the Moondah (MH4), Albion Vale (AV4), Boggy Creek (BG3) and Potosi (PT5) land systems, and the relict lakebed of Lake Dunn (LD4), Slogan Downs (SD2, SD3) and Teewarrina (TA1, TA5) land systems. However, as a co-dominant with boree (*A. tephrina*) and gidgee, the area extends into the Thistlebank (TK3) and Gordonbrook (GK5) land systems, respectively.

Brigalow: Woodlands dominated by brigalow are clearly defined along the eastern and northern boundary of the study area on the heavy clay soils of the Balfes Creek (BF2), Belyando (BR1), Beenboona (BB2 & 4), Companion Creek (CC1), Charters Towers Metamorphics (CM5), Lagoon Creek (LC2), Slogan Downs (SD2), Teewarrina (TA2) and Willandspey (WY4) land systems, together with an extensive area in the Alice Clays (AC4) land system northwest of Jericho. As a co-dominant with gidgee, the distribution of brigalow is still confined to the eastern and northern sides of the study area, and includes the Cape-Campaspe River (CR4), Gainses (GS1), Jordan Creek (JC2, JC3), Lake Galilee (LG2), Maynard (MD2), Oakvale (OE6) and Willandspey (WY4) land systems.

Gidgee: Gidgee is the most versatile and widespread of the acacia tree species. It appears as the dominant species in fifteen different land systems ranging from the friable brown Dermosols on the basaltic Clyde Park (CP2 & 5) land system, the lakebed clays exposed in the Corea (CA3, CA4), Cape-Campaspe River (CR4), Moondah (MD3), Gainses (GS1), Lake Dunn (LD3), Maynard (MD3), Teewarrina (TA1) and Willandspey (WY2) land systems, the sandy red Chromosols on the dunes of Lake Galilee (LG6), overlying buried clays in the Delta South (DS2, DS3 and DS4), Lake Huffer (LH2), Lochinvar (LR2 and LR 4) and Ravenswood (RD2) land systems, to the escarpments of the Waterview (WV3 and WV5) land system where the underlying mudstones have been exposed and formed friable brown clay soils. Gidgee is co-dominant with boree along the whole western boundary where the cracking clay soils of the Downs (Aramac (AR1) and Dunrossie (DE1) land systems) and the lower slopes of the Desert Uplands escarpment (Stagmount Scarp (SS5) land system) form a transition zone. The co-dominance of gidgee and brigalow has been discussed in the previous section.

Lancewood and bendee: Lancewood has an affinity for shallow soils, ironstone and steep slopes. Invariably lancewood is dominant on the plateau margins and the steep escarpment where ironstone is exposed or very close to the surface in the Badlands (BD1 and BD2), Britannia (BT3), Bromvil (BL1), Charters Towers Metamorphics (CM3), Cudmore (CE2 and CE3), Colorado (CO2), Doncaster (DR2), Gordonbrook (GK2), Joe Joe (JJ3), Oakvale (OE2), Potosi (PT4), Southern Cross (SC3, SC4), Wattlevale (WE4), Vacquera (VA3) and White Mountains (WM1) land systems. Bendee often accompanies lancewood at these locations, and prefers slightly deeper soils on the escarpment – usually on the mid-lower slopes - but not in numbers approaching co-dominance except for very small areas.

Acacia communities favour and support high abundances of particular fauna groups, including arboreal mammals (particularly where the woodlands are associated with riparian zones), reptiles, and woodland bird species that prefer dense canopy structure (Morgan *et al.* 2002).

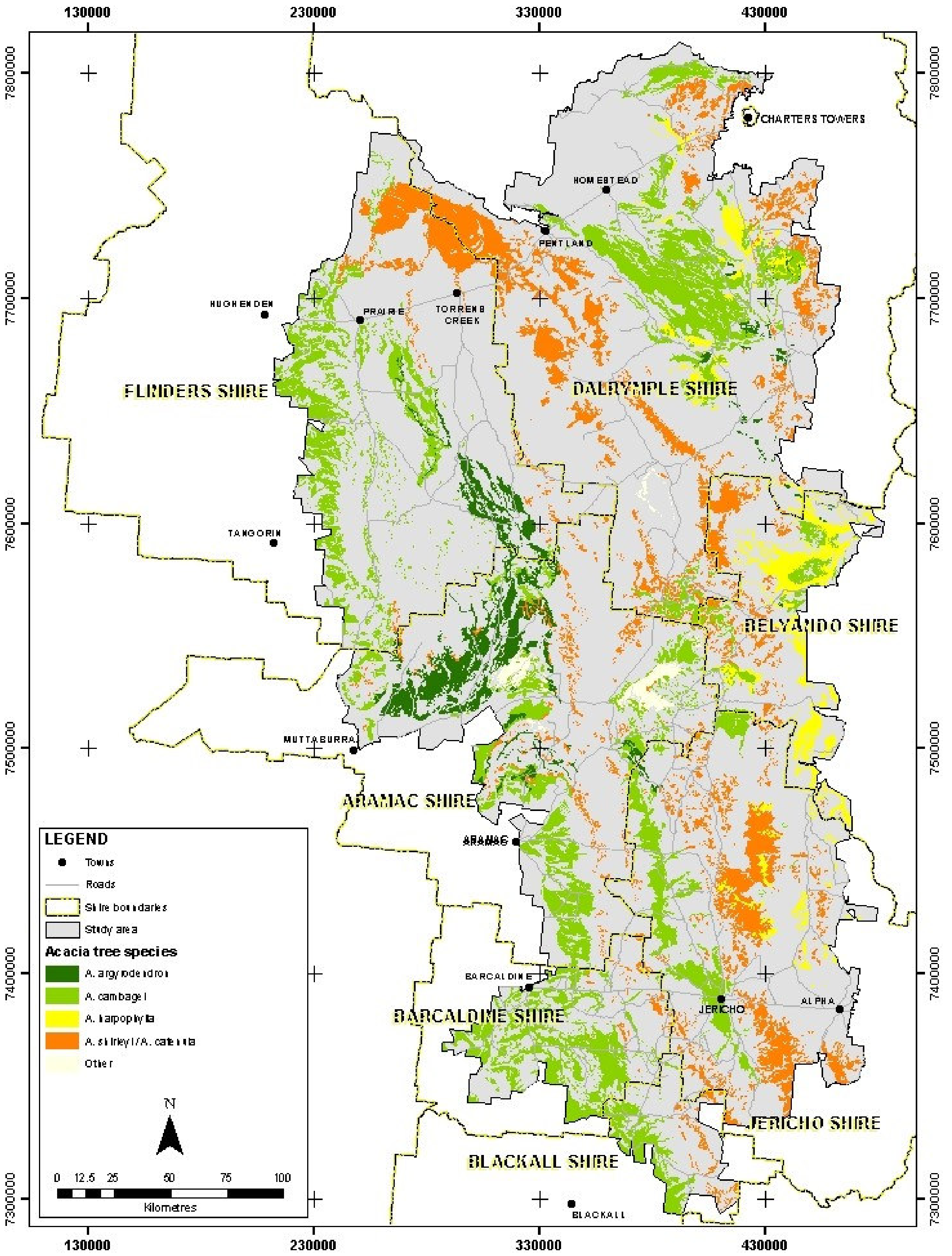


Figure 5.3 **The location of forests and woodlands with dominant and co-dominant acacia tree species**

5.2.3 Bloodwoods

Twenty species of bloodwood were recorded in the study area. The most common ones include gum-topped bloodwood (*Corymbia brachycarpa*), Clarkson's bloodwood (*C. clarksoniana*), ghost gum (*C. dallachiana*), rustyjacket (*C. leichhardtii*), large-fruited bloodwood (*C. plena*), applejack (*C. setosa*), desert bloodwood (*C. terminalis*) and Moreton Bay ash (*C. tessellaris*), and they occupy a considerable proportion of the study area, either as the dominant or co-dominant tree species (Figure 5.4).

Ghost gum: This is by far the most common bloodwood. It is represented in approximately 70 percent of all the land units containing bloodwoods in dominant or co-dominant numbers and occupies a diverse range of soil types and landscape positions. For example, the shallow soils overlying a hardpan in the Waterview (WV1), Southern Plateau (SP1), (Gordonbrook (GK1) and Wattlevale (WE1) land systems, the basaltic soils of the Toomba (TM1, TM2) land system, the moderately deep sandy soils on outwash fans of the Buchanan–Galilee Fan (BE2), Delta South (DS1) and Longton (LN2) land systems, the deep, red sandy gradational soils on sand sheets in the Wishaw (WW3) land system, and the deep silty loam alluvial soils on young flood plains of the Companion Creek (CC2) land system. Because of this extensive range, it is often found in association with other bloodwoods, such as Clarkson's bloodwood, large-fruited bloodwood, desert bloodwood and Moreton Bay ash, which all have their own specific requirements.

Large-fruited bloodwood: Favoured locations tend to be deep, well-drained soils that have slightly better soil moisture characteristics than adjacent areas, for example, Desert (DT3), Buchanan-Galilee fan (BG2), Lambton Meadows (LM3), Longton (LN2) and Webb Lakes (WL1) land systems. When in association with ghost gum, the large-fruited bloodwood occurs in the extreme north and south sectors, and two or three areas in the central sector, of the bioregion where the ironstone hardpan is less than one metre from the surface (Prairie Plains (PP1), Oakvale (OE4) and Colorado (CO4) land systems).

Applejack: This species is often the only bloodwood on remnant areas of the old sand sheet. The red, sandy soils can be deep gradational or texture-contrast profiles, or the ironstone hardpan may be within a metre of the surface (Britannia (BT2), Gordonbrook (GK3), Joe Joe (JJ1) and Northern Plateau (NP2) land systems). Even in association with ghost gum, applejack favours 'erosional' surfaces, that is, positions in the landscape that have been subjected to a relatively high rate of erosion when the present landscape was forming.

Clarkson's bloodwood and gum-topped bloodwood: Clarkson's bloodwood occurs as a dominant bloodwood, but in association with Queensland yellowjacket (*Eucalyptus similis*), specifically on the deep, sandy red, gradational soils of the Desert (DT1) land system, which extends along the main ridge south of Pentland, and on a broken ridge to the east of Lake Buchanan and Lake Galilee, to a latitude similar to that of Aramac. Further south, on the same ridgelines and similar soils, but a different land system (Grant (GT1)), gum-topped bloodwood becomes co-dominant with Queensland yellowjacket. Interestingly, gum-topped bloodwood also occurs as a co-dominant with ghost gum and white's ironbark in the far northwest of the study area in the Wishaw (WW3) land system. Both locations suggest gum-topped bloodwood has a preference for higher rainfall areas.

Desert bloodwood: This species occurs in several areas of subregion 1 as a co-dominant with White's ironbark (*Eucalyptus whitei*) on a gently undulating plain with moderately deep sandy soils overlying a hardpan (Badlands (BD4), Bromvil (BL3) and Wishaw (WW2) land systems). In the Jericho shire it is often dominant, or co-dominant with poplar box (*E. populnea*), on sandy alluvial soils (Lagoon Creek (LC1 and LC3). Scattered occurrences with ghost gum appear in the Lake Dunn (LD1), Towerhill Creek (TC1), Lochinvar (LR1), and Torrens Creek Fan (TF4) land systems, which represent a range of landscape positions; a sandy lunette, a sand ridge overlying a hardpan, a sandy profile overlying a sodic clay and uniform sandy soils on creek levee banks, respectively, all with the common feature of a sandy, well-drained soil profile.

Moreton Bay ash: It is one of the few bloodwoods not found as a co-dominant with ghost gum, as its requirements are for the wetter, often flood prone, areas associated with the current floodplains of rivers and major creeks. Representative land systems include Burdekin River (BK1), Belyando River (BR3), Alice Clays (AC4), Companion Creek (CC4), Colorado (CO5) Jordan Creek (JC1) and Lolworth Creek (LW1, LW3).

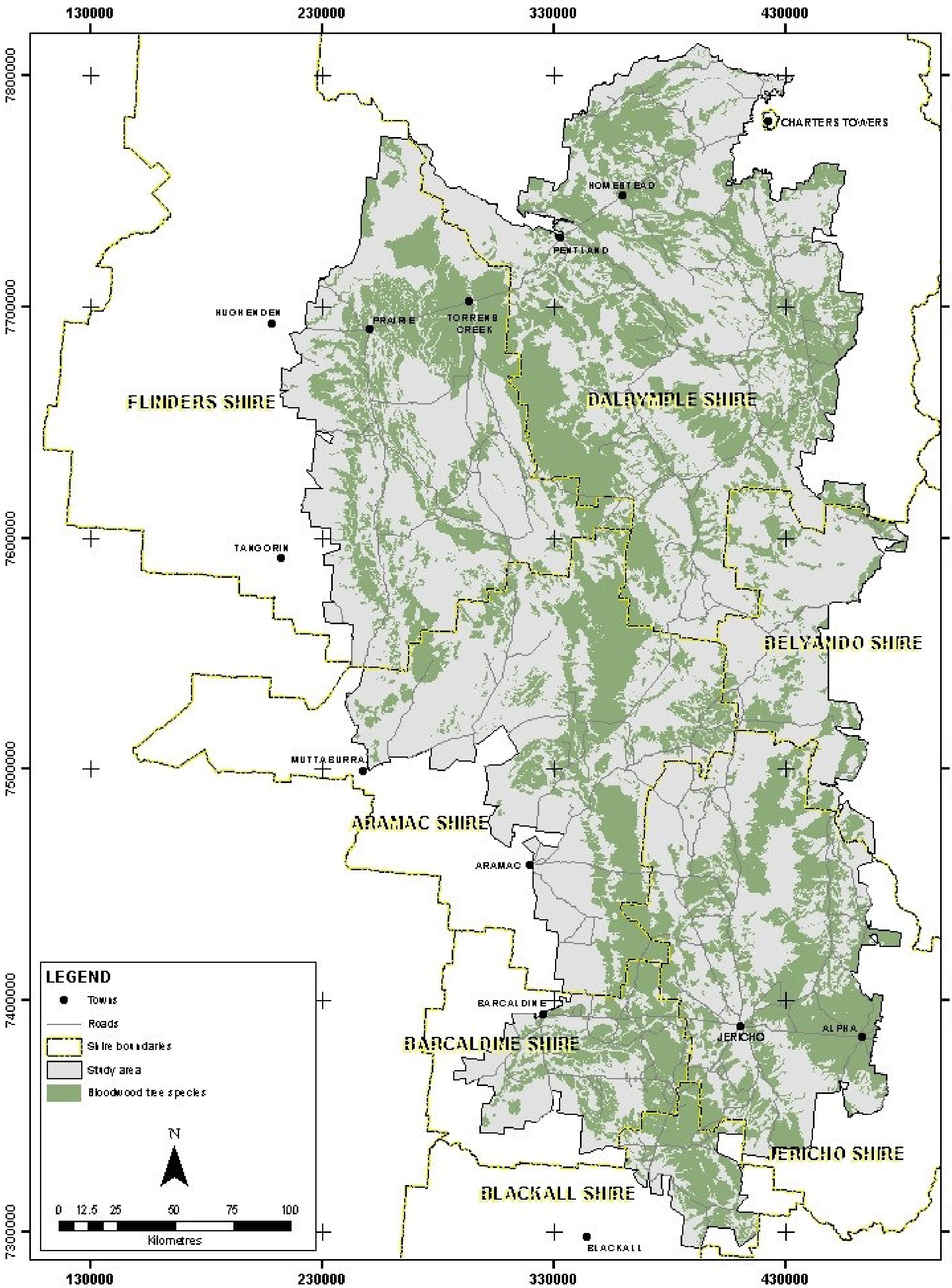


Figure 5.4 **The location of woodlands with dominant and co-dominant bloodwood tree species**

5.2.4 Boxes

The location of woodlands in which Reid River box (*Eucalyptus brownii*), poplar box (*E. populnea*) or coolabah (*E. coolabah*) are dominant or co-dominant with other tree species is shown in Figure 5.5. The following patterns emerge:

Reid River box: This species favours the northern half of the study area and occurs in approximately 64 different land units on a range of soil types and landscape positions, mostly on lower slopes and in drainage depressions (Buchanan-Galilee Fan (BE4), Corea (CA5), Charters Towers metamorphics (CM2), Cape-Campaspe River (CR3), Gainses (GS2), Longton (LN3, LN4), Plain Creek (PK3, PK5) and Vacquera (VA5) land systems). However, it is not unusual to find Reid River box on relatively shallow soils overlying an ironstone hardpan (Northern Plateau (NP1) land system) co-dominant with ironbark.

Poplar box: This species is dominant or co-dominant with silver leaved ironbark (*Eucalyptus melanophloia*) on alluvial fans and lower slopes (Cudmore (CE4, CE5), Colorado (CO4, CO5), Degulla (DA1, DA2, DA3), Delta South (DS1, DS2), Jordan Creek (JC3), Lambton Meadows (LM2), Lochnivar (LR1) and Southern Plateau (SP3) land systems), and adjacent to drainage depressions and creeks (Jordan Creek (JC4) and Joe Joe (JJ5) land systems) in the southern half of the study area, which appears to coincide with a higher incidence of winter rainfall and associated longer growing season.

An area in between these Reid River box and poplar box communities represents a transition zone involving the land systems of Texas Fan (TS2 and TS3), Aramac-Barcaldine Rises (AB4) and Ravenswood (RD1), in which the two species co-exist.

Coolabah: Typical locations are the low-lying areas or depressions that are flooded or inundated with water on a seasonal basis, such as current floodplains, billabongs, wetlands, back plains and ephemeral lakebeds. Coolabah is usually co- dominant, or in association, with river red gum (*E. camaldulensis*) on current flood plains (Belyando River (BR1, BR3, BR4), Cape-Campaspe River (CR3), Dunrossie (DE3), Delta South (DS4), Maynard (MD4), Moondah (MH4), Prairie Plains (PP5), Potosi (PT6), Slogan Downs (SD3), Towerhill Creek (TC4), Thistlebank (TK4) and Waterview (WV5) land systems) and most wetland areas (Desert (DT4), Lake Galilee (LG5), Ludgate LG3), and Thistlebank (TK2) land systems).

Box woodlands are the most species-rich habitats for fauna in the bioregion and are particularly significant for many declining woodland bird species, granivorous birds, bats, terrestrial and arboreal mammals and some restricted reptiles (Morgan *et al*. 2002).

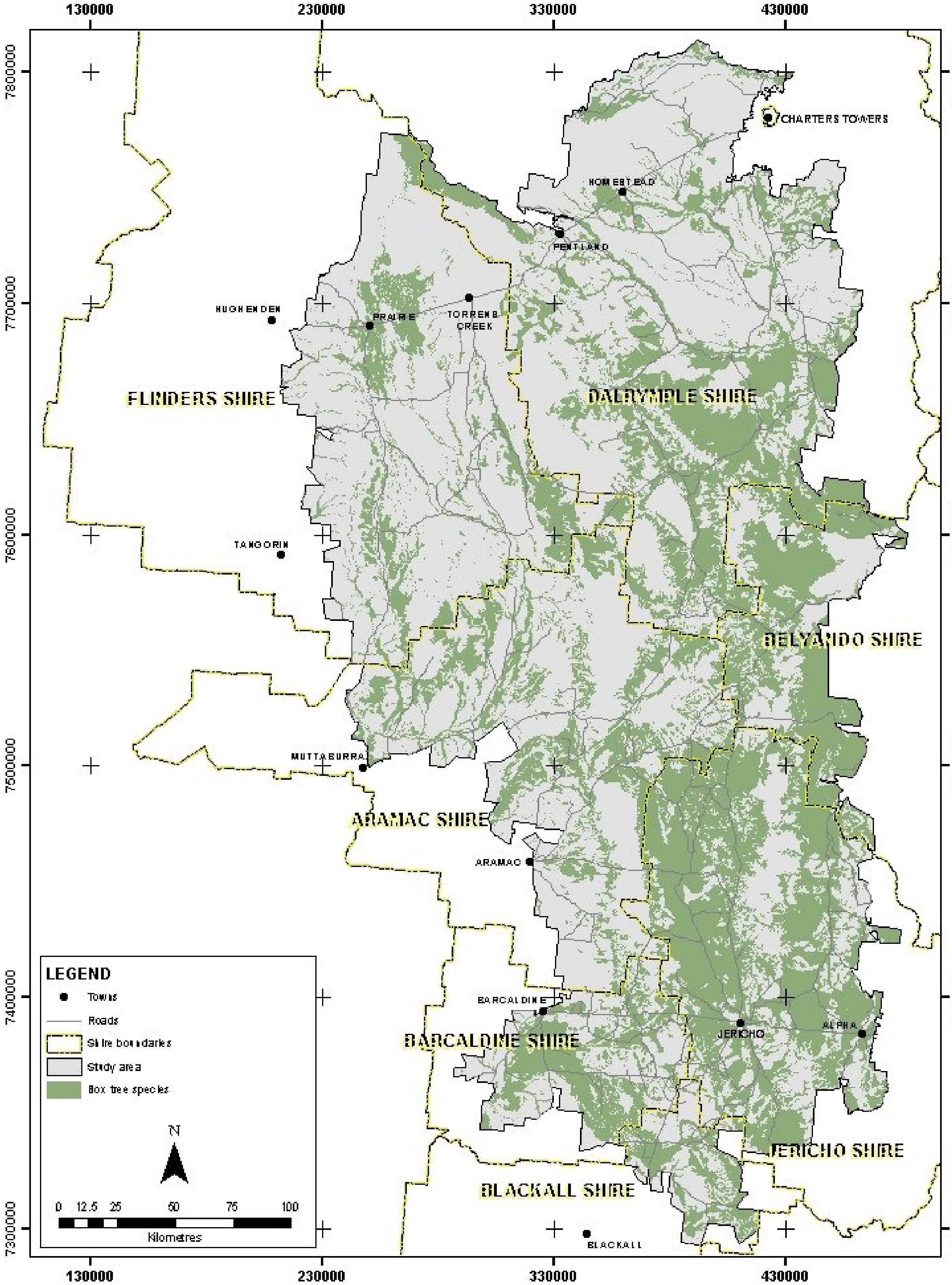


Figure 5.5 **The location of woodlands with dominant and co-dominant box tree species**

5.2.5 Gums

Three eucalypt species; river red gum (*Eucalyptus camaldulensis*), blackbutt or Dawson River gum (*E. cambageana*) and napunyah or Thozet's gum (*E. thozetiana*), occur as dominant or co-dominant tree species in clearly defined areas throughout the bioregion (Figure 5.6). One might expect ghost gum (*Corymbia dallachiana*) to be included in this group, but technically it is a bloodwood and is included in Figure 5.4.

River red gum: This common species occurs in approximately 39 different land units throughout the study area along the banks of rivers and the larger creeks, where young sandy or silty alluvial soils predominate and a seasonal flooding regime is common. River red gum also occurs, often in association with coolabah (*E. coolabah*), within or flanking ephemeral wetland areas. These riparian communities provide an important habitat and refuge for many plants and animals, in particular arboreal mammals, woodland birds, hollow-roosting species and amphibians including the greatest number of plants of conservation significance of any vegetation community in the bioregion (Morgan *et al*. 2002).

Blackbutt: This species occurs in approximately 24 different land units throughout the study area and is usually confined to low-lying areas and soil profiles with sodic clays and a moderate to high salt content. The trees often appear as emergents above mid-high woodlands of Reid River box (*E. brownii*), poplar box (*E. populnea*), blackwood (*Acacia agyrodendron*), gidgee (*A. cambagei*) or brigalow (*A. harpophylla*). Land systems containing blackbutt include Balfes Creek (BF2), Belyando River (BR1), Charters Towers Metamorphics (CM5), Corea (CA3), Lagoon Creek (LC2), Lambton Meadows (LM3), Ulcanbah (UH2, UH4), Oakvale (OE6), Maynard (MD2) and Vacquera (VA5).

Napunyah: The usual location for napunyah is on escarpments and the adjacent lower slopes, although the numbers rarely reach dominant proportions. Land systems Aramac-Barcaldine Rises (AB3), Badlands (BD2, BD3), Plain Creek (PK3), Stagmount Scarp (SS3), Ulcanbah (UH2) and Vacquera (VA3) have a high proportion of the slender white tree trunks that are so characteristic of napunyah.

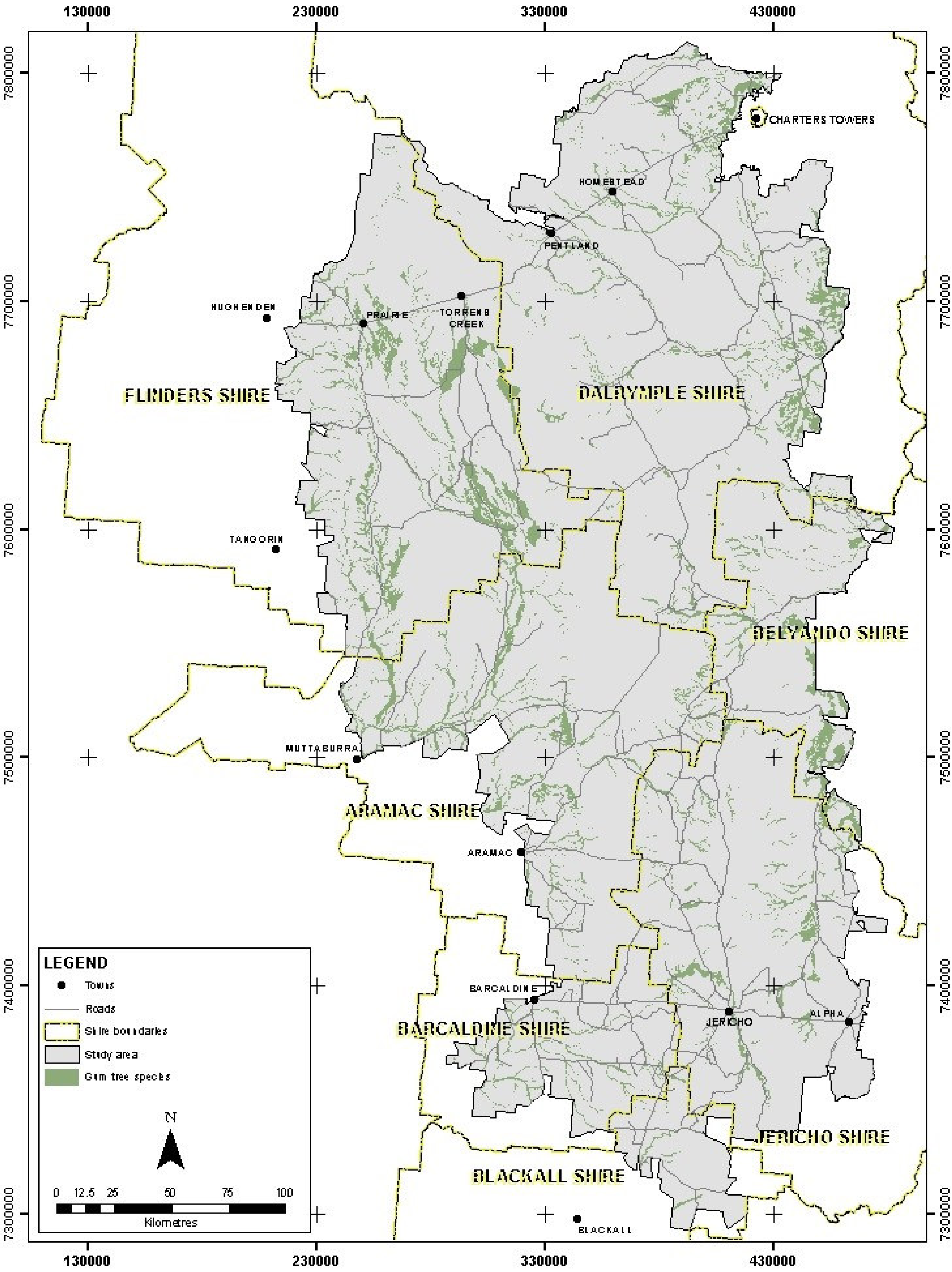


Figure 5.6 **The location of woodlands with dominant or co-dominant gum tree species**

5.2.6 Ironbarks

Nine species of ironbark have been recorded in the Desert Uplands study area. Figure 5.7 clearly shows the extent of this group across the bioregion, but also shows an interesting distribution of the three dominant species, narrow-leaved ironbark (*Eucalyptus crebra*), silver-leaved ironbark (*E. melanophloia*) and White's ironbark (*E. whitei*), which represent about 90 percent of the land units in which ironbarks are dominant or co-dominant.

Narrow-leaved ironbark: It occurs almost entirely within the Dalrymple Shire on a wide range of country and in the higher rainfall areas, such as the landforms on granodiorite (land systems Barrington (BN3, 4, 5 & 6) and Koolyn (KN1 & 2)), the shallow soils on hill slopes (land systems Charters Towers Metamorphics (CM1 & 2), Plain Creek (PK2), Windsor (WR2) and Wishaw (WW4)) and plains (land systems Corea (CA1) and Toomba (TM1)), the deeper soils on lower slopes and plains (land systems Britannia (BT1 & 4), Charters Towers Metamorphics (CM4), Gainses (GS2), Plain Creek (PK3) and Southern Cross (SC5)), and the deep soils on alluvial fans (land systems Charters Towers Metamorphics (CM6), Longton (LN2), and Southern Cross (SC5)).

However, small areas of narrow-leaved ironbark occur in the study area portion of the Belyando Shire, in the Plain Creek land system (PK2 & PK3). Further south in the Jericho Shire, narrow-leaved ironbark only occurs in dominant or co-dominant numbers in the Cudmore land system (CE1 & 3).

Silver-leaved ironbark: This species of ironbark is by far the most common in the study area. It extends the entire length of the bioregion and occupies most of the central and eastern portion. Rather than present an extensive list of different land types where the species occurs, suffice it to say that of the 79 land systems and 335 land units in the Desert Uplands bioregion, silver-leaved ironbark is present as the dominant or co-dominant tree species in 33 land systems (42%) and 55 land units (16%).

White's ironbark: It occurs predominantly in the Flinders and Aramac Shires, with significant areas down the western side of the Dalrymple Shire, and relatively small areas in the Belyando, Jericho and Barcaldine Shires. White's ironbark is second to silver-leaved ironbark when it comes to the number of land systems and land units in which it is the dominant or co-dominant tree species. Of the 79 land systems and 335 land units in the Desert Uplands bioregion, White's ironbark is present in 23 land systems (29%) and 44 land units (13%).

As with the box woodlands, the ironbark open woodlands are equally widespread and provide a significant habitat for vertebrate fauna in the bioregion. Both woodland communities, often with a mix of tree species, support a very high richness of fauna species (Morgan *et al*. 2002).

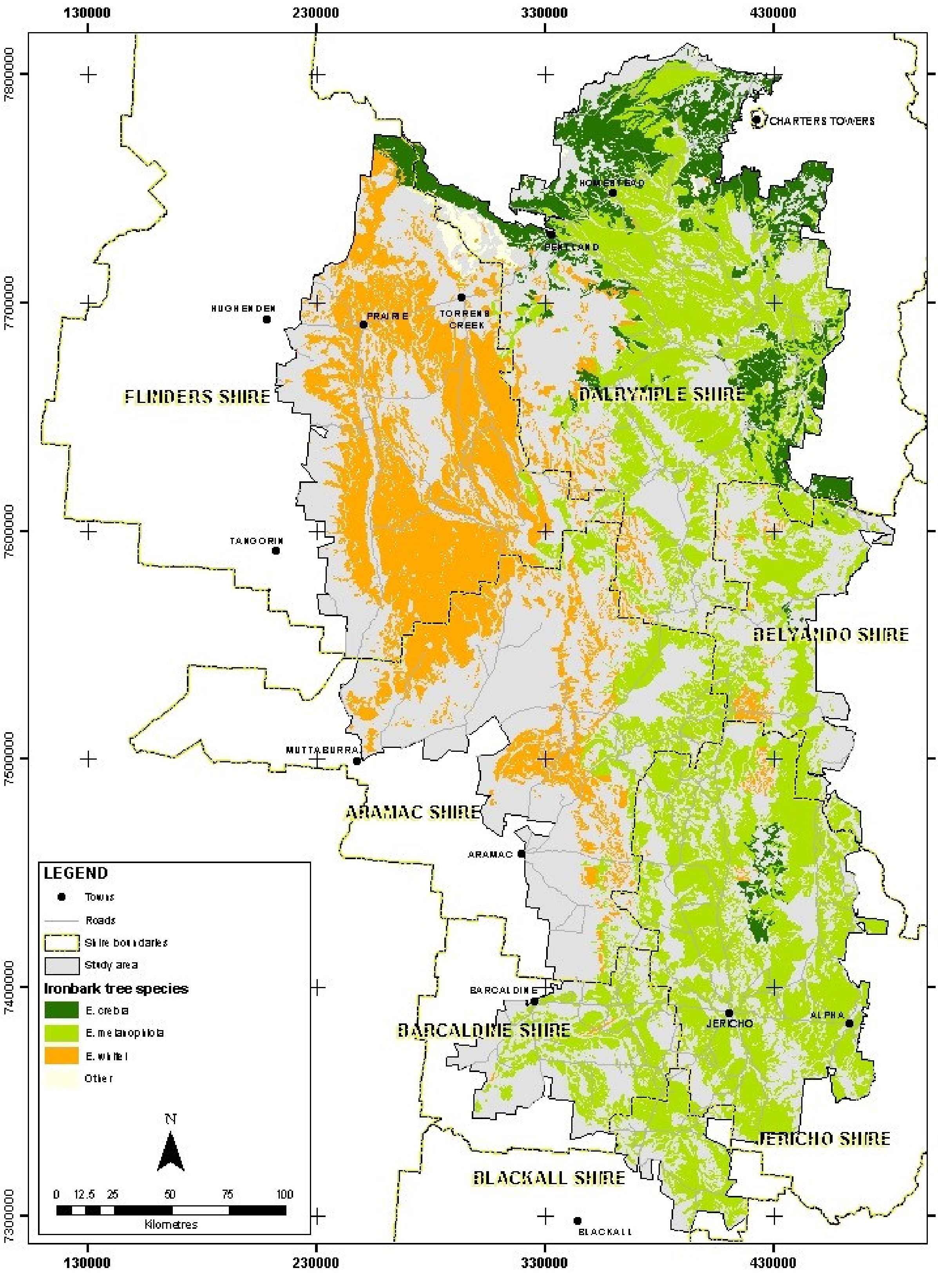


Figure 5.7 **The location of woodlands with dominant and co-dominant ironbark tree species**

5.2.7 Yellowjacket

Queensland yellowjacket (*Eucalyptus similis*) does not belong in the *Corymbia* genus, even though the bark is distinctive and closely resembles that of rusty jacket (*Corymbia leichhardtii*), and although it is classified in the *Eucalyptus* genus its appearance (bark and form) is unlike that of ironbark, box, gum or stringybark. Hence, it belongs to a group all by itself.

Queensland yellowjacket: This species is confined to the deep sandy, red gradational-textured soils known locally as the ‘desert country’ (Desert (DT1) and Grant (GT1) land systems). This vegetation community forms an almost continuous band from Pentland in the north to the Blackall Shire in the south (Figure 5.8), together with a parallel, broken band to the east of Lake Buchanan and Lake Galilee extending south to Jericho. Several land systems, namely, Joe Joe (JJ2), Northern Plateau (NP2), Oakvale (OE3), and Wishaw (WW3) also have this characteristic soil-vegetation association, although the soil profiles are usually much shallower than normal because they represent remnants of the original sand sheet.

The yellowjacket woodlands are the biodiversity heartland of the Desert Uplands, due to the generally pristine condition of the habitat, the large number of species of conservation significance, and the overall high number of animal species found within this plant community (Morgan *et al*. 2002).

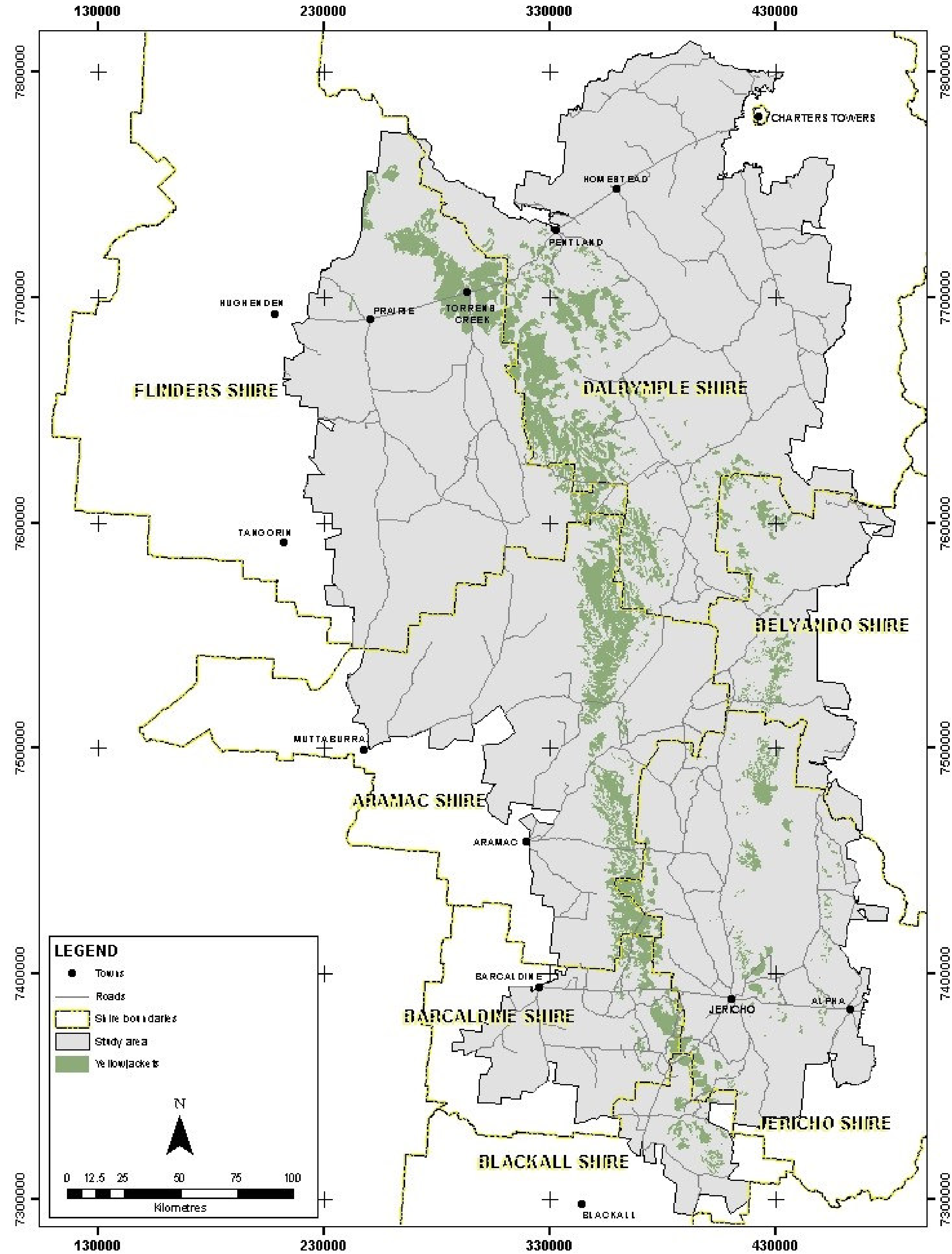


Figure 5.8 The location of woodlands with dominant and co-dominant yellowjacket tree species

6. Land use implications

6.1 Introduction

The DUSLARA project was initiated and completed as a result of concerns by the DUBDSC for "the sustainability of the region's natural resources and well being of their community". In 1996 the DUBDSC published a Position Paper, which highlighted "the region's unique geographical location, fauna, flora, primary production system and community issues". The Paper also described "the threats to these unique values: low levels of enterprise profitability, degraded natural resources and a number of social problems" (DUBDSC, 1998). It soon became apparent that the level of land resource information was quite inadequate for the objectives of the Committee and its proposed Community Scheme – not only was the information in several different reports and at different mapping scales, but it was incomplete and not detailed enough to address property management issues. This report provides a land resource database that is consistent across the whole region, and which can be used to address land management issues from a regional level right down to an individual property level.

Land managers need to recognise the inherent capabilities and limitations of the land if they are to determine the most appropriate land use, and how they should manage the land to achieve sustainable levels of productivity without causing on-site or off-site damage to the land resource.

6.2 Land Management Units (LMUs)

This report identifies 335 different land units, each having a unique landscape context and a characteristic association of soil and vegetation. A number of these land units have similar characteristics and, in very general terms, similar inherent capabilities and limitations for land use. In order to simplify this diverse range of soils and vegetation into a manageable number of easily recognisable land types, Morgan *et al*. (2002) described fifteen land management units (LMUs). The author has revised some of those LMU descriptions to highlight their features and clarify the differences between them. Each of the 335 land units fits into one of these fifteen LMUs (Table 5), thereby allowing useful generalisations to be made about the characteristics of each LMU and the influence those characteristics may have on land use.

To determine the LMU associated with any specific land unit, refer to Appendix 9, which lists all 335 land units in alphabetical order complete with a brief description, the corresponding Regional Ecosystem code(s) and the appropriate Land Management Unit number.

Table 5 Land Management Units (LMUs): their description, relationship to land systems and land units, and proportion in the study area

LMUs	Description	Relevant land systems and land units	Proportion of the study area
1	Shallow stony soils on bedrock or hardpan of ironstone, silcrete or calcrete at an average depth of less than 0.5m, with lancewood, bendee, eucalypts, bloodwoods or shrub lands, usually on hills and ridges.	BD1, BD2, BD3, BL1, BL2, BL3, BN1, BN3, BT2, BT3, CE1, CE2, CE3, CM1, CM2, CM3, CO1, CO2, CP2, DR1, DR2, DR3, GK1, GK2, JJ2, JJ3, LE1, LE4, LE5, NP1, OE1, OE2, PK2, PT1, PT3, PT4, SC3, SC4, SN1, SP1, SS1, SS2, TA4, TM1, TM4, TM5, UH1, VA2, VA3, WE2, WE4, WM1, WR1, WV2, WY1.	25.7%
2	Sandy soils with sally wattle, ironwood, beefwood, gidgee or silver-leaved ironbark on dunes (including beach ridges and lunettes) associated with lakes and playas.	LB1, LD1, LG1, LG4, LG6, LH2, LH4, MD2, WL1	0.4%
3	Red, sandy 'desert' country with Queensland yellowjacket, bloodwood and ghost gum, and a ground cover usually dominated by spinifex.	DT1, DT3, GK3, GT1, GT3, GT4, JJ1, NP2, OE3, WW1, WW3	8.9%
4	Sandy loam topsoils with sodic clay subsoils and a blackbutt woodland, grassland, herb land or shrub land, giant spinifex on sandy dunes, and associated artesian springs. Some areas are prone to salinity.	EN1, EN2, LB3, LR3, RD4	0.2%
5	Thin sandy topsoils overlying saline, heavy clays with a herbfield or low shrubland usually adjacent to saline lakes.	LB4, LH5	0.1%
6	Sandy loam topsoils with clayey sodic subsoils and Reid River box or poplar box woodlands in drainage depressions and on adjacent gentle slopes.	AB4, AC2, AC3, BE3, BE4, BF4, CA5, CE5, CM7, DA3, JJ5, LD5, LE6, LM2, LM3, LN3, LN4, MD1, NP3, NP4, OE5, SP3, TA5, TS2, TS3, WE3	4.8%
7	Deep sandy soils on gently sloping country overlying saline lakebed clays or clays derived from shales, with sparse woodlands of sally wattle, bloodwood and beefwood.	LB2, LH1.	0.2%
8	Sandy uniform, gradational or texture-contrast soil profiles on alluvial fans, plains and older terraces, with ironbark woodlands and the occasional bloodwood or ghost gum.	AA1, AA2, AC1, AE1, AV2, BA2, BB1, BB2, BB3, BC1, BC2, BD4, BE1, BE2, BF1, BG1, BG2, BL4, BN6, CC2, CC3, CM6, CO4, CP3, CR1, DA1, DA2, DR4, DS1, FR1, JC1, JJ6, LC1, LD2, LM1, LN1, LN2, LR1, LW1, RC1, RD1, TC1, TF1, TF2, TF3, TS1	12.6%

LMUs	Description	Relevant land systems and land units	Proportion of the study area
9	Red and yellow gradational and texture-contrast soils, with sandy loam topsoils and an ironstone hardpan or weathered bedrock at a depth of greater than 0.5 metres, on gently undulating plains. Ironbark woodlands with desert oak and bloodwood. Cypress pine is restricted to the southern areas.	AB1, AB2, AB3, AV1, BH1, BN2, BN4, BN5, BT1, CA1, CA2, CA3, CE4, CM4, CO3, DT2, GK4, GS2, GT2, JJ4, KN1, KN2, LE2, MH1, OE4, PK1, PK3, PP1, SC1, SC2, SC5, SN2, SP2, TM2, VA1, VA4, WE1, WM2, WR2, WR3, WV1, WW2, WW4.	21.7%
10	Deep sands on the current floodplain, banks and streambed of creeks and rivers, subject to seasonal flooding, with red gum, bloodwoods, melaleucas and occasional coolabah.	AA3, AE2, AE3, AL3, AR3, AV3, BA4, BB4, BC3, BD5, BG3, BK1, BK2, BL5, BN7, BR2, BR3, BR4, BT4, CC4, CO5, CR3, CR5, DE3, DR5, DS4, FR2, GS3, JC4, KN3, LC3, LH6, LR4, LW3, MD4, MH4, PK5, PP5, PT6, RC2, RC4, RD5, SC6, TC4, TF4, TK4, VA5, WE5, WM3, WV5, WY4.	5.9%
11	Heavy clays with friable topsoils and gilgai micro-relief on undulating plains and rises, underlain by shale or calcareous sandstone. Open woodlands of blackwood, gidgee, napunyah, brigalow or blackbutt; tussock grasslands of Mitchell and Flinders grasses or localised shrublands of saltbush and samphire.	AR1, AV4, CP5, DE1, DS2, DS3, LR2, PT5, RD2, RD3, SS3, SS4, SS5, TK3, UH2, WV3, WV4.	7.5%
12	Deep, grey and black cracking clays on alluvial plains and old lakebed deposits, and red friable clays and black cracking-clay soils on basalt, no longer subject to seasonal inundation by water. Woodlands of acacia species, blackbutt, false sandalwood, bauhinia or belah, grasslands of Mitchell, Flinders, blue or peppergrass and minor areas of ironbark woodland.	AC4, AL1, AL2, BA1, BA3, BF2, BH2, BR1, CA4, CM5, CP1, CP4, CR4, GK5, GS1, JC2, JC3, LD3, LG2, LG3, MD3, MH2, MH3, PK4, PP2, PP3, SD1, SD2, SD3, SN3, SN4, SN5, TA1, TA2, TA3, TC2, TC3, UH3, UH4, WY2, WY3.	7.2%
13	Deep, cracking-clay soil profiles with self-mulching topsoils on gently undulating plains (‘Downs’ country) with open grasslands of Mitchell grass, Flinders grass and bluegrass.	AR2, DE2, TK1	3.3%
14	Freshwater lakes, swamps, billabongs and backplains subject to seasonal or semi-permanent inundation by water. Woodlands of red gum, coolabah, Reid River box (often with bulrush or lignum), blackwood or blackbutt with brigalow.	AC5, BF3, CC1, CR2, DT4, LC2, LD4, LD6, LE3, LG5, LH3, LW2, PP4, TK2, TM3, TM6, WL2, WL3.	1.0%
15	Saline clays in shallow depressions, playas and lakebeds, with bare topsoils or salt-tolerant plant species such as samphire.	EN3, LB5, LG7, LG8, PT2, RC3.	0.5%

6.2.1 Land Management Unit 1

General description

Shallow stony soils on bedrock or hardpan of ironstone, silcrete or calcrete at an average depth of less than 0.5m, with lancewood, bendee, eucalypts, bloodwoods or shrub lands, usually on hills and ridges. These areas represent 25.7% of the study area (Figure 6.1).

Common characteristics

- Shallow, gravelly soils with bedrock or a hardpan, sometimes exposed at the surface.
- Slopes vary from 3 percent to vertical cliffs, however the really steep areas represent only a small area of the land management unit.
- A hardpan may be present within 1 metre of the surface.
- Water movement and rooting depth of plant species, particularly for trees, is restricted where a shallow hardpan occurs.
- A low to very low water storage capacity of the soil.
- The topsoil is susceptible to compaction and sheet erosion.
- Areas receiving runoff, particularly where the water merges into channel flow, are highly susceptible to gully erosion.
- The deeply weathered bedrock usually contains high levels of soluble salts, which are often visible as white crystals on rock surfaces exposed at the base of the scarp.
- The scarps usually have irregular boundaries and restricted access.
- The quantity of dry matter produced by the native pastures is very low.

Special features

- High scenic value, particularly the sandstone formations and caves sculptured by wind and water, red laterite cliffs, and views from the escarpment across valleys and plains.
- A natural refuge for native wildlife that have specialised habitat needs, including bare stony ground, sheltered gorges, or caves and crevices in sandstone and ironstone.
- Good potential for water harvesting and site locations for water storage.
- Lancewood and bendee timber, although not spread throughout the unit, makes good stockyard rails with a life expectancy of 20-25 years.
- Mulga (*Acacia aneura*) is a useful stock fodder during drought periods.
- The occurrence of red mallee (*E. socialis*) in the eastern section of Dyllingo Creek catchment. This tree is closely related to the red mallee (*E. transcontinentalis*) in Western Australia, but is usually found in association with white mallee (*E. dumosa*) and blue-leaved mallee (*E. polybractea*) in Victoria and New South Wales.

Implications for land use and land management

- The growing season for plants, and therefore dry matter production, is greatly reduced by the droughty nature of these soils.
- The frequency of rainfall has a direct bearing on the quantity of pasture growth, with regular falls of rain able to ‘top up’ soil moisture during the wet season. This is preferable to all the rain occurring in one or two storms and being lost from the site as runoff. The soil profile can hold only a limited amount of water at any time.
- The low nutrient status and phosphorus deficiency of the soils limits the potential productivity of native and introduced pasture species.

- Although spinifex is well adapted to these harsh conditions, the individual tussocks usually stand proud above the soil surface, as if on a pedestal, and are susceptible to physical damage by the hooves of cattle. Sheet erosion from around the tussocks also increases the risk of damage.
- A very fragile equilibrium exists between the sparse vegetative ground cover and soils that are highly susceptible to erosion. Any form of soil disturbance or reduction in ground cover can initiate a degradation process that will be difficult to reverse. Reclamation of degraded areas can be achieved if total grazing pressure is removed during, and for a period after, the wet season. Even then, and with good seasonal rainfall, regeneration can be slow.
- Roads and tracks increase runoff, which together with excessive overland flow, can initiate erosion and cause off-site problems such as deposition in dams and drains, and along fence lines.
- Opportunities exist for alternative land uses, such as a low-impact form of eco-tourism, given the natural features and scenic vistas, as well as the colourful display of flowering trees and shrubs during the winter-spring period.
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands' http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

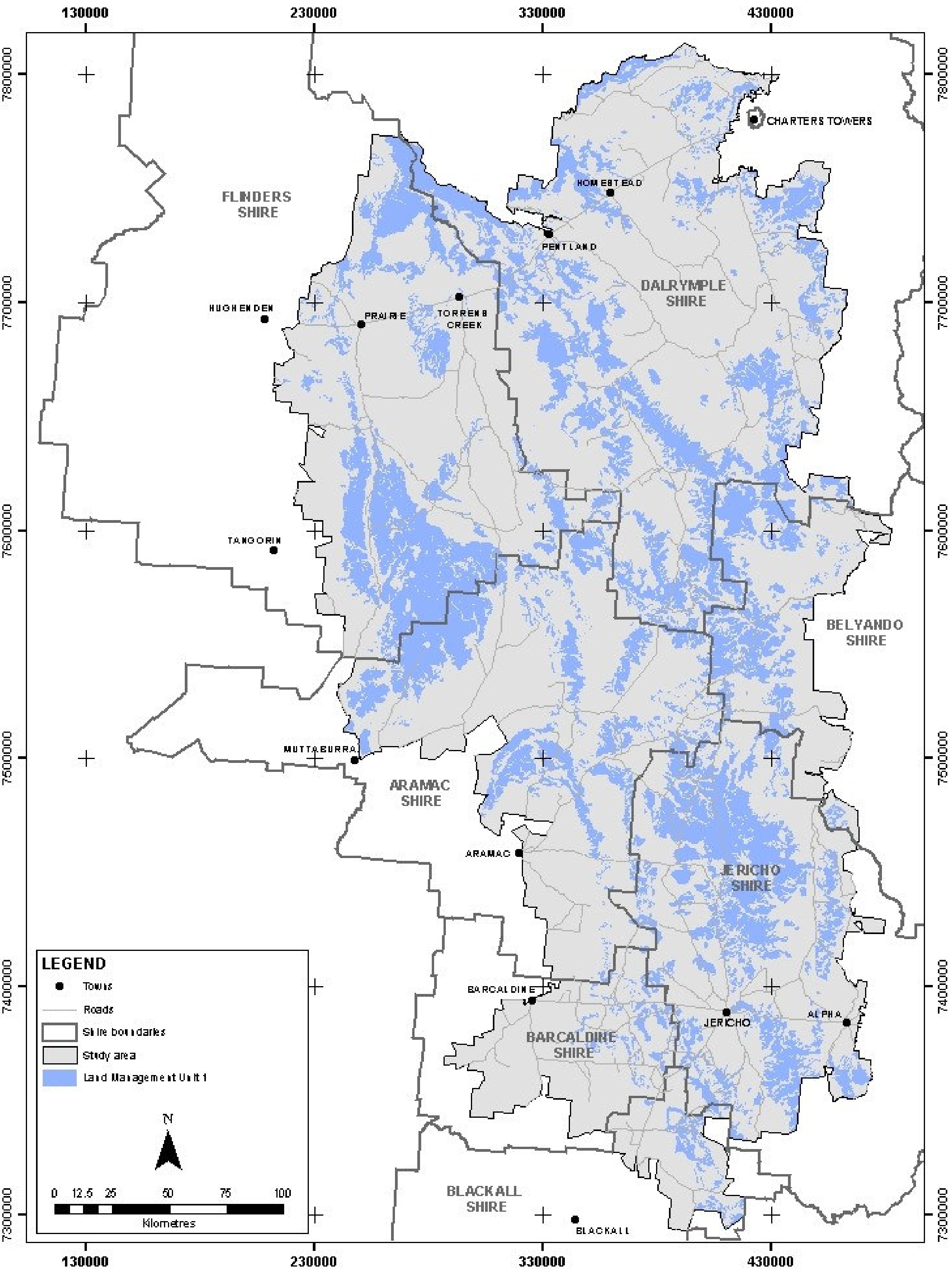


Figure 6.1 **Distribution of Land Management Unit 1 in the study area**

6.2.2 Land Management Unit 2

General description

Sandy soils with sally wattle, ironwood, beefwood, gidgee or silver-leaved ironbark on dunes (including beach ridges and lunettes) associated with lakes and playas. These areas only represent 0.4% of the study area (Figure 6.2).

Common characteristics

- The deep sandy topsoils have very low fertility.
- A calcrete hardpan may be present at a depth of approximately 1 metre, restricting water movement and root penetration to lower depths.
- The growth of plant species that survive in this harsh, local environment is limited by the sodic nature of the clay subsoils and the constant exposure to windborne salt and sand.
- The soil profiles tend to dry out very quickly. Consequently, ground cover consists of shallow-rooted annuals, which have adapted to short periods of available moisture, and pasture production is low. Trees are able to survive because their root systems can tap into deep soil moisture.
- Saline seeps occur at the base of these dunes where deep percolation of rainfall is impeded by a hardpan or clayey layer.
- Dunes around the south-western margins of Lake Galilee are more susceptible than the other dunes to erosion by water.

Special features

- The different dune systems provide a record of past climates and of flooding regimes of the lakes.
- The vegetation on the dunes provides a significant feeding, roosting and nesting habitat for large populations of migratory waterbirds, and a general or seasonal habitat for a number of other birds of conservation significance.

Implications for land use and land management

- The fine sandy topsoil is extremely susceptible to erosion by wind. Once the clay subsoil or calcrete hard pan is exposed, revegetation is extremely difficult.
- The native plant communities have adapted to specific zones between the crest of the dune and the lakebed, according to the general salt and moisture contents within that zone. For example, coolabah trees grow at the base of some dunes where the heavy clay soils are kept moist for extended periods by seepage from the dune and salt levels are low. Whereas, further away from the dune a saline water table is close to the soil surface, evaporation is high, salt levels in the topsoil are high and only the salt-tolerant *Halosarcia* species are present. A change in land use, particularly when it reduces the vegetative cover on the dunes, can upset this hydrological balance and cause the size of saline seeps to increase, producing undesirable changes in the composition and productivity of native and introduced pasture species on adjacent areas.
- The native pasture species provide very little fodder value or bulk for the grazing animal but do provide protection against wind erosion.
- The dune soils on the southern and western margins of Lake Galilee have a high productive potential. A large proportion of this area (approximately 80 percent) has been cleared and replaced with buffel grass, which has the potential to spread into adjacent areas of native pastures and reduce the natural biodiversity.
- Because of their limited extent and the impact of clearing and/or grazing, the majority of land units in this Land Management Unit have an ‘Endangered’ or ‘Of Concern’ biodiversity conservation status (Environmental Protection Agency 2005).
- The environment on the sandy dunes is a harsh one. Excessive grazing pressure will remove the more palatable species, reduce the biodiversity and degrade the natural features of the area. Increases in

productivity from introduced species may only be temporary and further studies are needed to determine the rate of nutrient rundown under any new grazing system.

- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in ‘The Conservation of Biodiversity in the Desert Uplands’ http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

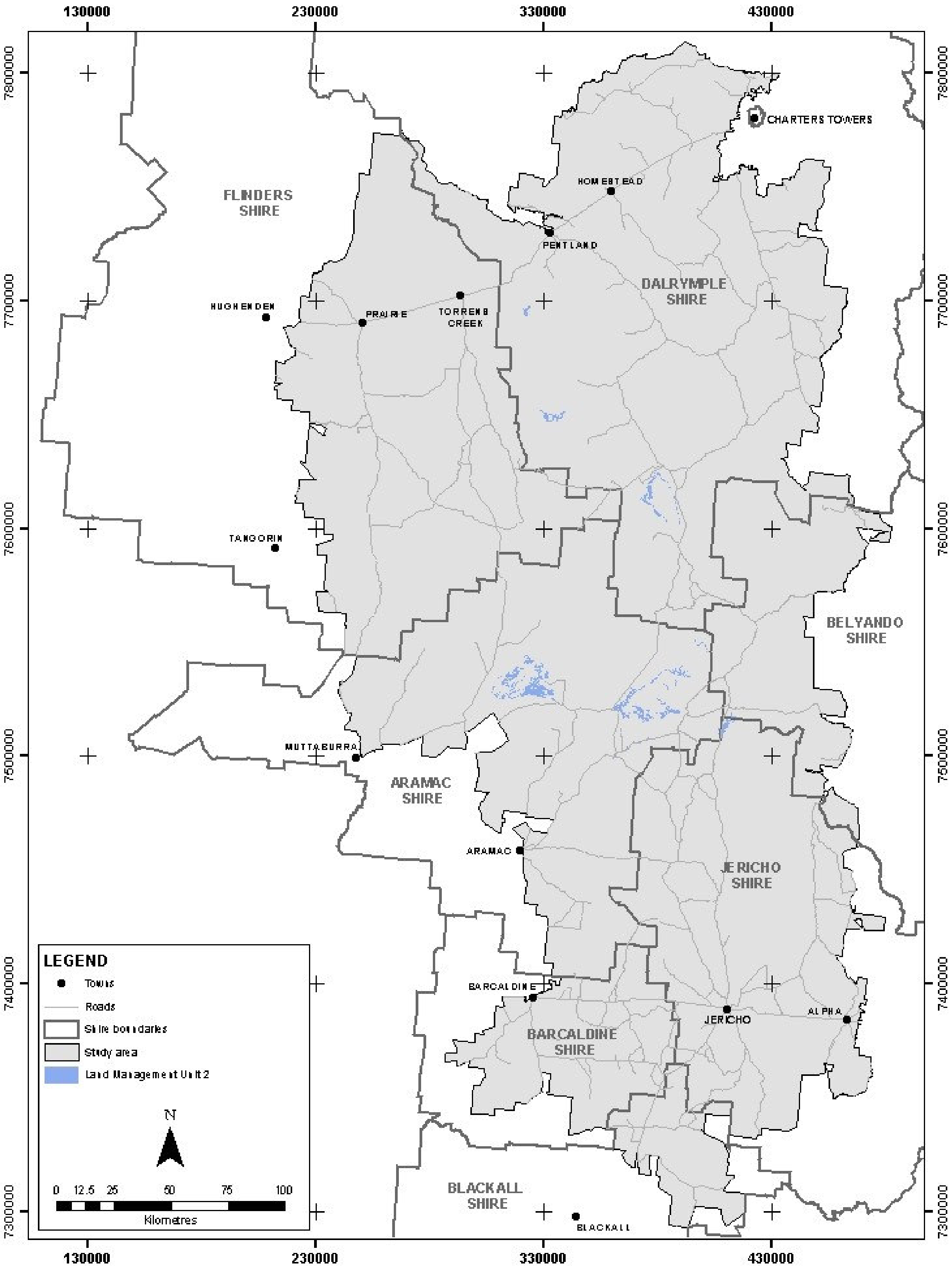


Figure 6.2 **Distribution of Land Management Unit 2 in the study area**

6.2.3 Land Management Unit 3

General description

Red, sandy 'desert' country with Queensland yellowjacket, bloodwood and ghost gum, and the ground cover usually dominated by spinifex. These areas represent 8.9% of the study area (Figure 6.3).

Common characteristics

- The pH and nutrient status of these soils is very low.
- The area lacks semi-permanent or permanent surface waters, but ponding in shallow depressions may occur for short periods during the wet season.
- The risk of fire is high, particularly in those months leading up to the wet season, when pastures are dry. Spinifex has a high content of inflammable resin and lightning strikes are common at that time of year.
- Heartleaf poison bush is common in this land type and causes stock losses, particularly in weaners and imported cattle. The poison bush is especially toxic immediately after fire and/or rain, when it is actively growing.
- The loose sandy topsoils are susceptible erosion.

Special features

- These soil-vegetation associations represent the intact Tertiary land surface that forms the heart of the Desert Uplands bioregion.
- The age, low fertility and isolation from similar areas of this old surface mean that species have evolved here that are unique to it.
- These red earths have a number of plants and animals of conservation significance, including rare and threatened species and endemic species (Morgan *et al*. 2002).
- This 'red desert country', as it is often referred to, has a remarkable range of flowering herbs, bushes and shrubs.
- The lack of semi-permanent and permanent water, low nutritional values and the presence of heartleaf poison bush have effectively protected this country from heavy grazing pressure, so that the native vegetation over quite large areas remains in near pristine condition with biodiversity and wilderness values of regional and national significance.
- The very deep soil profiles, with the special characteristics of low runoff and high infiltration rates, represent an important recharge zone for the Great Artesian Basin.

Implications for land use and land management

- There is a potential to market cut flowers and foliage and to attract tourists into the area to witness the spring colours.
- Degraded areas take a long time to re-vegetate naturally.
- The low nutrient content of the original substrate, the leaching that has occurred over the millennia, and the well-drained nature of the soil profile, result in a very low potential for increased productivity. It is unrealistic to expect any introduced pasture species to perform better than the native species in the long-term, unless additional water and nutrients are provided. Hence, the failure of introduced pasture species can lead to long-term land degradation if the native species do not readily re-establish.
- If erosion occurs, it can remove the sandy surface layer and expose the subsurface soil, with its slightly higher clay content, to the sun and raindrop impact. A hard surface crust forms, causing major difficulties for plant seeds to germinate and become established. Infiltration is reduced, runoff increases and less rainfall enters the soil making it more difficult for the existing plant species to survive the next dry season. Increased runoff causes further erosion, particularly on the long gentle slopes that characterise this LMU.

- Wildfires, as well as prescribed burns, in a spinifex pasture can generate so much heat, particularly if there is a heavy fuel load, that even the more fire-tolerant species can be killed. The resultant lack of ground cover exposes the topsoil to erosive rainfalls, which often follow the intense storm activity of a good wet season. Wildfires, and burn-offs that get out of control, can create a fodder drought on a property over night.
- The slightly better moisture and nutrient status found in low-lying depressions and drainage lines produces a more diverse and greater quantity of plant growth. Consequently, these areas are prone to overgrazing.
- If current research into the inoculation of cattle with a rumen micro-organism that can break down the toxic fluoro-acetates of heartleaf poison bush is successful, many thousands of hectares of this LMU will be opened up for grazing. The risk of pasture decline and soil erosion will increase, the value of the area as a recharge zone for the Great Artesian Basin will be threatened, and the potential to develop alternative, sustainable land uses for the area could be diminished.
- The native plant species found in this LMU exist because they have adapted, and are best suited, to the extremely low nutrient status of the soils. Increasing the total grazing pressure will most likely have an adverse effect on the vigour, composition and diversity of the native vegetation, and reduce the natural values of the area.
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands' http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

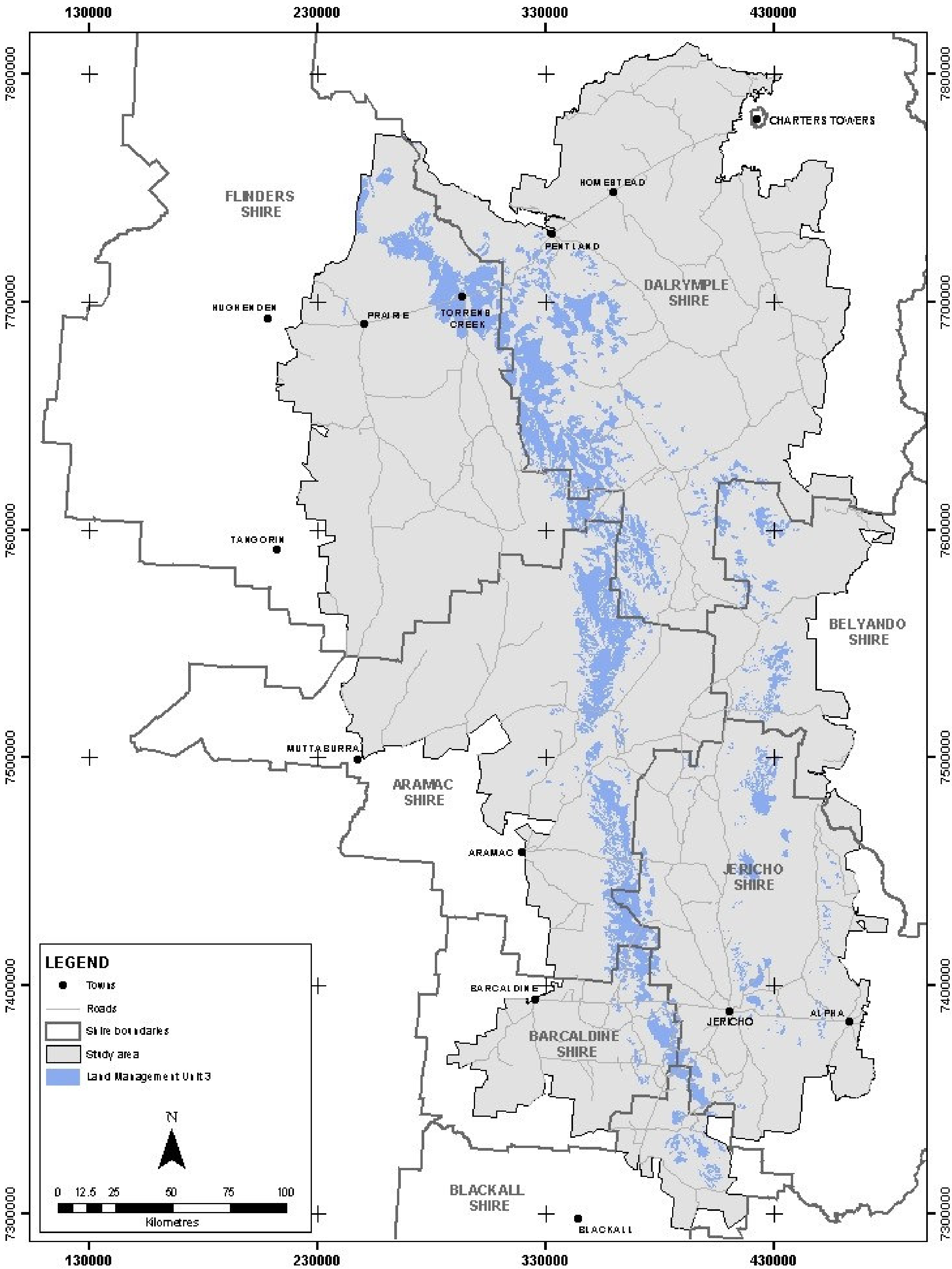


Figure 6.3 **Distribution of Land Management Unit 3 in the study area**

6.2.4 Land Management Unit 4

General description

Sandy loam topsoils with sodic clay subsoils and blackbutt woodlands, grasslands, herb land or shrub land, giant spinifex on sandy dunes, and associated artesian springs. Some areas are prone to salinity. These areas represent only 0.2% of the study area (Figure 6.4).

Common characteristics

- Some of these areas are prone to flooding during wet periods.
- The topsoils are susceptible to sheet erosion and salting.
- A saline water table occurs within the soil profile, the depth of which varies according to the amount of rainfall over the wet season.
- The soil profile may contain permeable gravel beds.
- The native pastures, consisting mainly of annuals, are sensitive to grazing by stock and native animals.
- Wind eroded clay pans occur naturally in this landscape.

Special features

- The land unit complex associated with the artesian springs supports a number of species significant for nature conservation, including five endangered or rare plants, and a specialized, restricted fauna that includes two endemic and endangered fish (Morgan *et al*. 2002).

Implications for land use and land management

- Dams and tanks constructed in this land unit may leak or become saline.
- Blackbutt (*Eucalyptus cambageana*) and river red gum (*E. camaldulensis*) are tolerant of sodic and, to a lesser extent, saline soils. Their ability to transpire large quantities of water helps keep the water table at depth, thereby allowing rainfall to infiltrate the soil profile and leach the soluble salts down below the root zone of pasture plants.
- Grazing animals can have a significant adverse impact on sensitive areas such as artesian springs.
- Due to their limited extent and a general decline in condition, most of these communities and associated endemic species have an ‘Endangered’ or ‘Of Concern’ biodiversity conservation status (Environmental Protection Agency 2005).
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in ‘The Conservation of Biodiversity in the Desert Uplands’ http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

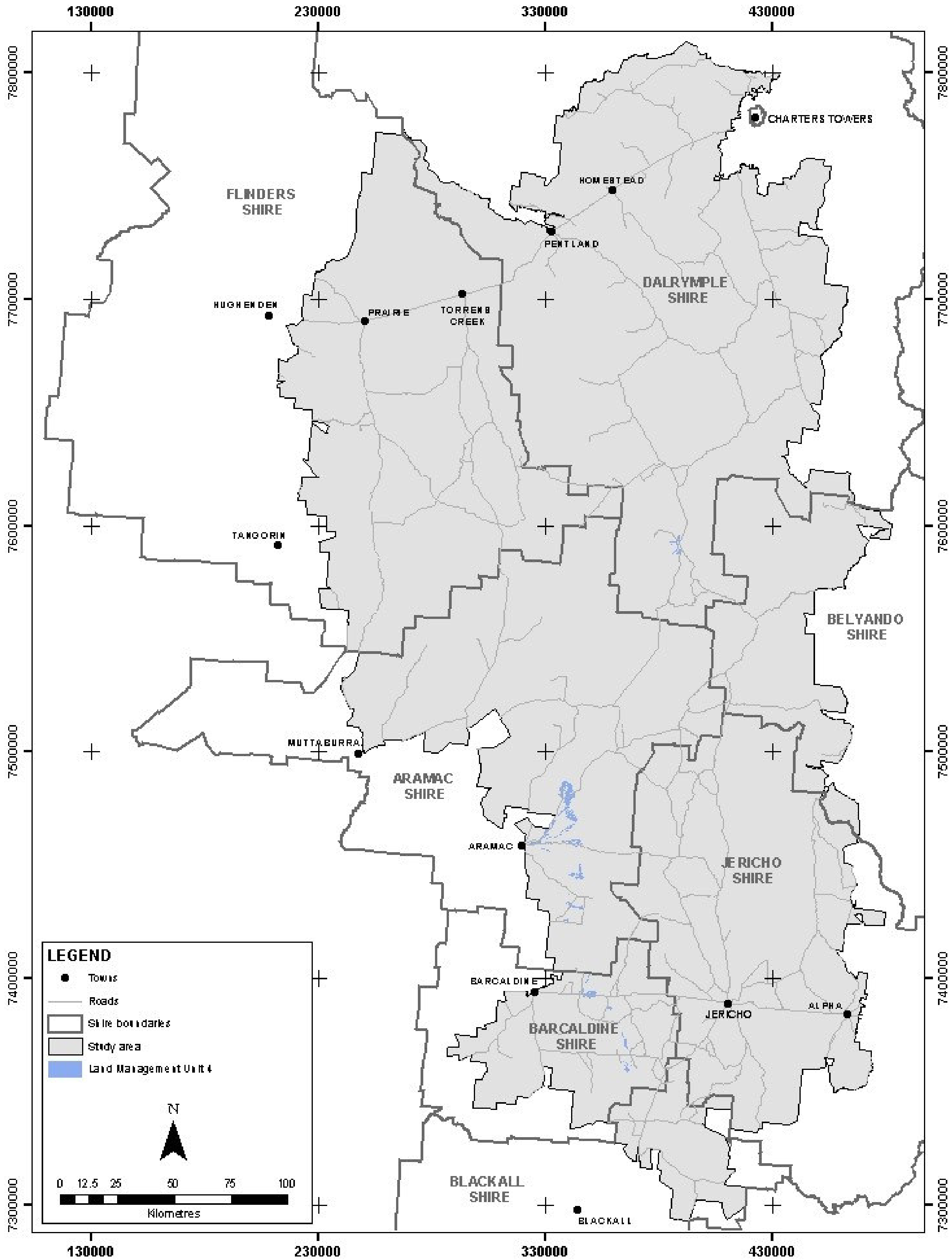


Figure 6.4 **Distribution of Land Management Unit 4 in the study area**

6.2.5 Land Management Unit 5

General description

Thin sandy topsoils overlying saline, heavy clays with a herbfield or low shrubland usually adjacent to saline lakes lakes. These areas represent only 0.1% of the study area (Figure 6.5).

Common characteristics

- A calcrete hardpan occurs in some areas of this unit at a depth of approximately 0.5m, restricting the rooting depth of plants, drainage, and the water-storage capacity of the soil profile.
- The saline nature of the soil profile also restricts plants to those that are tolerant of high subsoil pH and high salt levels.
- Plants adjacent to the lake are subject to extremely harsh conditions, such as abrasion by wind-borne sand and salt particles, desiccation by hot winds off the dry lakebed, and salt spray when water is present.
- The heavy sodic clay soils have poor drainage, which creates anaerobic conditions for plant roots.
- These areas are subject to extended periods of inundation.

Special features

- *Lawrencia buchananensis*, a small shrub listed as vulnerable under the *Nature Conservation Act (1992*), is restricted to this unit, adjacent to Lake Buchanan.
- The different dune systems provide a record of past climates and of flooding regimes of the lakes
- The dune-swale combination of soil and vegetation provides a unique range of plant species adapted to a saline environment, including several endemic species.
- The land units provide significant feeding, roosting and nesting habitat for large populations of migratory waterbirds, and general or seasonal habitat for a number of other birds of conservation significance.

Implications for land use and land management

- Accumulations of wind-borne salt in the topsoil make it more difficult for plants, already struggling to survive in a harsh environment, to extract soil moisture. Rainfall cleanses the plants and leaches the accumulated salts out of the topsoil.
- The opportunities to improve pasture productivity are limited and the successful establishment of exotic pasture species is most unlikely.
- Cattle obtain their salt intake requirement when they graze the plants in this unit. However, the ability for plants to survive the extremely harsh local environment is only made more difficult if cattle are added to the equation. The palatable plant species are limited in number and a continuous grazing strategy eventually removes them from the sparse pasture, and reduces the biodiversity of the area.
- Because of their limited extent and the impact of grazing, some land units have an ‘Endangered’ biodiversity conservation status (Environmental Protection Agency 2005).
- The protection offered to small ground fauna and nesting birds by shrubs and low bushes, such as *Lawrencia buchananensis,* which is palatable to stock, is at risk under heavy grazing pressure.
- These saline plains represent a unique ecosystem, but they are limited in extent and some of the unique characteristics could be lost under a grazing enterprise.
- Opportunities exist to recognise the values of this land management unit through eco-tourism and research studies in the fields of flora, fauna, ephemeral wetlands and geomorphology, if the area can be managed and retained in its natural condition.
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal

production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in ‘The Conservation of Biodiversity in the Desert Uplands’ http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

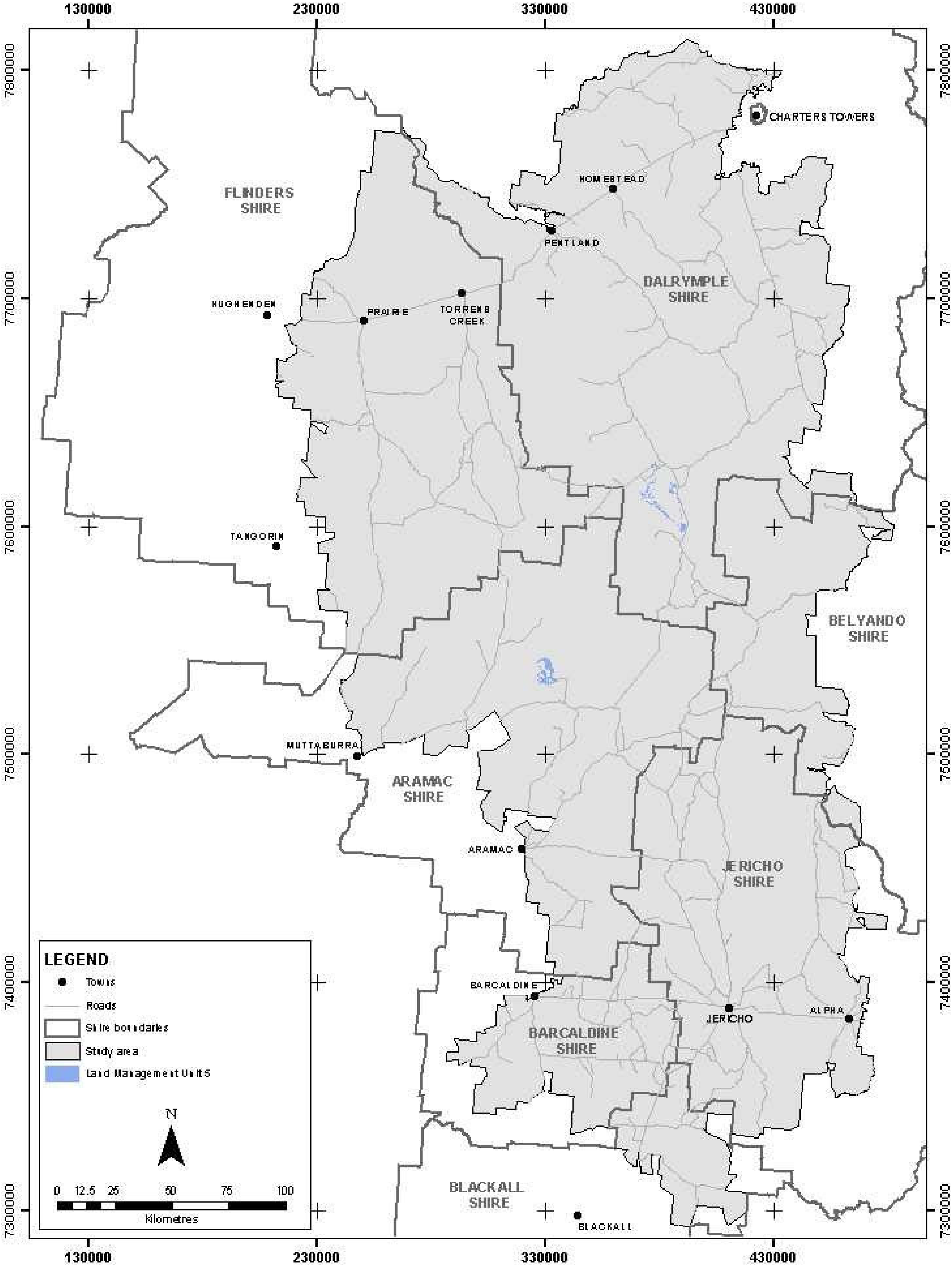


Figure 6.5 **Distribution of Land Management Unit 5 in the study area**

6.2.6 Land Management Unit 6

General description

Sandy loam topsoils with clayey sodic subsoils and Reid River box (*Eucalyptus brownii*) or poplar box (*E. populnea*) woodlands in drainage depressions and on adjacent gentle slopes. These areas represent 4.8% of the study area (Figure 6.6).

Common characteristics

- The surface soils are susceptible to sheet erosion and scalding. The hazard is increased if protective vegetative cover is reduced.
- The clayey subsoils have a very low permeability and in most cases are sodic.
- Most areas are prone to seasonal flooding and the sodic subsoils are susceptible to gully erosion.
- Drainage depressions are dry for most of the year and rarely have permanent or semi-permanent waterholes.
- Riparian zones are notorious for the appearance of weed species.

Special features

- These areas are important habitat for native fauna because of the prolific growth and variety of vegetation resulting from a better moisture supply and longer growing season than that of most other units in the bioregion.
- Box woodlands support the greatest diversity of animal species of any habitat in the bioregion and are particularly significant for many woodland bird species that are declining in numbers in other parts of Australia, as well as granivorous birds, bats, terrestrial and arboreal mammals and some restricted reptiles.

Implications for land use and land management

- Sheet erosion removes the light-textured topsoil, leaving behind bare, hard-surfaced areas that are very difficult to re-vegetate.
- Despite the gentle gradient of one percent or less, surface water flow can be rapid and substantial. (It is not unusual to have a volume of water 150m wide and 0.5m deep flowing along these depressions after heavy rain). Clearly, the position and design of fences, roads, buildings, stockyards, etc. in, or adjacent to, these locations require careful consideration.
- In general, the gradient is not steep enough for channel-flow and associated gully erosion to occur, but the subsoils are sodic and susceptible to gully erosion. The risk is increased if any excavation work leaves the soil profile exposed.
- Sightings of ellangowan (*Myoporum desertii),* which is toxic to hungry stock, have been reported in these areas.
- Overgrazing reduces competition by pasture species and provides weed species with an opportunity to become established and a potential problem, both on site and further downstream.
- Changes in vegetation density in these areas, or on sand sheets upslope of them, may lead to increased water logging and salinity.
- The majority of these areas have an 'Of Concern' biodiversity conservation status (Environmental Protection Agency 2005).
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management

practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands'
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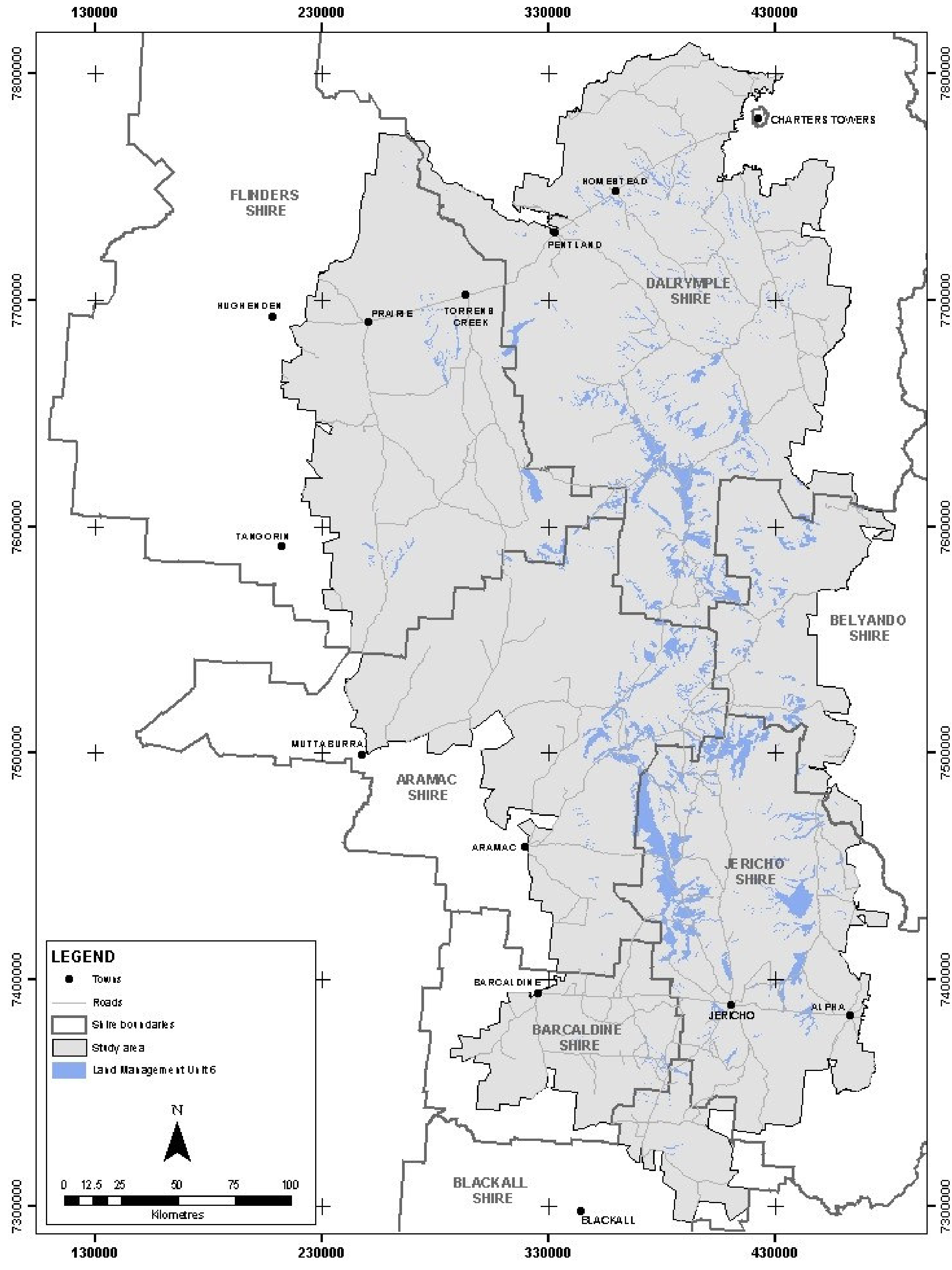

Figure 6.6 **Distribution of Land Management Unit 6 in the study area**

6.2.7 Land Management Unit 7

General description

Deep sandy soils on gently sloping country overlying saline lakebed clays or clays derived from shales, with sparse woodlands of sally wattle, bloodwood and beefwood. These areas represent only 0.2% of the study area (Figure 6.7).

Common characteristics

- The deep sandy topsoil has a low moisture-holding capacity and is considered to be 'droughty'.
- The soil is deficient in most plant nutrient requirements.
- The quantity and quality of production from the native annual pasture is extremely low.
- The area is susceptible to invasion by woody weeds.

Special features

- Only deep-rooted species, such as *Grevillea, Melaleuca* and *Acacia*, that can tap the moisture reserves at depth, are able to grow and persist. These flowering trees and shrubs are an important source of pollen and nectar for insects and birds.

Implications for land use and land management

- The shallow-rooted annual species are present only because they can germinate, mature and set seed within a few weeks after rain.
- The risk of invasion by woody weeds is increased if cattle are allowed to graze the area continuously.
- The low production of dry matter makes the control of woody weeds with fire very difficult.
- The net benefit of grazing these areas at all is doubtful, as the quantity and nutritional value of the available forage is very low.
- The droughty, nutrient-deficient soils are unlikely to produce good pasture growth from introduced pasture species unless extra nutrients and water are provided.
- Because of their limited extent and the impact of grazing, these areas have an 'Endangered' or 'Of Concern' biodiversity conservation status (Environmental Protection Agency 2005).
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands' http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

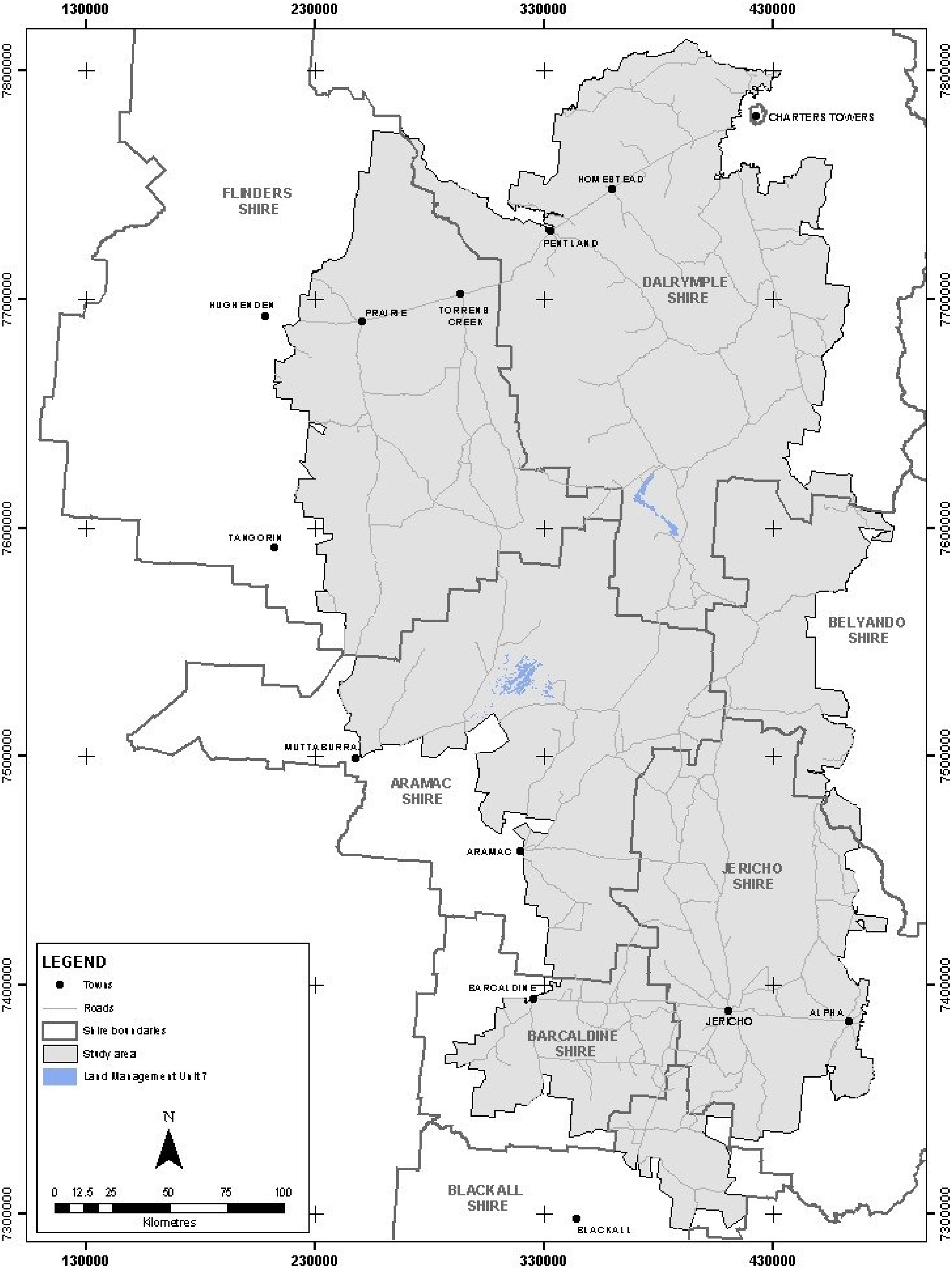

Figure 6.7 **Distribution of Land Management Unit 7 in the study area**

6.2.8 Land Management Unit 8

General description

Sandy uniform, gradational or texture-contrast soil profiles on alluvial fans, plains and older terraces, with ironbark woodlands and the occasional bloodwood or ghost gum. These areas represent 12.6% of the study area (Figure 6.8).

Common characteristics

- The fine sandy loam topsoils are usually structureless, and susceptible to compaction and sheet erosion.
- The topsoils are typically hard setting and runoff can be high after heavy rainfall if there is insufficient ground cover.
- The lower slopes have structureless topsoils overlying relatively impermeable clays, and can become boggy after heavy rain.
- The characteristics and attributes of these soils change according to their position on the outwash fan. Soil profiles on the upper slopes have better drainage, but they are more susceptible to erosion by water. On the other hand, soil profiles on the lower slopes have deep topsoils and a better water-holding capacity, but may have sodic subsoils and poor drainage.
- Nutrient levels, particularly phosphorus, are very low.

Special features

- Ironbark woodlands support a very high number of animal species, including many of conservation significance. They have a higher proportion of terrestrial mammals and reptiles than the box country, but are similarly significant for woodland bird species (Morgan *et al.* 2002).

Implications for land use and land management

- Tree and grass roots help to bind the topsoil and stabilise the slopes. Reduced protective ground cover increases the risk of erosion, and subsequent loss of topsoil causes increased run-off, reduced soil moisture storage and reduced ability of tree and ground cover species to survive extended dry periods. This downward spiral in land condition will continue unless the level of pasture management is improved.
- It is the ability of native plants to adapt to low-fertility soils that allows such a diverse range, and abundant quantity, of vegetation to persist. While the introduction of exotic pasture species may be successful in the short term their persistence, productivity and nutritive value may decline as the limited nutrient supply is depleted.
- The sodic, mottled subsoils on the lower slopes of alluvial fans support plant species that have adapted to this soil type. Any changes to the quantity and composition of the vegetative cover can produce undesirable changes to the profile hydrology, which can affect the ability of the remaining species to survive. The removal of trees and shrubs also removes the mechanism that controls excess subsoil moisture and salinity.
- In addition to the grazing pressure of cattle on the pasture, the physical pressure of hooves sinking into the loose sandy topsoils and breaking the lateral roots or knocking out individual plants also reduces ground cover.
- If the topsoil is lost from these areas, revegetation on the exposed clayey subsoil is difficult and extremely slow.
- A small proportion of land units in this LMU have an ‘Of Concern’ biodiversity conservation status (Environmental Protection Agency 2005).
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal

production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands'
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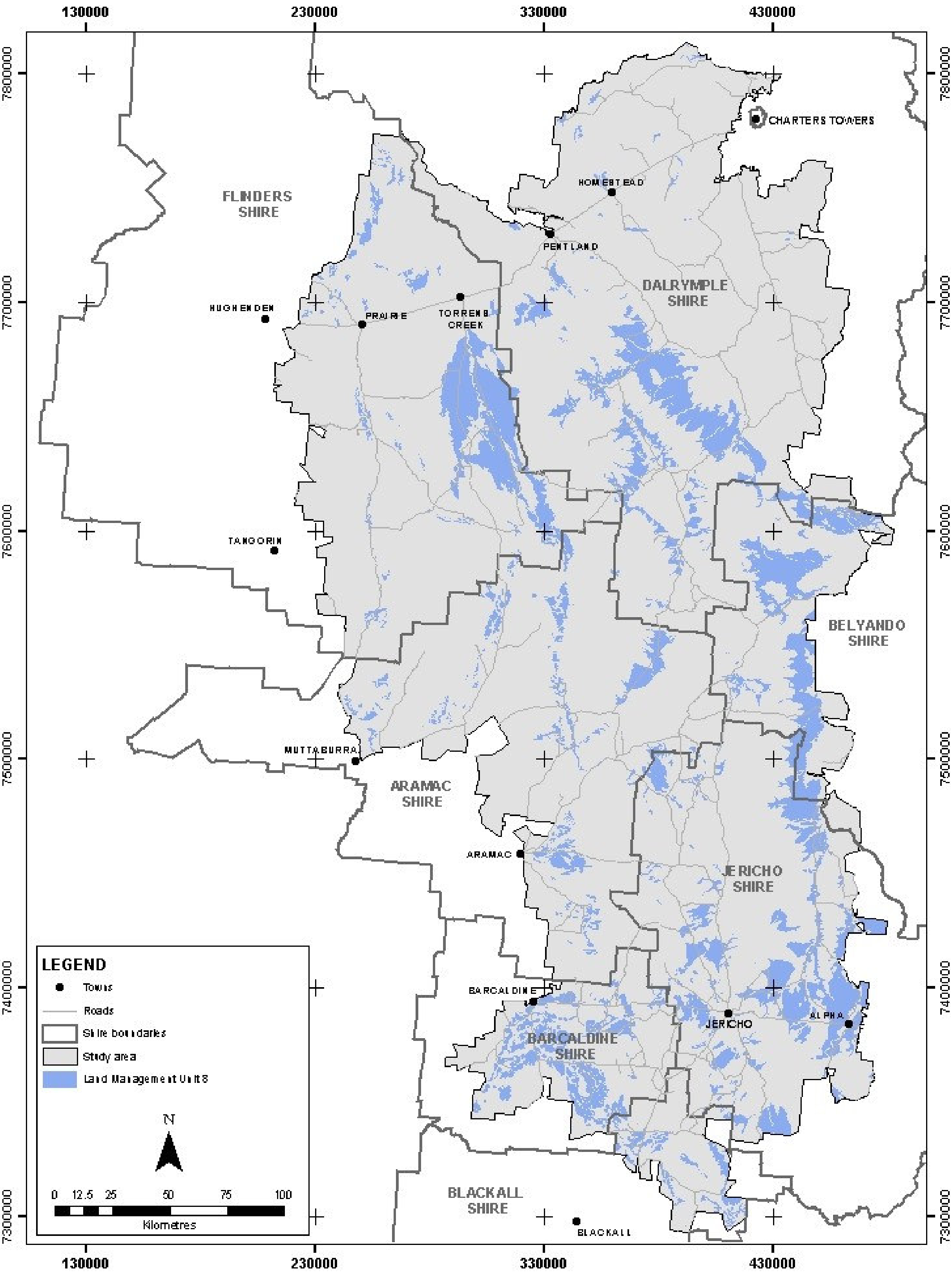

Figure 6.8 Distribution of Land Management Unit 8 in the study area

6.2.9 Land Management Unit 9

General description

Red and yellow gradational and texture-contrast soils, with sandy loam topsoils and an ironstone hardpan or weathered bedrock at a depth of greater than 0.5 metres, on gently undulating plains. Ironbark woodlands, with desert oak and bloodwood. Cypress pine is restricted to the southern areas. These areas represent the largest proportion, at 21.7%, of the study area (Figure 6.9).

Common characteristics

- Hardpans are usually present below a depth of 0.5 metres.
- The soils have a very low nutrient status and a low pH, particularly in the shallow profiles.

Special features

- Ironbark woodlands support a very high number of animal species, including many of conservation significance. They have a higher proportion of terrestrial mammals and reptiles than the box country, but are similarly significant for woodland bird species (Morgan *et al*. 2002).
- This unit is characterised by a wide variety of plant species, at ground level and mid-strata level under the open canopy of ironbark.

Implications for land use and land management

- Dense pastures and a good ground cover of litter are necessary to maintain a loose open seedbed with good infiltration characteristics.
- Runoff, and the risk of soil erosion, increases if the protective ground cover or tree vegetation are removed.
- Maintaining a high density of the perennial grasses (that is, a grass basal area of greater than two percent and ground cover of 30-40 percent) not only ensures a rapid response to rain and optimum grass production, but the dense pasture holds the rain where it falls and allows time for infiltration.
- If pastures are overgrazed the more palatable, nutritious species are removed, allowing the less desirable species such as neverfail, wiregrass and currant bush to take over. As the area of bare ground increases, the amount of water infiltrating and being stored in the soil is reduced, causing higher runoff, erosion and less soil-water storage. It becomes more difficult for plant species to survive the next dry period, and so more bare ground is exposed and the situation deteriorates further, resulting in a shorter growing season, lower productivity and a loss of biodiversity.
- Spinifex is very slow to regenerate because it relies more on vegetative propagation, rather than seed to establish new plants. It may take two to three good wet seasons and prolonged spelling to increase plant density.
- By moving stock from one paddock to another the grazing pressure on the more palatable plant species is reduced, giving those species a chance of maintaining a presence in the pasture.
- The hardpan within the soil profile impedes rooting depth and deep water movement, and restricts the amount of moisture that can be stored in the soil, however, on the positive side, a hardpan prevents the deep percolation of soil water beyond the root zone.
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands' http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

- A small proportion of land units in this LMU have an 'Of Concern' biodiversity conservation status (Environmental Protection Agency 2005).

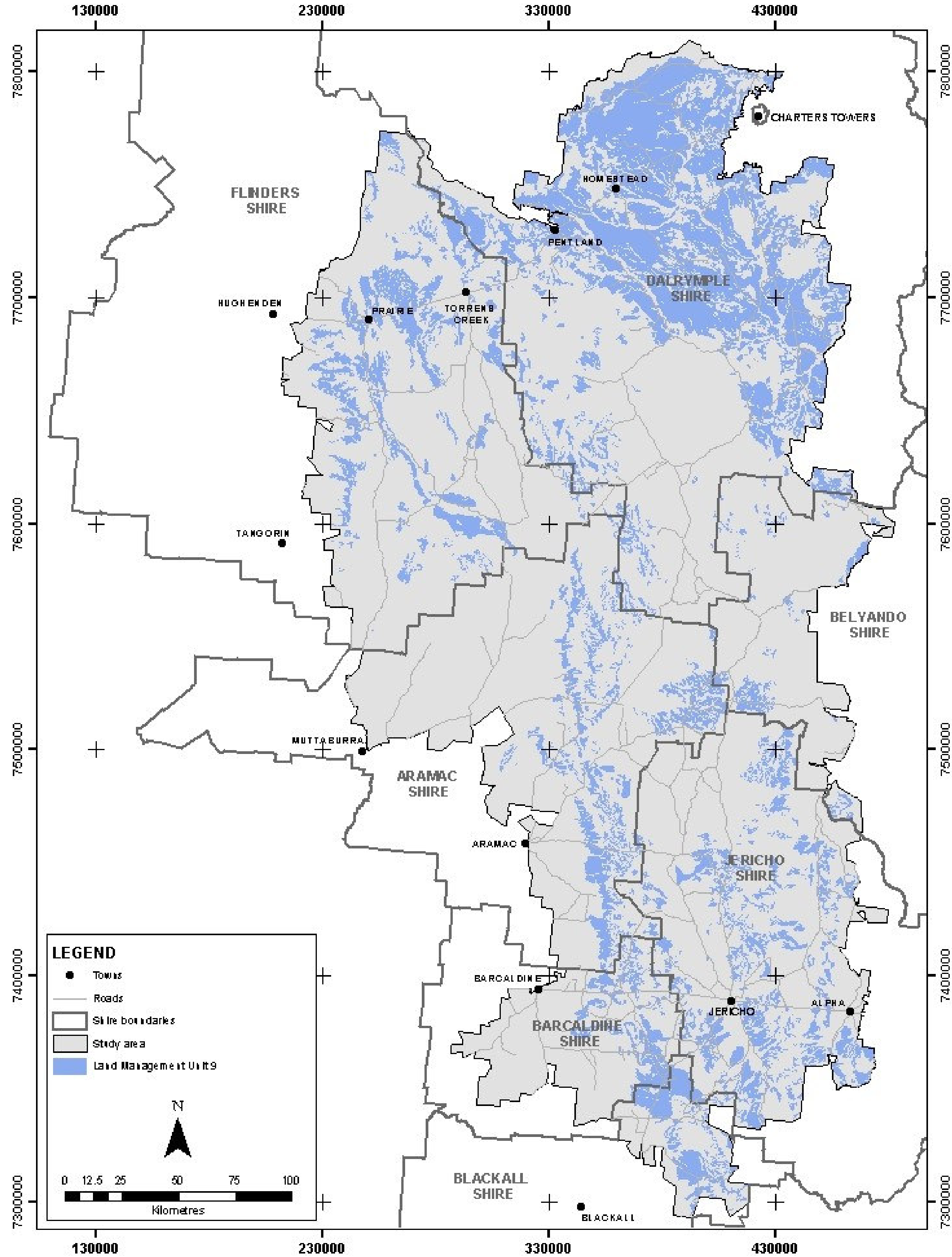

Figure 6.9 **Distribution of Land Management Unit 9 in the study area**

6.2.10 Land Management Unit 10

General description

Deep sands on the current floodplain, banks and streambed of creeks and rivers, subject to seasonal flooding, with red gum, bloodwoods, melaleucas and occasional coolabah. These areas represent 5.9% of the study area (Figure 6.10).

Common characteristics

- The alluvial deposits of loose, sandy material are unconsolidated and quite unstable.
- Floodwaters can rework the unconsolidated soils, moving the material further downstream.
- The loose sandy soils have a very high infiltration rate, a very low nutrient status and the ground cover is usually sparse.

Special features

- These ribbons of habitat provide an important seasonal refuge and resources for a variety of species, in particular arboreal mammals, woodland birds, hollow-roosting species and amphibians. Many birds of prey preferentially nest in tall riparian trees.
- Riparian areas contain the highest number of threatened plants and other plants of conservation significance of all habitats in the Desert Uplands (Morgan *et al*. 2002).

Implications for land use and land management

- Because these watercourses are often narrow and occupy a relatively small area, it is often impractical to isolate them and manage them differently.
- Riparian zones are considered to be of critical importance in stabilising stream banks, providing refuge areas and corridors for wildlife, trapping nutrients from overland flow and maintaining water quality.
- Watercourses are susceptible to infestation by weed species, brought in by runoff from the upper catchment areas.
- The hooves of cattle, sinking into the loose sandy topsoil, break lateral roots and weaken the tussock grasses and herb species, which may then be kicked or pulled out of the soil by the grazing animal.
- Riparian zones have an 'Of Concern' biodiversity conservation status (Environmental Protection Agency 2005).
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands' http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

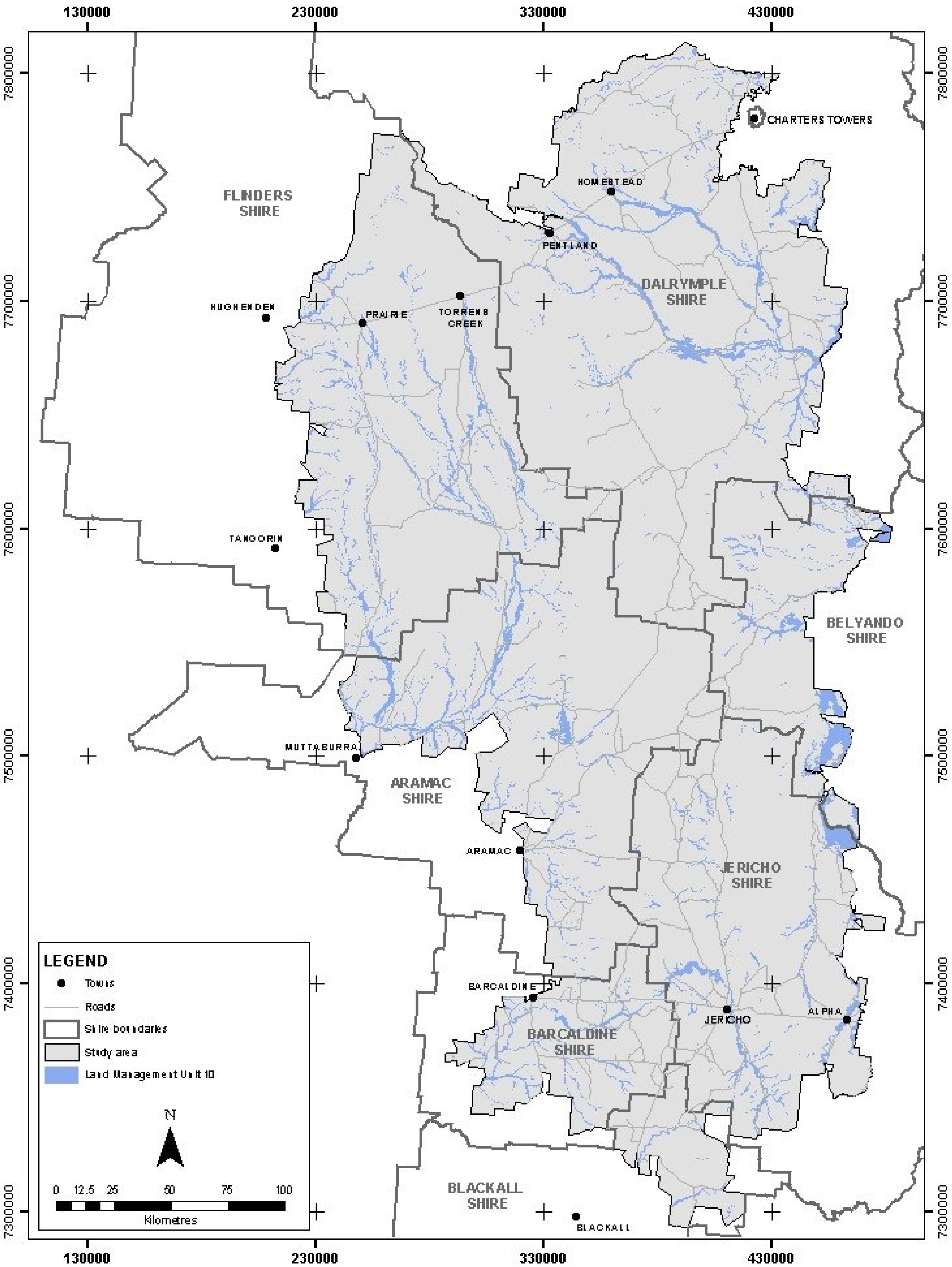

Figure 6.10 **Distribution of Land Management Unit 10 in the study area**

6.2.11 Land management unit 11

General description

Heavy clays with friable topsoils and gilgai micro-relief on undulating plains and rises, underlain by shale or calcareous sandstone. Open woodlands of blackwood, gidgee, napunyah, brigalow or blackbutt, tussock grasslands of Mitchell and Flinders grasses or localised shrublands of saltbush and samphire. These areas represent 7.5% of the study area (Figure 6.11).

Common characteristics

- It could be said that these soils are too good for the climate in which they occur - moisture rather than fertility is the major limiting factor.
- These self-mulching clay soils are highly susceptible to infestation by parthenium.
- Raindrop impact on a bare soil surface quickly leads to the formation of a surface crust, which reduces infiltration and increases runoff.
- Despite the soil in this land unit having a high potential productivity, the native pastures under the canopy of acacia scrub tend to be sparse.
- The soils often have a high salt content throughout the soil profile.

Special features

- The acacia woodlands support high abundances of particular animals, including arboreal mammals (particularly where the woodlands are near watercourses), arboreal reptiles, and woodland bird species that prefer a dense canopy structure (Morgan *et al*. 2002).
- These Vertosols represent one of the few soil types in the Desert Uplands bioregion with moderate levels of phosphorus in the topsoil, based on the analysis of soil samples collected during the project.

Implications for land use and land management

- Parthenium causes respiratory and allergy problems in humans and has the potential to completely overrun areas of land, particularly where the self-mulching clay soils have been disturbed, such as table drains, road easements and pipelines. Properties with infestations of parthenium face loss of production and devaluation of their land. Preventing infestations, by being vigilant and adopting simple quarantine measures, is a better option than trying to eradicate the pest plant once it is established.
- Lack of moisture is the major factor limiting production, rather than low fertility. The growing season for annuals and other shallow-rooted species is very short if follow-up rainfalls do not occur, since the amount of water available to plants is quite small. Maximum production and minimum physical trauma only occurs if rainfall is spread evenly throughout the growing season.
- The wide cracks appearing during the dry season are of major benefit in an area subject to violent summer storms or monsoon rainfall. Runoff is minimal and huge quantities of water pour down the cracks and replenish the subsoil moisture reserves, thereby guaranteeing continued pasture growth from the perennials well into the dry season.
- The hydrological equilibrium in this unit can be easily upset by dramatic changes in land use or land management, thereby threatening the future productivity of the area.
- The massive expansion and contraction of these soils, as they wet up and dry out, can cause major problems for roads, buildings, power and telephone lines, underground pipes and cables, dam banks and general trafficability. The effect on plant growth is equally traumatic. Plant roots, small and large, are literally torn apart as the soil dries out and large cracks appear.
- Approximately 50 percent of land units in this LMU have an ‘Of Concern’ biodiversity conservation status (Environmental Protection Agency 2005).
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal

production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands'
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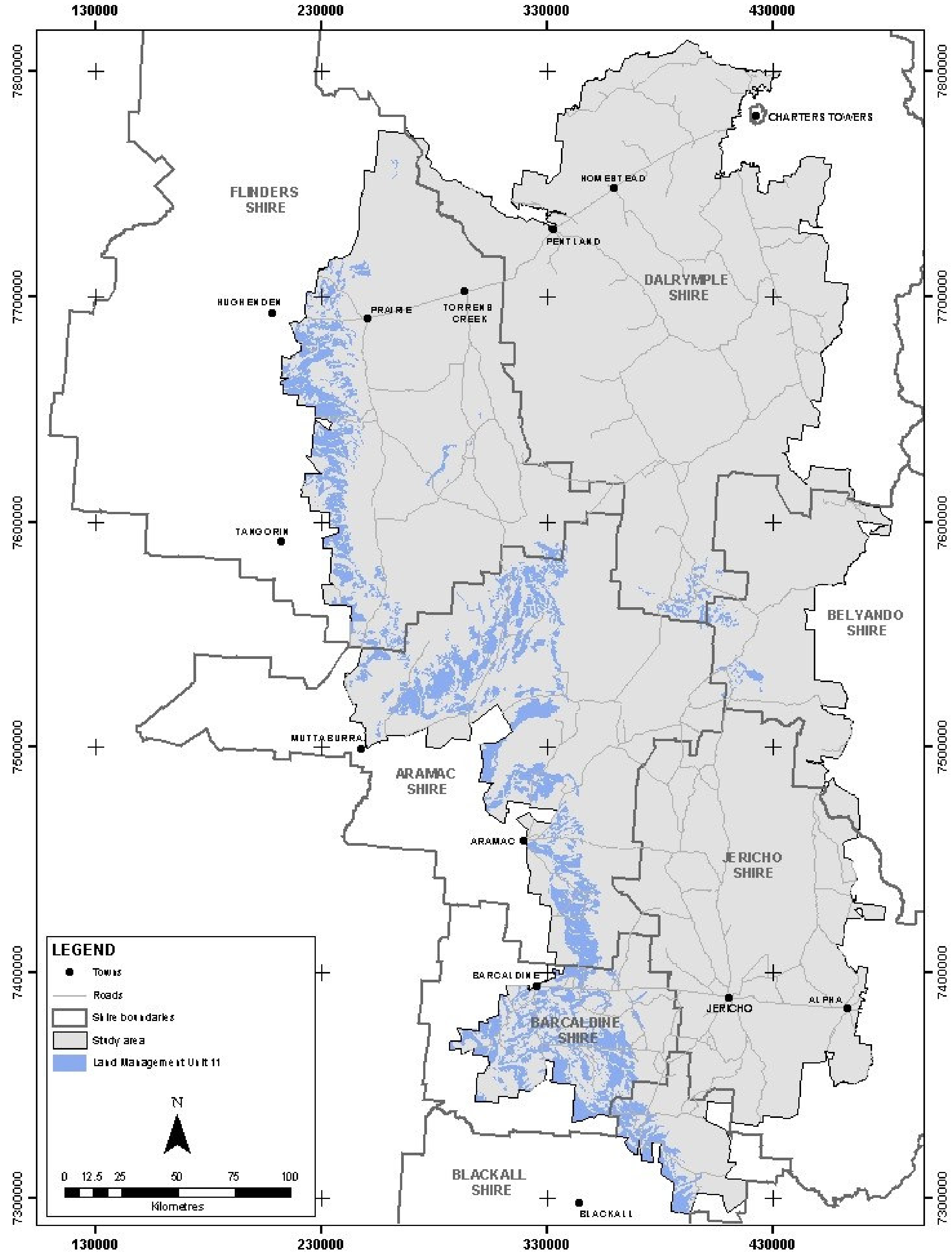

Figure 6.11 **Distribution of Land Management Unit 11 in the study area**

6.2.12 Land Management Unit 12

General description

Deep, grey and black cracking clays on alluvial plains and old lakebed deposits, and red friable clays and black cracking-clay soils on basalt, no longer subject to seasonal inundation by water. Woodlands of acacia species, blackbutt, false sandalwood, bauhinia or belah; grasslands of Mitchell, Flinders, blue or peppergrass and minor areas of ironbark woodland. These areas represent 7.2% of the study area (Figure 6.12).

Common characteristics

- The heavy clay soils have low available moisture for plant growth, particularly for the annual pasture species, which are shallow-rooted and have a short growing season.
- Movement by stock and vehicles is severely restricted on the heavy clay soils during wet periods.
- The soils have the typical gilgai micro-relief of deep clays that swell when moist and shrink as they dry out.
- Areas can be partially inundated with water after heavy rain – the gilgai depressions can hold water for several weeks.
- The subsoil contains moderate–high levels of soluble salts.
- Stream-bank erosion can be a problem where run-on from adjacent areas flows through the area.

Special features

- The acacia woodlands support high abundances of particular animals, including arboreal mammals (particularly where the woodlands are near watercourses), arboreal reptiles, and woodland bird species that prefer a dense canopy structure (Morgan *et al*. 2002).
- The grasslands have a very specialised group of animals that are almost entirely restricted to this habitat and its associated microhabitat features, including its deep cracking soils and tussock bases (Morgan *et al*. 2002).
- An isolated community of belah (*Casuarina cristata*) occurs on deep clay soils with excessive gilgai micro-relief in land unit LG3 of the Lake Galilee catchment.

Implications for land use and land management

- Lack of moisture is the major factor limiting production, rather than low fertility. The growing season for annuals and other shallow-rooted species is very short if follow-up rainfalls do not occur, since the amount of water available to plants is quite small. Maximum production and minimum physical trauma only occurs if rainfall is spread evenly throughout the growing season.
- The reddish-brown clays are potentially the most productive soils in the Desert Uplands, however the lack of soil moisture for most of the year is a severe limitation. Land managers may have unrealistic expectations of pasture production from this land type after clearing.
- The massive expansion and contraction of these soils, as they wet up and dry out, can cause major problems for roads, buildings, power and telephone lines, underground pipes and cables, dam banks and general trafficability. The effect on plant growth is equally traumatic. Plant roots, small and large, are literally torn apart as the soil dries out and large cracks appear.
- Tussock grasses such as Mitchell grass have adapted well to these soils by sending primary roots down to tap the deep moisture and nutrient reserves directly below the plant, while the surface roots are confined to an area within the major cracks and take advantage of any light rain or nutrients that accumulate in the topsoil. Once the soil dries and cracks open the growing season is over for any plant that cannot tap the deep subsoil moisture reserves.
- The wide cracks appearing during the dry season are of major benefit in an area subject to violent summer storms or monsoon rainfall. Runoff is minimal and huge quantities of water pour down the cracks and replenish the subsoil moisture reserves, thereby guaranteeing continued pasture growth from the perennials well into the dry season.

- Overgrazing will change the pasture composition to annual species and productivity will be severely reduced.
- There is insufficient data on the local hydrology to know if a watertable occurs under these acacia communities and if that watertable is saline. If a change in land use results in a saline watertable rising to within two metres of the soil surface, then evaporation and the associated salt accumulation will prevent all but the most salt-tolerant plants from growing, and the grazing value of the area will decline.
- The clay soils, particularly those with disturbed or self-mulching topsoils, are susceptible to infestation by parthenium (*Parthenium hysterophorus*).
- The majority of land units in this LMU have an ‘Of Concern’ biodiversity conservation status mainly due to a loss of biodiversity in the ground cover and a history of land clearing (Environmental Protection Agency 2005).
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in ‘The Conservation of Biodiversity in the Desert Uplands’ http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

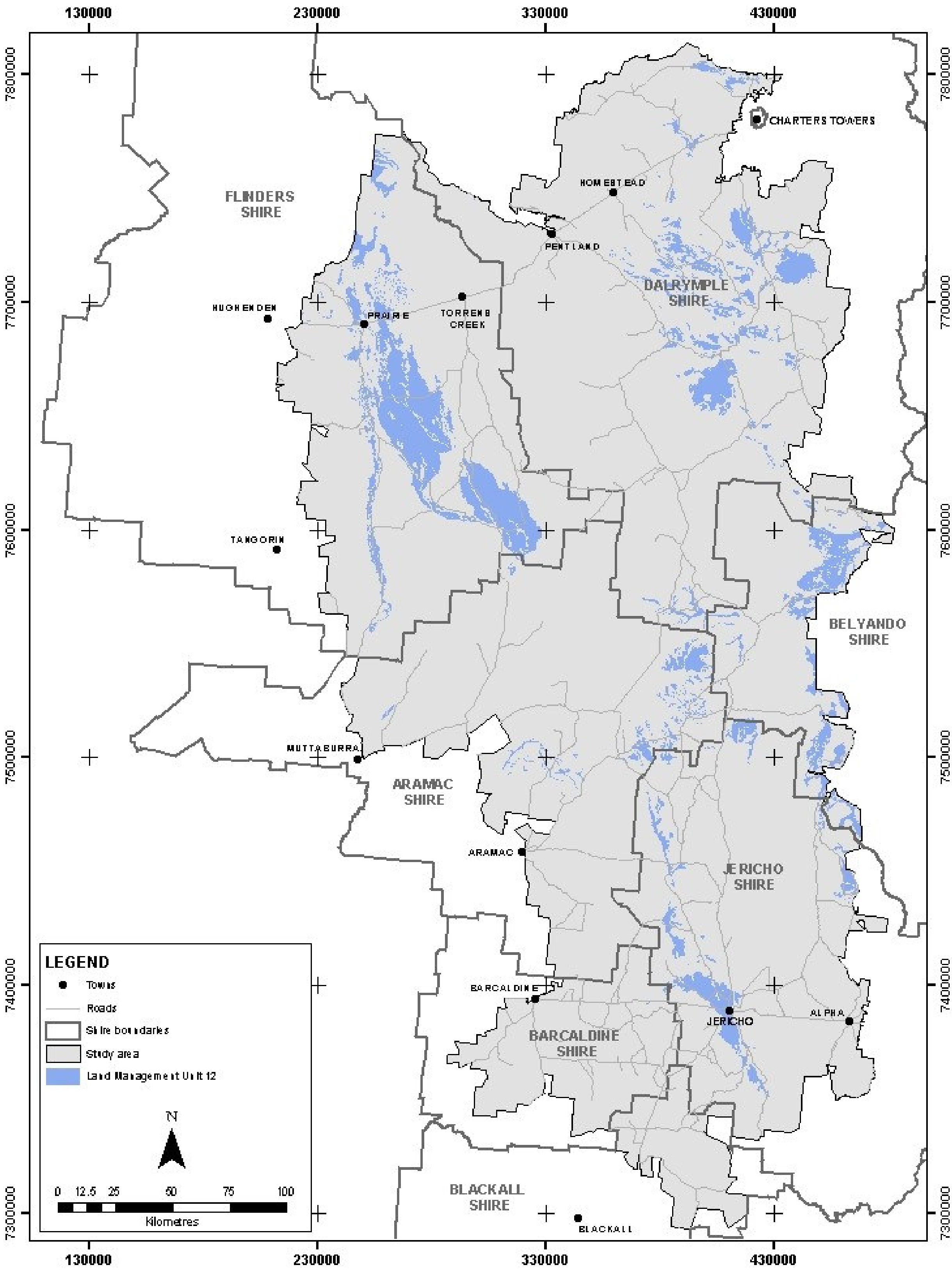

Figure 6.12 **Distribution of Land Management Unit 12 in the study area**

6.2.13 Land Management Unit 13

General description

Deep, cracking-clay soil profiles with self-mulching topsoils on gently undulating plains ('Downs' country) with open grasslands of Mitchell grass, Flinders grass and bluegrass. These areas represent 3.3% of the study area (Figure 6.13).

Common characteristics

- The shallow-rooted pasture species (annuals) have a short growing season.
- The moisture that is available to plants in these heavy clay soils - that is, the difference in moisture content when the soil is at field capacity and when it is at wilting point - is low.
- The shrink-swell characteristics of the grey clays cause physical problems for plant roots, particularly for trees and shrubs.
- Stream-bank erosion can be a problem where runoff from adjacent areas of higher elevation forms channels across these clay plains.
- The drainage depressions are prone to flooding during wet periods.
- The soil profile usually has a high salt content.
- This country 'holds on' after good rain with the nutrient value staying in the perennial grasses through the winter and spring period of the dry season.

Special features

- Good quality artesian water is available throughout the area.
- The wet season rains initiate the growth of a diverse range of annual grass and forb species that provide a highly nutritious diet for domestic and native herbivores.
- These grasslands have a very specialised group of animals that are almost entirely restricted to this habitat and its associated microhabitat features, including its deep cracking soils and tussock bases (Morgan *et al*. 2002).

Implications for land use and land management

- The perennial tussock grasses provide protection and stability to the clayey soils. If that protective cover is removed or drastically reduced, surface sealing and increased water runoff can occur. Less water will enter the deep subsoil, thereby reducing the ability of any remaining perennial species to survive the next dry season.
- Tussock grasses such as Mitchell grass have adapted well to these soils by sending primary roots down to tap the deep moisture and nutrient reserves directly below the plant, while the surface roots are confined to an area within the major cracks and take advantage of any light rain or nutrients that accumulate in the topsoil. Once the soil dries and cracks open the growing season is over for any plant that cannot tap the deep subsoil moisture reserves.
- Parthenium causes respiratory and allergy problems in humans and has the potential to completely overrun areas of land, particularly where the self-mulching clay soils have been disturbed, such as table drains, road easements and pipelines. Properties with infestations of parthenium face loss of production and devaluation of their land. Preventing infestations, by being vigilant and adopting simple quarantine measures, is a better option than trying to eradicate the pest plant once it is established.
- The massive expansion and contraction of these soils, as they wet up and dry out, can cause major problems for roads, buildings, power and telephone lines, underground pipes and cables, dam banks and general trafficability. The effect on plant growth is equally traumatic. Plant roots, small and large, are literally torn apart as the soil dries out and large cracks appear.
- The wide cracks appearing during the dry season are of major benefit in an area subject to violent summer storms or monsoon rainfall. Runoff is minimal and huge quantities of water pour down the

cracks and replenish the subsoil moisture reserves, thereby guaranteeing continued pasture growth from the perennials well into the dry season.

- Overgrazing will change the pasture composition to annual species and productivity will be severely reduced.
- If bare soil surfaces in low-lying areas, where a groundwater table is within two metres of the surface, are allowed to remain devoid of vegetative ground cover, then evaporation and the associated salt accumulation in the topsoil will prevent all but the most salt-tolerant plants from growing, and the grazing value of the area will decline.
- Land Management Units 11 and 13 are usually adjacent to each other, but unless they are separated by a fence stock will naturally take shelter in the timbered areas of Land Management Unit 11 from the summer heat and the winter cold on the open ‘Downs’. The extra physical and grazing pressure associated with cattle camps increases the risk of topsoil compaction, soil erosion and weed infestation.
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in ‘The Conservation of Biodiversity in the Desert Uplands’

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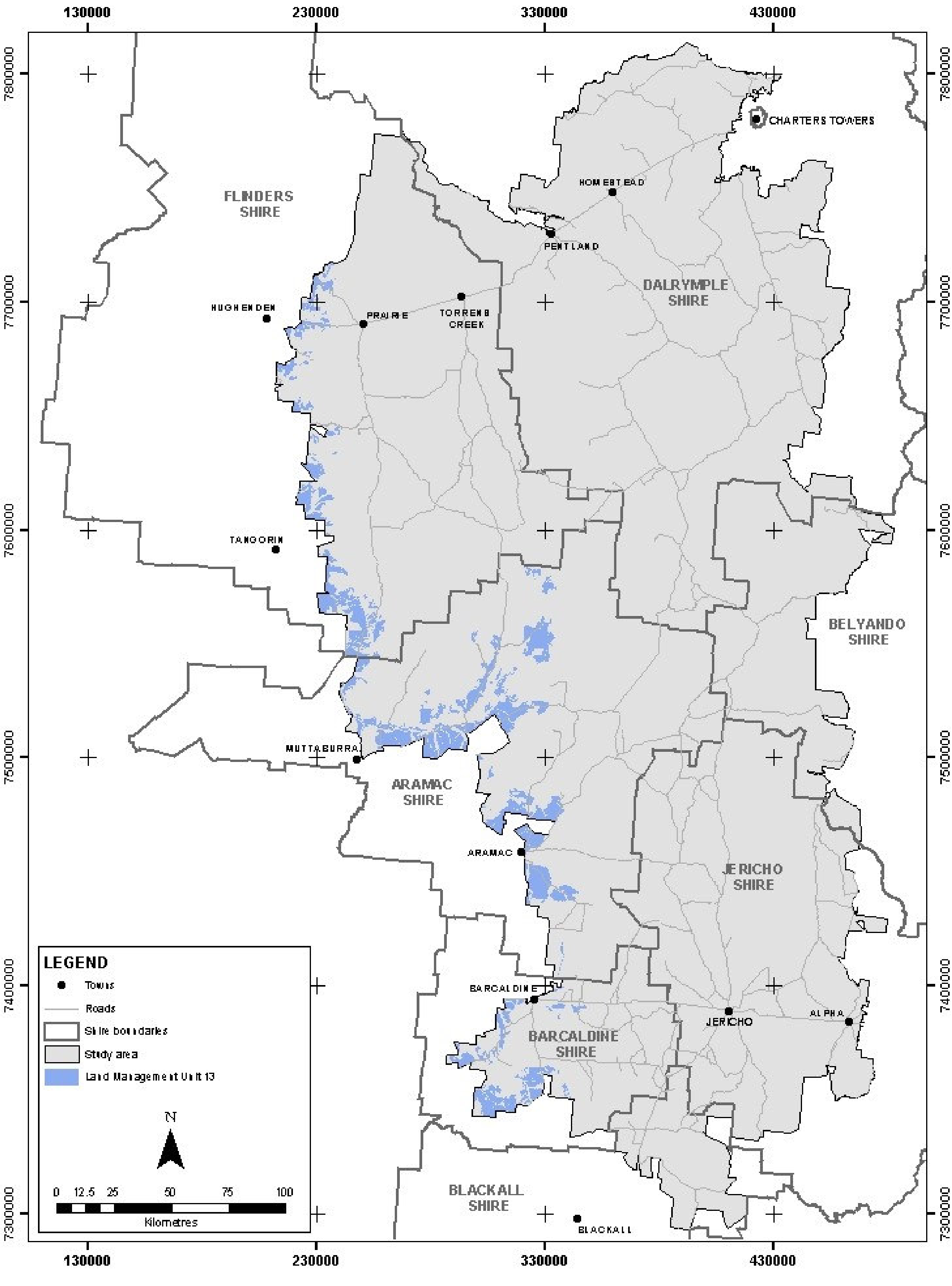

Figure 6.13 **Distribution of Land Management Unit 13 in the study area**

6.2.14 Land Management Unit 14

General description

Freshwater lakes, swamps, billabongs and backplains subject to seasonal or semi-permanent inundation by water. Woodlands of red gum, coolabah, Reid River box, (often with bulrush or lignum) or blackbutt with brigalow or blackwood. These areas represent only 1.0% of the study area (Figure 6.14).

Common characteristics

- These areas are prone to inundation for extended periods.
- The wetlands have a wide range of vegetation types, ranging from bare with only seasonal grasses and forbs, to woodlands. Includes the fringing vegetation.
- The area is susceptible to invasion by parkinsonia (*Parkinsonia aculeata*).
- Pigs are attracted to these areas.
- The clay soils may remain wet and boggy, even when the surface water has disappeared.

Special features

- Wetlands provide seasonal feeding and breeding sites for migratory waterbirds, as well as refuge for a variety of species, in particular arboreal mammals, woodland birds, hollow-roosting species and amphibians. Many birds of prey preferentially nest in tall riparian trees (Blackman *et al*. 1999).
- These wetlands are an unexpected and welcome relief to the surrounding dry, dusty landscape and provide land managers and visitors, particularly the avid bird-watchers, an opportunity to observe the diverse wildlife of the Desert Uplands.

Implications for land use and land management

- Wetlands are considered to be of critical importance in trapping nutrients from overland flow and maintaining water quality.
- Most perennial pasture species are intolerant of inundation for extended periods and useful forage is limited to annuals that can germinate and set seed once the surface water has gone and the soils remain moist.
- The heavy clay soils in the wetlands lend themselves to locations for excavated water storages, however the excavation process may reveal a saline water table or permeable aquifers at depth.
- Cane toads, which pose a major threat to the native wildlife, can survive in the deep hoof-prints left in the mud by cattle for many weeks after the surface water has dried up.
- Pigs, together with foxes and dingoes, represent a serious threat to the wildlife in these natural refuge areas as they prey on bird's eggs, chicks and small animals. Apart from causing major soil disturbance as they wallow in the mud and burrow for plant roots and tubers, pigs foul the waterholes and damage fences; they also carry the infectious cattle disease leptospirosis.
- Parkinsonia is a woody weed that grows in areas where moisture is available for extended periods. It can form an impenetrable thicket around dams and waterholes, and, if not eradicated, will spread downstream into adjacent paddocks and neighbouring properties.
- Uncontrolled grazing is incompatible with the conservation of wetlands and associated wildlife, and fencing may be the only way of protecting these areas and restricting access by stock.
- Almost every land unit in this LMU representing a seasonal, fresh-water swamp has an 'Of Concern' biodiversity conservation status (Environmental Protection Agency 2005).
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management

practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands'
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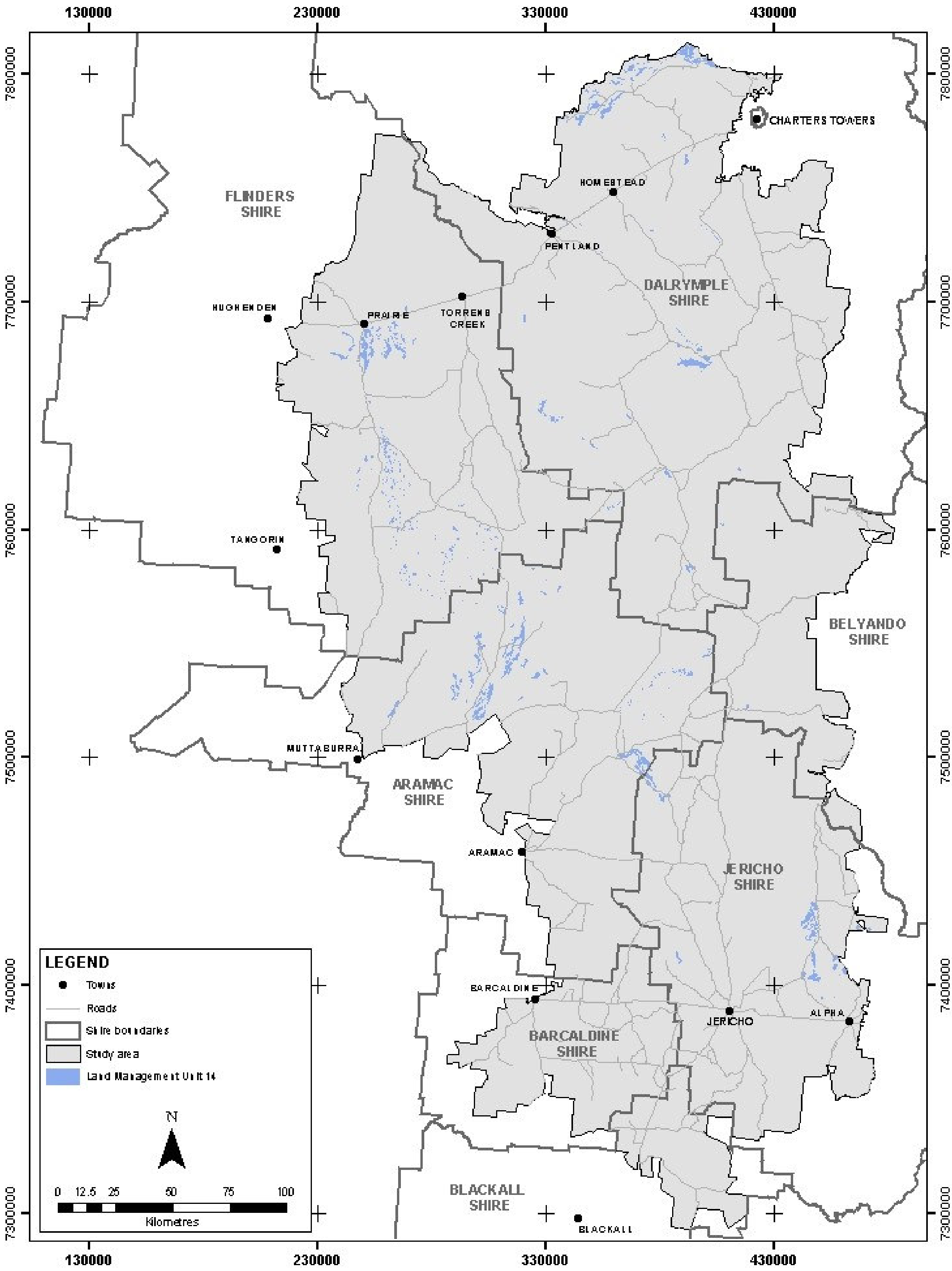

Figure 6.14 **Distribution of Land Management Unit 14 in the study area**

6.2.15 Land Management Unit 15

General description

Saline clays in shallow depressions, playas and lakebeds, with bare topsoils or salt-tolerant plant species such as samphire (Figure 6.15).

Common characteristics

- The ephemeral nature of these wetlands determines the variety and number of water birds visiting the area. The lakebeds can be inundated with water after good wet season rains.
- Lake Buchanan and Lake Galilee have enclosed drainage systems.
- The vegetation on the bed of Lake Galilee is restricted to species that are tolerant of sodic clays and saline conditions, and growth rates are slow.
- Thickets of pea-bush (*Sesbania* spp.) and/or parkinsonia (*Parkinsonia aculeata*) may occur around the margins of the brackish and fresh waterholes

Special features

- These areas are significant seasonal habitat for migratory waterbirds, with large numbers of many species having been reported to feed, breed and nest on these lakes.
- Lake Galilee is listed on the Register of the National Estate, and in the Directory of Important Wetlands in Australia.
- The low bushes and shrubs around the shores, and the salt tolerant forbs, provide protection and habitat for small ground dwelling fauna and nesting birds.
- These salt lakes represent the northern-most occurrence in eastern Australia.

Implications for land use and land management

- The opportunities to improve pasture productivity are limited and the successful establishment of exotic pasture species is most unlikely.
- Cattle obtain their salt intake requirement when they graze the plants in this unit. However the ability of plants to survive the extremely harsh local environment is made more difficult if cattle are added to the equation. Plants that are palatable to stock are limited in number and a continuous grazing strategy will eventually remove them from the sparse pasture and reduce the biodiversity of the area.
- In general, cattle should be excluded from this land management unit. They tend to pug the wet clay areas and foul small bodies of water with urine and dung as they wade into deeper water to drink. High nutrient loads and warm shallow water are a recipe for algal and slime infestation, which degrades the habitat for the flora and fauna in the water and mud as well as the bird population that feed on them.
- There is a general misconception that these salt playas are just a wasteland. In fact, there is a range of organisms in the sediments and saline water that have adapted to these extreme conditions. They provide a food source for the migratory and local water birds that visit the area during the wet season and while surface waters remain, but this delicate ecological balance could be threatened by changes in land use within the catchment or by the contamination of the lakebed sediments.
- The number and types of plant and animal species naturally occurring in a land unit varies markedly from one unit to another. When the natural biodiversity is at its maximum level for a specific area the land is generally classed as being in good condition. Striking a balance between levels of animal production and keeping the land in good condition can be achieved if the total grazing pressure is sustainable, and the natural biodiversity is maintained, over the long term. Specific management practices to maintain biodiversity can be found in 'The Conservation of Biodiversity in the Desert Uplands' http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/desert_uplands/conservation_of_biodiversity

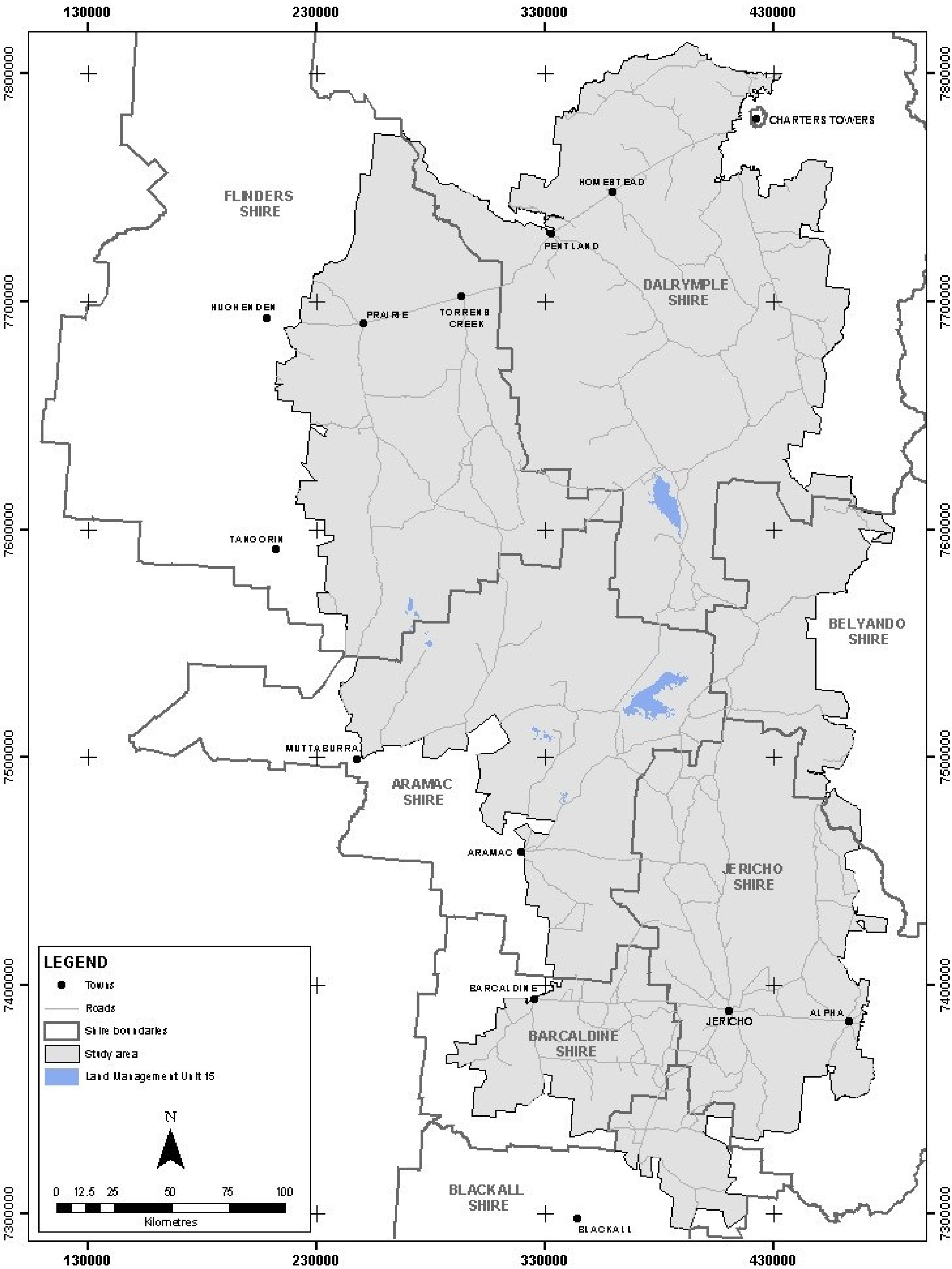

Figure 6.15 **Distribution of Land Management Unit 15 in the study area**

7. Appendices

Appendix 1. The land resource assessment team

Project leader and coordinator:

Dr Mal Lorimer

(B.Agr.Sc. M.Agr.Sc. PhD)

Principal Conservation Officer, Environmental Protection Agency, Townsville

Mal moved from Victoria in 1993 to join the (then) Dept of Environment and Heritage (DEH), bringing extensive experience in describing and classifying soils and recognising the limitations and capabilities of different land types for a range of land uses. The DUSLARA project became an extension of his first project with DEH, which concentrated on identifying and describing the different land types in the Lake Buchanan – Lake Galilee district of the Desert Uplands. Mal's primary responsibilities for the DUSLARA project were to:

- train the field team in the methods of land resource survey;
- supervise the work program of the field team;
- analyse all satellite and radiometric images, and aerial photographs for the study area and create the line work for digitising into the GIS;
- review all line work and codes on all map sheets;
- prepare text for all map legends, land system and land unit and field site descriptions;
- write the regional overview sections for climate, geomorphology, soil, vegetation and Land Management Units;
- keep the project within time and budget constraints;
- attend and provide regular financial and progress reports to the DUBDSC;
- maintain contact with land managers and Desert Uplands community, and
- answer any requests for information.

Field Team:

David Phillips

(B.App.Sc – Conservation and Park Management)

Resource Management Officer, Queensland Parks and Wildlife Service, Innisfail.

Dave took up the position of Team Leader (field work) on a temporary three-year contract as Senior Conservation Officer. He was responsible for site descriptions, classification of soils, collection of soil samples and planning field trips, together with the administrative needs of the project and keeping a close watch on expenditure. David produced a number of very useful computer programs to assist the team with sorting and interpreting the huge quantity of field data, and also played a major role in planning the initial ACCESS program, which allowed the interrogation of all the information in the database.

Marnie McCullough

(B.Rural Sc.Hons., Cert.Extension)

Project Officer, Department of Primary Industries and Fisheries, Townsville

Marnie was seconded from Department of Primary Industries and Fisheries for two years (but extended to 2 ½ years) to take up the position of Temporary Botanist with the field team. Her primarily responsibilities were to accurately describe the vegetation communities, which included measuring canopy and ground cover, assessing land condition, identifying plant species and collecting specimens of those that required more detailed identification procedures. Marnie also had the daunting task of sorting, identifying and collating all the plant specimens that had been collected from 500 sites during the first year of the project, when the team was without a botanist. The final task before returning to DPIF was to collate the vegetation data into separate files relating to composition and structure, and a list of more than 1200 plant species, complete with botanical and common names, identified during the project.

Adam Marks

(Dip. Aquatic Res. Mgmt., B.Env.Sc.)

Project Officer, Forestry and Wildlife, Environmental Protection Agency, Brisbane.

Adam left a position of Temporary Conservation Officer with the (then) Department of Environment and Heritage to take up the three-year contract as Technical Officer with the Desert Uplands project. His responsibilities were many and varied, but the first task was to oversee the construction of a trailer, designed specifically to meet the camping and fieldwork needs of the team. Adam's main tasks were to organise, purchase and maintain all field equipment, and to assist with the collection of soil and vegetation information in the field. Adam prepared all the soil samples (approx. 1200) for chemical analyses and played a major role in entering the GPS, site and soil information collected during field trips into a computer database.

GIS team:

Michael Hartcher

(B.Sc.Hons.)

Spatial modeller CSIRO Townsville

Mick joined the team in July 2000 (18 months after project commenced) as Conservation Officer (GIS) bringing much needed experience in developing databases, entering complex data sets, digitising detailed polygons and producing accurate maps. Mastering the use of an antiquated Artiscope, catching up with the backlog of digitising and keeping ahead of the field team with preliminary 'land type' maps, prepared from the interpretation of satellite images and aerial photographs, was a major challenge, successfully accomplished. After 12 months, Mick resigned to take up a position with CSR, however the sound GIS database structure and methodology established by Mick allowed a smooth handover and transition period for his replacement.

Rod Nielson

(B.App.Sc.)

Regional Information Systems Coordinator
Queensland Murray Darling Committee, Toowoomba

Rod joined the team in June 2001 as Temporary Conservation Officer (GIS) having just completed a science degree specialising in GIS spatial analysis and environmental management. Rod's primary responsibility was to fill the vacancy left by Michael Hartcher, and to digitise, code and extract statistical facts for all the remaining land system and land unit polygons, and prepare map coverage at 1:100 000 scale for the first stage of the project. A less patient person would not have tolerated the numerous changes and corrections required as new site information necessitated the review of existing polygons and the creation of new land systems and land units. At the same time, it was necessary to keep the number of land units to a minimum so that the resulting maps would be easy to understand and read.

Cherie Stafford (B.Sc. – Botany/geography)

Senior Conservation Officer (GIS), Environmental Protection Agency, Townsville

Cherie joined the GIS team in February 2003 and immediately set to work on designing the information sheets and collating the data for the land systems and land units, scanning photographs, preparing map layout and legends and preparing approximately 400 individual property maps. With several staff changes in the GIS section, Cherie assumed the important role of 'quality controller', which involved building an accurate and complete database, maintaining a high standard of data presentation, and ensuring any changes to the text or database carried through to all other related files. Cherie played a major role in preparing a printout of all maps and text for the official handover of the initial project report by the whole team and the Director-General of EPA to the DUBDSC. For the second stage of the project, which added the Dalrymple Shire to the original study area, Cherie's role included scanning the preliminary map polygons into the GIS and then entering the numerous corrections to line work and polygon codes as the project leader interpreted specific site data.

Mirjam Alewijnse (B.App.Sc.)

GIS Officer.

Australian Centre for Tropical Freshwater Research, Townsville

While awaiting confirmation of her Honours thesis at James Cook University, Mirjam worked with the GIS team, part-time, providing valuable assistance in the enormous job of preparing the land system, land unit and site information sheets (a total of approximately 3,940 pages). Another major task was the final detailed editing of the thirty-five 1:100 000 map sheets, which involved adding extra code symbols to large or convoluted land unit polygons, and checking for any typographical errors or inconsistencies in the text. Mirjam's assistance with the preparation and printout of all maps and text for the initial DUSLARA report to the Desert Uplands Build-up and Development Strategy Committee in November 2003 was greatly appreciated

Michelle Richards (B.App.Sc. (Hons))

Senior Conservation Officer (GIS), Environmental Protection Agency, Townsville.

Michelle played a major role in verifying all the linkages and 'Help' queries in the initial report, as well as formatting all the text, information sheets and maps into a stand-alone, user-friendly, computer program on CD-ROM. During the second phase of the project Michelle had the onerous task of extracting all the relevant land resource information from three different studies conducted over the last 20 years in the Dalrymple Shire and entering it into a common database from which specific data could be extracted and slotted into the relevant land system, land unit and site information sheets. With the additional text, maps, information sheets and photographs for the Dalrymple Shire added to the already large database of the initial report it was necessary for Michelle to develop a completely new database structure and presentation format to ensure the end-user could easily access the information on CD-ROM. This required re-designing the original land system, land unit and site information sheets, and putting this information into an Access Database. All the legends for the 1:100,000 map sheets also needed redeveloping due to the added information. Another task was to design a web page that complemented the Access Database. Consequently, the information was distributed as a 2 CD set, which Michelle played a major role in creating. One final task was to edit this technical report.

Appendix 2 Site description field sheet

DUSLARA SITE DESCRIPTION SHEET

Site	Way Point	1: 100,000 Map sheet	Air Photograph			Slope Cat. %	Eval	profile	plan	MT	Land Form			Notes
			Location	Run	Frame						R/Ms	Pattern	Element	

How site was	Desc. by	Date	Zone	Easting	Northing	R/O	Perm	Drain	Aspect	Dstb	Micro relief				Principal Profile Form
											agt	cm	Vert	Hori	
			5 5							0					

Erosion						Aggrdd	Surf Coarse					Rock		Surface Soil		Solum Depth	TSO	Substrate			Australian Soil Classification					Conf'nce
Type	Str	Deg	Type	Str	Deg		Abun	Size	Shp	Lith	Strn	Abun	Lith	Cond	NSW Soil Classification			Con	Depth	Lith	O	SO	G	SG	Family	
															/ /											

Horizon	Upper Depth	Lower depth	Colour	PH	Electrical Conduct.	Bou		Mottles				Coarse						Field Texture	Structure				Pans				Segregations				
						D	S	A	Si	Ct	C	A	Si	S	Lit	St	Di		G	Si	T	C	C	T	C	St	A	N	F	Si	Ef

Appendix 3 Soil analyses

All soil samples (1176) were sent to 'Incitec Ltd', Morningside, Queensland 4170, for analyses. The analyses and methods used are listed below:

Soil colour	SLM 101	Visual assessment of moist soil against Munsell colour chart
Soil texture	SLM 101	Field texture techniques of Northcote
pH (1:5 water)	SLM 102	1 to 5 soil to water dilution, stirred, stand 1 hour and read while stirring, using combination electrode
pH (1:5 Ca Cl_2)	SLM 116	1:5 soil to 0.01M Calcium Chloride, stirred, read using combination electrode.
Buffer pH	SLM 115	Mehlich buffer – 1:1 soil:water for ½ hour add buffer to 1:2 soil solution, stand 1 hour, read while stirring
Organic carbon	SLM 111	Walkley and Black, using H_2SO_4 and $K_2Cr_20_7$ in 1:100 dilution, measured colormetrically.
Nitrate nitrogen	SLM 104	1:5 soil to water, intermittent stirring over 1 hour, centrifuged nitrate measured colormetrically in segmented flow analyser.
Ammonium nitrogen	SLM 118	1:5 soil to solution of 2M KCL plus 0.05M H_2SO_4 – 1 hour shake centrifuged – measured on segmented flow.
Sulfur (MCP)	SLM 110	1:5 soil to solution of 0.01M Ca $(H_2PO_4)_2$, end-over-end for 16 hour shake, centrifuge, measured on ICP AES as phosphate extractable sulfur (sulfate).
Sulfur (KCl-40)	SLM 121	3:20 soil to solution of 0.25 M KCl heated @ 40^{o}C for 3 hours. Solution is filtered, measured on ICP
Phosphorus (Colwell)	SLM 108	1:100 soil to solution of 0.5 M $NaKCO_3$ end-over-end 16 hour shake, centrifuge, measured colormetrically in segmented flow analyser.
Phosphorus (Bray)	SLM 122	1.4:10 soil to solution of 0.03M NH_4F/0.024M HCl reciprocating shaker, for precisely 60 seconds, filtered immediately, measured colormetrically in segmented flow analyser.
Phosphorus (Lactate)	SLM 123	1:50 soil to solution of 0.005 M $C_6H_{10}CaO_6$ shaken by Orbital shaker for 90 minutes. Measured colormetrically by segmented flow analyser.
Phosphorus (Olsen)	SLM 124	1:20 soil to solution of 0.5 M Sodium Bicarbonate at pH 8.5, end-over-end 30 minute shake. Measured colormetrically in segmented flow analyser.
Phosphorus (BSES)	SLM 109	1:200 soil:solution of 0.01 N H_2SO_4, end-over-end 16 hour shake, centrifuge, measured colormetrically in segmented flow analyser.
Potassium calcium magnesium, sodium	SLM 105	1:10 neutral, normal ammonium acetate, ½ hour vigorous shake, centrifuged, measured on ICP AES.
Potassium (Colwell)	SLM 126	1:100 soil to solution of 0.5M $NaHCO_3$ end-over-end – 16 hour shake – centrifuged measured on Atomic Absorption Spectrophotometer.
Aluminium	SLM 112	1:10 soil to solution of 1M KCL, 1 hour vigorous shake, centrifuged, measured on Atomic Absorption Spectrophotometer,
Chloride	SLM 104	1:5 soil to water, intermittent stirring over 1 hour, centrifuged and chloride measured colormetrically in segmented flow analyser.

Electrical conductivity	SLM 103	1:5 soil to water, stirred, stand 1 hour and read by conductivity meter.
Copper, zinc manganese, iron	SLM 106	1:10 soil:solution of DTPA, triethanolamine and Ca Cl_2 ½ hour vigorous shake, centrifuged, measured on ICP AES.
Boron	SLM 107	1:2 soil:solution of hot 0.01M Ca Cl_2, refluxed for 10 minutes, centrifuged, measured on ICP AES.

Slaking-dispersion test

Stage 1

- Place approximately 50 vials on the black background - well separated
- Record soil sample number on the respective vial and result sheet
- Half-fill vials with distilled water
- Record starting time (try for about midday)
- Gently lower an air-dry soil sample (approx. 1 cc) into the appropriate vial
- After five (5) minutes assess* and record the degree of slaking in each vial
- After two (2) hours assess* and record the degree of dispersion in each vial
- After twenty (20) hours assess* and record the degree of dispersion in each vial

NB. At this stage the contents of any vial showing some degree of dispersion can be discarded and the sample number on the vial erased and return to Step 3 to prepare a new batch of samples for analyses

Stage 2 (For those samples that did not disperse after 20 hours)

- Discard the contents of the vial and rinse
- Half-fill the emptied vials with distilled water
- Take a fresh sample from the same soil sample and mould a bolus to field capacity
- Place the bolus into the appropriate vial
- Record the time
- After two (2) hours assess* and record the degree of dispersion in each vial
- After twenty (20) hours assess* and record the degree of dispersion in each vial
- Discard the contents of the vial, rinse and erase the number on the label

By now you have completed Stage 1 of the first and second batch and Stage 2 of the first batch. Now you will proceed to prepare the air-dry samples for Stage 1 of a third batch and the remoulded samples for Stage 2 of the second batch.

* Use Emerson's Dispersion Score below to assess the degree of dispersion

Slaking

The structural collapse, or slaking, of an air-dry soil aggregate will occur within the first five minutes of an air-dried aggregate being gently immersed in distilled water. A rating of 'Yes' or 'No' recognises the presence or absence of slaking. If the aggregate remains in its initial state after five minutes, that is no slaking, a rating of 'No' is recorded. However, if any reaction to the water is observed, for example, disintegration, structural collapse or a break down to smaller aggregates, the sample is given a 'Yes' rating. Air-dried aggregates of similar size (approx. 1 cubic centimetre) are chosen and the vials placed on a bench that is free of any movement or vibration during the observation period.

Dispersion

The Emerson Dispersion Score (a modified version of Loveday and Pyle, 1973) was applied to 1,176 samples to assess the erodibility of various soil profiles in the study area. An assessment is made 2 and 20 hours after an air-dried aggregate is gently lowered into a vial of distilled water. Using the Emerson Dispersion score, outlined below, a score is given for all samples at both time intervals. If dispersion does not occur, a second sample is chosen, moistened to field capacity and remoulded with a spatula to form a bolus, which is placed gently in a vial of distilled water and reassessed after a further 2 and 20 hours. If any dispersion occurs on an air-dry aggregate within the first 20 hours, a value of 8 (4+4) is added to the scores recorded after 2 and 20 hours, as it can be assumed that complete dispersion would occur if the sample were moulded in a moistened state. The four scores for each sample are added to give a total score between 0 and 16.

Emerson dispersion score:

0	no dispersion
1	Slight dispersion - recognised by a slight milkiness of water adjacent to the aggregate and sometimes by a narrow edging of dispersed clay on parts of the aggregate.
2	Moderate dispersion - clearly visible, less than 50 percent of the aggregate affected.
3	Strong dispersion - considerable milkiness and about 50 percent of the aggregate dispersed away.
4	Complete dispersion - only the sand grains are left in a cloud of clay.

Final dispersion rating:

Total score	Rating
0 - 4	Low
5 – 8	Moderate
9 – 12	High
13 – 16	Very high

A dispersion rating of High or Very high identifies a soil that is susceptible to erosion and a source of turbidity in runoff water.

Appendix 4 Site location and land condition assessment field sheet

DUSLARA Vegetation Field Sheet

VEGETATION MAPPING RECORDING FORM			
SAMPLE AREA: 20M X 50M	SAMPLE_AREA	WPT:	SITE:
PROJECT: DUSLARA	MAP NAME:	DATE:	
EASTING:	NORTHING:	STRUCTURAL FORMATION:	
PROVINCE:	LAND ZONE:		
LOCALITY:___________	KM TO__________________	ON_______________	____________

Basal Area Factor (BAF): 0.25	Cover Assessment (M): 0.5

LAND CONDITION ASSESSMENT								
UNCLEARED:	Tree vigour:	Nil Dieback	5	4	3	2	1	Dead Crowns Common
	Basal Area:	Max Potential Gr'nd Cover	5	4	3	2	1	Bare Ground
	Plant Diversity:	Many Species	5	4	3	2	1	Mono specific/Nil species
	Presence of Weeds:	Nil	5	4	3	2	1	Many
	Tree rejuvination:	Common	5	4	3	2	1	Nil
	Litter, logs, stag trees:	Common	5	4	3	2	1	Nil

		RATING TOTAL						

CLEARED:	Basal Area:	Max Potential Gr'nd Cover	5	4	3	2	1	Bare Ground
	Plant Diversity:	Many Species	5	4	3	2	1	Mono specific/Nil species
	Presence of Weeds:	Nil	5	4	3	2	1	Many
	Tree Rejuvination:	Nil	5	4	3	2	1	Abundant

RATING TOTAL						

Disturbance	Present	Absent	Unsure
Clearing			
Fire			
Weeds			

SITE NOTES:

SOIL/GEOLOGY: sand / loam / clay

LANDFORM ELEMENT: plain / floodplain / valley flat / gilgai / drainage depression / gully / ephemeral river / hill slope / hill crest / escarpment

VEGETATION COMMUNITY: downs / savannah / open woodland / scrub / heath / cleared

GRAZING NOTES:

NATIVE WEEDS NOTES:

Appendix 5 Vegetation occurrence and height field sheets

Way Point:

Stem Count						Crown Cover Estimate			
E	**T1**	**T2**	**T3**	**S1**	**Species**	**Avg. Ht.**	**Diam.**	**Diam.**	**No.**

Way Point:

Ground Cover Assessment								
Position along transect	**Grass Species present**	**Basal Area grass**	**Other Species present**	**Basal Area other**	**Crypto. (%)**	**Rock (%)**	**Litter (%)**	**Bare ground (%)**

Appendix 6 Total crown cover field sheet

Way Point:

Ht (m)	<5%	5-20%	20-50%	50-80%	80-100%
20-35					
12-20					
6-12					
3-6					
1-3					
<1					

Appendix 7 Methodology for land condition assessment

The method of assessing land condition, described below, was developed during the first twelve months of the project, with criteria such as 'grazing pressure', quantity of litter, logs, stag trees, etc.', added as it became evident that the final 'condition score' did not correlate very well to the visual impression of vigour, diversity and biomass. Unfortunately, time did not allow the earlier sites to be revisited and evaluated using the final set of criteria. Three aspects of the method need to be clarified:

- For cleared land only four of the six criteria apply, whereas for uncleared land all six criteria apply.
- The percentage grass basal area (GBA) is a good measure of the perennial grass species, and hence the general grazing pressure on the pasture, as it indicates the ability of the pasture to maximise ground cover and pasture production. Tentative figures for GBA are provided in the assessment as a general guide for pastures in the Desert Uplands. An estimate of ground cover by itself is far too variable, as values can change within a few days under a very high stocking rate, or over night as a result of fire.
- For cleared land the rejuvenation of trees is undesirable as it defeats the reason for clearing the land in the first place and the score is downgraded as the amount of regrowth increases. However, for uncleared land if trees and shrubs are present at all stages of growth, from seedlings to old stag trees, it represents a balanced, sustainable vegetation community and would receive a maximum score. As the grazing pressure increases, the young tree and shrub species become the browse portion of the animal's diet and the land condition score is downgraded.

The resultant method provides a sound basis for assessing land condition – other criteria might be appropriate or the individual scores for each criterion might be 'weighted' to indicate a greater or lesser importance than the other criteria. However, the final scores, which appear on the site information sheets, give a good comparative assessment of the condition of that site at the time of sampling.

NB. Land condition assessment scores only apply to an area within a 50-metre radius of a site. They do not represent the condition of the whole land unit or general district because insufficient sites were recorded to make such a generalisation.

Step 1

(a) Tree vigour	**Score**
Nil dieback	5
Minor dieback	4
Moderate dieback	3
Some dead trees and crowns	2
Dead trees and crowns are common	1

(b) Grazing pressure	**Score**
Maximum potential ground cover (GBA >6%)	5
Good potential ground cover (GBA 4-6%)	4
Moderate potential ground cover (GBA 2-3%)	3
Low potential ground cover (GBA 1%)	2
Excessive bare ground, no perennials (GBA = 0%)	1
(- a browse line and sheet erosion are obvious)	

(c) Plant diversity	**Score**
Large numbers of species (eg >40)	5
Many different species (e.g. 30-40)	4
Moderate number of species (eg 20-30)	3
Few plant species (e.g. 10-20)	2
Very few or mono-specific range of species (e.g. <10	1
(- this will depend on the time of year and land type)	

(d) Presence of weed species*	**Score**
Nil	5
Few	4
Common	3
Many	2
Abundant	1

* For above-normal densities of natives plants, such as currant bush, wattles or false sandalwood, give a score of 1 to 3

(e) Tree rejuvenation	Score
For cleared land	
Nil	5
Few	4
Common	3
Many	2
Abundant	1
For uncleared land	
Nil	1
Few	2
Common	3
Many	4
Abundant	5

(f) Quantity of litter, logs, stag trees, etc.	
Abundant	5
Many	4
Common	3
Few	2
Nil	1

Step 2

Add the individual scores from (a) to (f) and read off the land condition assessment for cleared or uncleared land from the following table:

Total score		
Cleared land (Criteria b,c,d,e only)	**Uncleared land** (Criteria a – f)	**Land condition**
18 - 20	26 - 30	**Excellent**
15 - 17	21 - 25	**Good**
11 - 14	16 - 20	**Moderate**
8 - 10	11 - 15	**Poor**
5 - 7	6 - 10	**Very poor**

Note:

It is recommended that a record of the individual scores be kept (see Appendix 4) so that the reason for a site having a particular score can be identified (Two different sites may have the same condition score, but for different reasons).

Appendix 8 The DUSLARA geographic information system (for stage 1 of the project)

Land System/Land Units of the Desert Uplands Bioregion METADATA

What does this data set describe?

Title: Land System/Land Units of the Desert Uplands Bioregion

Abstract:

The technical report and the accompanying digital and ACCESS databases, present the results of the Desert Uplands Strategic Land Resource Assessment (DUSLARA) project and the Rationalisation of Dalrymple Land Resource Data project, which were initiated by the Desert Uplands Build-up and Development Strategy Committee (DUBDSC) in partnership with the Environmental Protection Agency (EPA).

The land resource study is based on the land system concept within the Desert Uplands Bioregion and involves the use of remote sensing techniques initially to identify broad geomorphic features, followed by an intensive period of field work to collect site, soil and vegetation information and finally, to present the data in a GIS and ACCESS database format. The land system method, in which soil-vegetation associations conform to a predictable and recurring pattern within areas of similar geology, physiography and climate, provides a consistent, logical identification of different land types across the whole bioregion. Once identified, the different land types are described according to inherent limitations and capabilities for current and future land uses.

Approximately 4,135 field sites from five different sources have been used to collate the vast amount of information contained in this database. In total, 48 map sheets at a scale of 1:100,000, 79 land system information sheets, 335 land unit information sheets, 3,218 site information sheets and 524 individual property maps have been prepared, all of which can be viewed or printed from the ACCESS database and used in conjunction with this GIS.

The Desert Uplands Strategic Land Resource ACCESS Database can be accessed and viewed at a variety of scales, thereby providing a versatile tool with general information at a bioregional level through to detailed information at a property level. The GIS and ACCESS database is available on CD-ROM from the DUBDSC office in Barcaldine and from the Environmental Protection Agency, Northern Region GIS Unit, Pallarenda, Townsville.

How should this data set be cited?

EPA/QPWS, Queensland, December 2005, Land System/Land Units of the Desert Uplands Bioregion:, Queensland EPA/QPWS, Queensland.

Online Links:

\\DYJ5C1S\C$\duslara\data\lslu.shp

This is part of the following larger work.

Lorimer, Dr. M.S. , 2005, *The Desert Uplands: an overview of the Strategic Land Resource Assessment Project.*

What geographic area does the data set cover?

West_Bounding_Coordinate: 144.156139

East_Bounding_Coordinate: 146.833208

North_Bounding_Coordinate: -19.754101

South_Bounding_Coordinate: -24.470022

What does it look like?

Does the data set describe conditions during a particular time period?

Calendar_Date: December 2005

Currentness_Reference: *publication date*

What is the general form of this data set?

Geospatial_Data_Presentation_Form: vector digital data

How does the data set represent geographic features?

How are geographic features stored in the data set?

This is a Vector data set. It contains the following vector data types (SDTS terminology):

G-polygon (9915)

What coordinate system is used to represent geographic features?

The map projection used is Transverse Mercator.

Projection parameters:

Scale_Factor_at_Central_Meridian: 0.999600

Longitude_of_Central_Meridian: 147.000000

Latitude_of_Projection_Origin: 0.000000

False_Easting: 500000.000000

False_Northing: 10000000.000000

Planar coordinates are encoded using coordinate pair
Abscissae (x-coordinates) are specified to the nearest 0.001024
Ordinates (y-coordinates) are specified to the nearest 0.001024
Planar coordinates are specified in meters

The horizontal datum used is D_GDA_1994.
The ellipsoid used is Geodetic Reference System 80.
The semi-major axis of the ellipsoid used is 6378137.000000.
The flattening of the ellipsoid used is 1/298.257222.

Vertical_Coordinate_System_Definition:

Altitude_System_Definition:

How does the data set describe geographic features?

lslu

Land system/land unit polygon features (Source: see technical report for further information on these features)

FID

Internal feature number. (Source: ESRI)

Sequential unique whole numbers that are automatically generated.

Shape

Feature geometry. (Source: ESRI)

Coordinates defining the features.

OBJECTID

ID Number

L_S_U2

Land Unit Code

L_ZONE

Land Zone code

L_SYSTEM

Land System Code

MAP_UNIT

Combination of land zone and land unit codes

LAND_SYSTE

Land System Name

LANDFORM_D

Landform description

Shape_Leng

Perimeter in metres

Shape_Area

Area of feature in metres squared. (Source: ESRI)

Positive real numbers that are automatically generated.

Hectares

Area of feature in hectares.

Who produced the data set?

Who are the originators of the data set? (may include formal authors, digital compilers, and editors)

Queensland EPA/QPWS

Who also contributed to the data set?

To whom should users address questions about the data?

Sharon King
Environmental Protection Agency, Northern Region
GIS Coordinator - Northern Region
PO Box 5391
Townsville, Queensland 4810
Australia

07 4722 5270 (voice)
07 4722 5274 (FAX)
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Why was the data set created?

A GIS was created to allow the application of spatial models and processing techniques to support biogeographic inventory, research and evaluation, and regional conservation planning and management for a variety of natural resources for the Desert Uplands Bioregion.

ArcGIS was used in the compilation and analysis of the GIS. Image processing was achieved using ERDAS Imagine.

How was the data set created?

From what previous works were the data drawn?

How were the data generated, processed, and modified?

(process 1 of 3)

The Desert Uplands digital database was completed in two stages.

For the first stage, three methods were used to create the digital line work:

1. The first method of transfer employed an artiscope to transpose the line work from aerial photography to clear film. The CSIRO printed a series of transparencies with Landsat TM (bands 7, 5 & 1) satellite imagery overlaid with a 1:100,000 grid using ArcView software. These sheets were taped to the top of the artiscope (to prevent movement), and the corresponding aerial photograph was placed on the tray below with the north arrow pointing towards the operator. The focus and magnification were adjusted until the area of interest on the photograph lined up with the satellite image. The line work was then traced onto the transparent satellite overlay.
2. The second method was to digitise directly on-screen using ArcInfo's ArcEdit function. This option was rarely used except for editing and edge matching. Snapping and editing tolerances were set at 25m so nodes that were at or less than 25m apart would snap together.
3. Lastly, line work was drawn by eye onto a registered, laminated Landsat TM satellite image sheet (complete with a 1000 metre grid). Land-units that had been identified through stereo viewing of aerial photography could then be identified on the satellite image sheet by changes in colour, shade, tone, texture and landscape features i.e. rivers and roads.

For the second stage (the inclusion of the Dalrymple Shire), the following method was used:

Linework was transposed onto a clear overlay taking information from aerial photography and the 2001 SLATS satellite imagery (the clear overlay had a black 10km x 10km grid printed onto it and the linework was drawn using a blue 0.1 ultrafine permanent marker - equivalent to a 30m line width). The clear overlays were then scanned, rectified and clipped. A supervised classification was then performed on the scanned image to pull the linework off the image. This was then converted into an ArcInfo coverage (through the use of a specialised AML) as the preliminary linework for this digital database. The linework was then edited and edge matched in ArcMap within a geodatabase with a snapping tolerance of 10m and a cluster tolerance of 1m. This was then combined with the first stage linework. Once linework completed, polygons were built and attributes added, revised and checked.

Person who carried out this activity:

(process 2 of 3)

(process 3 of 3)

Metadata imported.

Data sources used in this process:

F:\temp\metadata_template.xml

What similar or related data should the user be aware of?

How reliable are the data; what problems remain in the data set?

How well have the observations been checked?

Complete

How accurate are the geographic locations?

Linework compatible with the 2001 SLATS imagery and aerial photography

How accurate are the heights or depths?

Where are the gaps in the data? What is missing?

Complete

How consistent are the relationships among the observations, including topology?

Linework compatible with the 2001 SLATS imagery and aerial photography

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How can someone get a copy of the data set?

Are there legal restrictions on access or use of the data?

Access_Constraints: Copyright and distribution rights are to be retained

Use_Constraints: Contact data custodian for use constraints

Who distributes the data set? (Distributor 1 of 1)

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What's the catalog number I need to order this data set?

`live data and maps`

What legal disclaimers am I supposed to read?

How can I download or order the data?

Availability in digital form:

Data format: Size: 42.484

Cost to order the data:

Who wrote the metadata?

Dates:

Last modified: 05-Dec-2005

Metadata author:

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Metadata standard:

FGDC Content Standards for Digital Geospatial Metadata (FGDC-STD-001-1998)

Metadata extensions used:

<http://www.esri.com/metadata/esriprof80.html>

<http://www.esri.com/metadata/esriprof80.html>

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Appendix 9 Land Unit descriptions and their relationship to Regional Ecosystems and Land Management Units

The regional ecosystem classification scheme and the associated regional ecosystem-mapping program being undertaken by the Queensland Herbarium are part of the biodiversity-planning framework developed by the EPA. Regional ecosystems are also used for several planning initiatives, including the guidelines for clearing under the Vegetation Management Act 1999, the preparation of local government planning schemes, the assessment of the adequacy and representativeness of the conservation reserve network, and as a guide for proactive conservation actions by government and non-government organisations.

Sattler and Williams (1999) define regional ecosystems as “vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil”. Regional ecosystems differ from land units in that they delineate areas independently of their surrounding landscape patterns. However, as land units are also described by their characteristic vegetation, soil and landform, regional ecosystems with similar characteristics can be readily identified.

The following table contains a brief description of each of the 335 land units, the regional ecosystems that are likely to occur in each unit, and the corresponding Land Management Unit. See Section 6.2 of this report for an explanation of Land Management Units.

Land unit	Description	Land Management Unit
AA1	Upper terrace. Yellow and brown texture-contrast profiles with sandy topsoils and mottled clay subsoils. Tall woodlands of silver-leaved ironbark with common occurrences of ghost gum and long-fruited bloodwood. Reid River box is common in the numerous small drainage depressions. Regional ecosystem 10.5.5 is predominant, but small areas of 10.3.6 and 10.5.2 are also present.	8
AA2	Mid-level terrace. Brown gradational-textured profiles and uniform sandy soils with little or no horizon development. Tall woodlands of silver-leaved ironbark with varying proportions of ghost gum and Reid River box. Regional ecosystem 10.3.28 is predominant, but small areas of 10.3.6 are also present.	8
AA3	Streambed and levee. Variable soils. Tall woodlands with variable proportions of silver-leaved ironbark, ghost gum and river red gum. Coolabah and Reid River box occur in areas with imperfect drainage. Regional ecosystems 10.3.6, 10.3.13 and 10.3.28 are co-dominant.	10
AB1	Crest and upper slope. Texture-contrast soils with thick sandy loam topsoils over a brown sandy clay with an ironstone hardpan at approximately 1m depth. Tall open woodlands of White's ironbark with bloodwood, ghost gum and desert oak, and a ground cover of wire grass and spinifex. Regional ecosystems 10.5.2 and 10.5.11 are co-dominant.	9
AB2	Lower slopes. Deep, red uniform sands with dark brown topsoils and red clayey sand subsoils. Tall sparse woodlands of gum-topped bloodwood together with waxy wattle, desert oak, wire grass and mountain wanderrie in the shrub and grass layer. Regional ecosystem 10.5.1 is predominant.	9
AB3	Hillslope on deeply weathered bedrock. Texture-contrast profiles with gravely sand topsoils and sodic grey clay subsoils. Tall open woodlands of White's ironbark and low isolated trees of napunyah with a gummy spinifex ground cover. Regional ecosystem 10.5.11 is predominant, with significant areas of 10.7.5 also present.	9
AB4	Drainage depression. Texture-contrast profiles with fine sandy loam topsoils over mottled yellowish-brown clays. Tall open woodlands of Reid River box (north) and poplar box (south). Regional ecosystems 10.3.6 and 10.3.27 are predominant.	6

Land unit	Description	Land Management Unit
AC1	Plain. Reddish-brown texture-contrast soils formed on alluvium, overlying lakebed clays. Tall open woodlands of silver-leaved ironbark with a ground layer of gummy spinifex and desert bluegrass. Regional ecosystem 10.5.5 is predominant.	8
AC2	Plain. A complex of texture-contrast profiles and grey, uniform cracking-clay soils, with poplar box - ironbark and gidgee-brigalow woodlands corresponding to soil type. Regional ecosystems 10.5.5 and 10.5.12 are predominant, but significant areas of 10.4.5 are also present.	6
AC3	Drainage depressions. Young sandy deposits of variable depth overlie lakebed clays. Tall open woodlands of river red gum along incised streams. Reid River box and poplar box occurring together indicates a transition zone between the northern and southern communities. Regional ecosystems 10.3.6, 10.3.14 and 10.3.27 are all present.	6
AC4	Lakebed. Deep, grey uniform cracking-clay soils with a high salt content in the sodic subsoils. Mid-tall woodlands of brigalow and gidgee with a sparse ground cover. Regional ecosystem 10.4.5 is predominant.	12
AC5	Lakebed. Current lakebed prone to seasonal inundation. Deep, uniform, grey clay soils with a gilgai micro-relief. Mid-high woodlands of coolabah with a sparse ground cover of perennial grasses such as rice grass and cane grass. Regional ecosystem 10.3.14 is predominant.	14
AE1	Upper terrace. Very deep uniform sands. Tall open woodlands of White's ironbark, Clarkson's bloodwood and ghost gum. Regional ecosystems 10.3.9 and 10.3.12 are predominant.	8
AE2	Scroll plain: a complex of interfluves, channels and billabongs. Deep uniform or gradational-textured sandy soils. Tall sparse woodlands of Clarkson's bloodwood and ghost gum. Regional ecosystem 10.3.12 is predominant.	10
AE3	Stream channels and levees. Young sandy soils of variable depth. Tall woodlands of river red gum and coolabah. Regional ecosystem 10.3.14 is predominant.	10
AL1	Plain. Very deep, self-mulching uniform clay soils. Open tussock grasslands of Mitchell grass and bluegrass. Regional ecosystem 10.4.8 is predominant.	12
AL2	A complex area of sandy bars, drainage depressions and interfluves. Texture-contrast soils alternate with uniform sands and cracking-clay soils. White's ironbark, ghost gum, blackwood, blackbutt or coolabah, and open grasslands. Regional ecosystems 10.3.9, 10.4.1 and 10.4.8 are all present in this complex land unit.	12
AL3	Streambed and drainage depression. Major stream beds with tall woodlands of river red gum, blackbutt or coolabah. Uniform clays or young sandy alluvium. Regional ecosystem 10.3.14 is predominant, but small areas of 10.3.9 and 10.4.1 occur at random.	10
AR1	Gentle crests on undulating clay plains. Shallow or moderately deep, uniform clay soils, often stony. Open woodlands of boree and gidgee. Mimosa and false sandalwood are common, with Mitchell grass and wire grass the predominant ground species. Regional ecosystem 4.9.7 is predominant.	11
AR2	Plain. A gently undulating landscape. Open grasslands of Mitchell grass and Flinders grass with isolated occurrences of whitewood and variable infestations of mimosa and prickly acacia. Very deep, grey-brown, cracking-clay soils. Regional ecosystem 4.9.1 is predominant.	13
AR3	Streambed and minor drainage depressions. Young sandy deposits, variable in depth and distribution, overlie heavy clay soils. Woodlands of coolabah and river red gum with some river cooba and lignum. Open grasslands of Mitchell grass and Flinders grass on the flood prone interfluves. Regional ecosystem 4.3.3 is predominant, but small areas of 4.3.14 and 4.9.1 are also present.	10

Land unit	Description	Land Management Unit
AV1	Hill slope. Shallow and moderately deep soils with gradational-texture profiles and red clay subsoils. Also, shallow uniform sands and deeper texture-contrast soils. Mid-tall woodlands of White's ironbark with isolated applejack and ghost gum, and a diverse range of shrub species. Regional ecosystem 10.5.11.	9
AV2	Plain. A sandsheet, with uniform sandy soils of variable depth and minimal profile development, overlies a cemented hardpan. Sparse mid-tall woodlands of ghost gum, desert bloodwood, applejack and White's ironbark. Regional ecosystem 10.5.2.	8
AV3	Drainage depression and creek bed. Variable soils and exposures of a mottled hardpan. River red gum and Reid River box are dominant, but coolabah and ghost gum are not uncommon. Regional ecosystems 10.3.6 and 10.3.14 are co-dominant.	10
AV4	Plain. Eroded areas are often saline and devoid of vegetation - salt tolerant species may be present. Where sandy loam topsoils remain, sparse woodlands of blackwood, mimosa, false sandalwood, bauhinia and leopardwood occur. Regional ecosystems 10.3.14, 10.3.16 and 10.3.25 are co-dominant, but small areas of the underlying 10.9.1 are also present.	11
BA1	Plain. Very deep, brown, cracking-clay soils with self-mulching topsoils. Open tussock grasslands of Mitchell grass and bluegrass. Regional ecosystem 10.4.8 is predominant.	12
BA2	Levee. Elongated low sandy ridges with uniform sands and texture-contrast soils. Mid-tall woodlands of ghost gum, large-fruited bloodwood and White's ironbark. Regional ecosystem 10.3.9 is predominant.	8
BA3	Plain. A complex area of uniform sands and texture-contrast soils, and brown, cracking-clay soils with self-mulching topsoils. Mid-tall woodlands of ghost gum, large-fruited bloodwood and White's ironbark alternate with open tussock grasslands of Mitchell grass and bluegrass. Regional ecosystems 10.3.9 and 10.4.8 are co-dominant.	12
BA4	Streambed and adjacent levee. Tall woodlands river red gum and coolabah, on young sandy alluvium. Regional ecosystem 10.3.13 is predominant.	10
BB1	Alluvial fan, upper slopes. Texture-contrast profiles with yellow subsoils predominate, with minor occurrences of uniform sandy profiles. An ironstone hardpan occurs within 1m of the surface. Mid-tall woodlands of silver-leaved ironbark. Isolated large-fruited bloodwood identifies with the sandier soils. Regional ecosystem 10.5.5 is predominant.	8
BB2	Alluvial fan, mid slopes. A complex unit of very deep red gradational soils and brown cracking-clay soils. Tall woodlands of silver-leaved ironbark with a diverse layer of shrubs and grasses, and dense woodlands of brigalow. Regional ecosystem 10.5.5 is predominant, but significant areas of 10.4.3 are also present.	8
BB3	Alluvial fan, lower slopes. Young, uniform sandy profiles with minimal profile development. Tall woodlands of large-fruited bloodwood, Clarkson's bloodwood and ghost gum. Black spear grass and wiregrass are the major ground-cover species. Regional ecosystem 10.5.2 is predominant, but small areas of 10.3.12 are also present.	8
BB4	Streambed, levees and interfluves. Young, uniform sandy profiles, often overlying a heavy clay layer within 2m of the surface. Tall woodlands of river red gum intermix with mid-high woodlands of coolabah and brigalow, in varying proportions. Regional ecosystems 10.3.3 and 10.3.14 are co-dominant.	10
BC1	Alluvial terrace. Reddish-brown texture-contrast soils profiles with occasional uniform sandy soils. Tall woodlands of White's ironbark. Regional ecosystem 10.3.9 is predominant.	8

Land unit	Description	Land Management Unit
BC2	Scroll plain. A complex area of sandy ridges, depressions and drainage lines. Reddish brown texture-contrast profiles with sodic subsoils. A tall sparse woodland of White's ironbark, ghost gum and Reid river box that vary in proportion depending on soil type and site drainage. Regional ecosystems 10.3.6 and 10.3.9 are co-dominant.	8
BC3	Drainage depressions. The streambed and major tributaries of Bullock Creek. River red gum occurs on the riverbanks and Reid River box is common in the minor drainage depressions and low-lying areas. Regional ecosystem 10.3.6 and 10.3.14 are co-dominant.	10
BD1	Plain, plateau margin. Shallow, gravelly soils with red gradational-texture profiles of variable soil depth and surface texture. An ironstone hardpan may be exposed. Sparse woodlands of Normanton box and Reid River box, with bush house paperbark and a ground layer of gummy spinifex. Regional ecosystem 10.7.2 is predominant, but small areas of 10.5.5 are also present.	1
BD2	Scarp. Steep slopes with stony gradational and texture-contrast profiles overlying an ironstone hardpan at variable depths. Subsoils may be sodic or acidic. Dense woodlands of lancewood and bendee, with occasional ghost gum or napunyah. A sparse ground cover includes spinifex, kangaroo grass and wiregrass. Regional ecosystem 10.7.3 is predominant, but small areas of 10.5.5 and 10.10.1 are also present.	1
BD3	Footslopes. A complex unit with a mixture of soil types. Shallow red gradational profiles, deep texture-contrast profiles with sodic clay subsoils, and deep uniform sandy profiles. Tall woodlands of silver-leaved ironbark intermixed with some Queensland yellow jacket, Normanton box, napunyah, Reid River box or river red gum on different soil types within the unit. Regional ecosystems 10.7.2 and 10.7.11 are predominant, but small areas of 10.3.6 and 10.3.14 are also present.	1
BD4	Alluvial fan. Moderately deep, uniform loamy sand soils overlie a buried clay soil. Tall woodlands of desert bloodwood and Reid River box. A diverse shrub layer overlaps with the vegetation of adjacent creeks. Regional ecosystems 10.3.6 and 10.3.10 are co-dominant.	8
BD5	Drainage depressions. Young, sandy uniform profiles of variable depth. Tall woodlands of river red gum and Reid River box with a diverse shrub layer. Regional ecosystem 10.3.6 and 10.3.14 are co-dominant.	10
BE1	Alluvial fan, upper slope. Brown gradational soils and yellowish-brown texture contrast soils with sodic subsoils. Tall open woodlands of silver-leaved ironbark with desert oak, yellow berry bush and currant bush in the understorey, and wiregrass and buck spinifex as ground cover. Regional ecosystem 10.5.5 is predominant.	8
BE2	Alluvial fan, young deposits. Deep, uniform sandy profiles. Diverse tall open woodlands include silver-leaved x White's ironbark, ghost gum, long-fruited bloodwood and rustyjacket, in varying proportions. Regional ecosystem 10.3.10 and 10.3.28 are co-dominant.	8
BE3	Alluvial fan, lower slopes. Deep, texture-contrast soils with thick sandy loam topsoils overlie yellowish brown sodic clays. Tall woodlands of ghost gum, Reid River box and long-fruited bloodwoods with a sparse shrub layer of desert oak, beefwood, woodland paperbark and currant bush, and a ground layer of spinifex. Regional ecosystem 10.3.6 and 10.3.10 are co-dominant.	6
BE4	Drainage depression. Yellowish-brown mottled, sodic texture-contrast soils with thick fine sandy loam topsoils predominate. Tall woodlands of Reid River box are dominant with an understorey of false sandalwood, currant bush, spinifex and wiregrass. Regional ecosystem 10.3.6 is dominant.	6

Land unit	Description	Land Management Unit
BF1	Terrace flats. Sandy reddish-brown gradational-textured profiles and texture-contrast profiles. Isolated trees indicate the original vegetation was tall woodland of silver-leaved ironbark with Reid River box in occasional low-lying areas. Regional ecosystem 10.5.5 is predominant, but small areas of 10.3.6 are also present.	8
BF2	Plain. Grey, self-mulching, uniform cracking-clay soils. Mid-high woodlands of blackbutt, together with brigalow and an understory of false sandalwood, desert bluegrass and silky browntop. Regional ecosystem 10.4.3 is predominant.	12
BF3	Lake. The soil profile is saturated for at least 2-3 months in most years. During dry periods, areas normally inundated with water are devoid of vegetation except for a sparse ground cover of green couch, spreading sneezeweed hairy nardoo. River red gum is common around the shoreline. Regional ecosystem 10.3.15 is predominant.	14
BF4	Drainage depression. Variable soils. Brigalow, whitewood, false sandalwood, Reid River box and bauhinia may be present. Regional ecosystem 10.3.14 is predominant.	6
BG1	Alluvial fan, upper slope. Deep, uniform-textured sandy soils. Tall woodlands of bloodwood and ironbark. Regional ecosystem 10.5.11 is predominant, but small areas of 10.3.6 are also present.	8
BG2	Alluvial fan, lower slopes. Reddish-brown, sandy, texture-contrast soils, underlain by ironstone hardpan or heavy clay. Mid-tall woodlands of White's ironbark and desert bloodwood. Regional ecosystem 10.5.11 is predominant, but small areas of 10.9.1 are also present.	8
BG3	Drainage depressions. Variable soils. Tall woodlands of river red gum and Reid River box with occasional blackwood. Regional ecosystems 10.3.6 and 10.3.14 are co-dominant, but small areas of 10.9.1 are also present.	10
BH1	Undulating plain. Open woodlands of silver-leaved ironbark, with varying proportions of ghost gum, Clarkson's bloodwood, wattle, black spear grass and wiregrass. Yellow texture-contrast soils with some red gradational soils and uniform sandy soils. An ironstone hardpan occurs at depth. Regional ecosystem 11.5.3 is predominant.	9
BH2	Depressions and lower slopes. Very deep, brown, uniform clays and texture-contrast profiles with sodic subsoils. Open woodlands of gidgee and brigalow with Reid River box around the margins. Regional ecosystem 11.4.8 is predominant.	12
BK1	Scroll plain. Very deep, brown, silty loam gradational-textured soils. Tall woodlands of Moreton Bay ash and narrow-leaved ironbark with an understory of currant bush, Queensland bluegrass, buffel grass and sabi grass. Regional ecosystem 9.3.3 is predominant.	10
BK2	Streambed and levee. Uniform sandy soils. Tall woodlands of river red gum and broad-leaved tea-tree. Regional ecosystems 9.3.1 and 9.3.12 are co-dominant.	10
BL1	Plateau remnant (mesas) and steep scarp. Very shallow gravelly soils with exposures of an ironstone hardpan. Proportions of Normanton box, bush house paperbark and lancewood vary according to the soil depth. Regional ecosystems 10.7.2 and 10.7.3 are co-dominant.	1
BL2	Footslope. Shallow, gravelly soils with texture-contrast profiles overlie a mottled hardpan. Sparse mid-high woodlands of Normanton box with some mulga and a ground cover of spinifex. Regional ecosystem 10.7.4 is predominant.	1

Land unit	Description	Land Management Unit
BL3	Undulating plain. Shallow texture-contrast profiles with red sandy clay subsoils overlie a hardpan. Desert bloodwood and White's ironbark are accompanied by a vigorous mid strata of acacias and grevilleas; the ground layer is dominated by spinifex, wiregrass and bluegrass. Regional ecosystem 10.7.10 is predominant.	1
BL4	Alluvial fan. Deep, texture-contrast profiles with brown clay subsoils. Diverse open woodland of dead finish, false sandalwood, White's ironbark, gidgee, spinifex, wiregrass and bluegrass, in varying proportions. Regional ecosystem 10.5.11 is predominant, but significant areas of 10.9.6 are also present.	8
BL5	Drainage depression and levee. Variable sols. Open woodlands of river red gum and coolabah. Regional ecosystem 10.3.14 is predominant.	10
BN1	Crests and steep slopes. Sites with detailed information on the soils and vegetation are not available. Regional ecosystem 9.12.5 is predominant, but small areas of 9.12.24 are also present.	1
BN2	Plain - limited area. Grey texture-contrast soil profiles with a bleached A2 horizon, slow permeability and imperfect drainage. Open forests of Leichhardt's rustyjacket and square-fruited ironbark. Regional ecosystems 9.12.4 and 9.12.5 are co-dominant.	9
BN3	Scarp. Ironstone capping and steeply dissected areas of deeply weathered parent material. Sites with detailed soil and vegetation information are not available. Regional ecosystem 10.5.4 is predominant, but significant areas of 10.7.3 and small areas of 10.3.14 are also present.	1
BN4	Hillslope. Moderately deep sandy uniform-textured and reddish-brown gradational-textured soil profiles. Mid-high woodlands of narrow-leaved ironbark with common occurrences of long-fruited bloodwood and gum-topped bloodwood. Sub-strata species include golden beard grass, quinine tree and black spear grass. Broad-leaved tea-tree and river red gum line the very narrow creek beds. Regional ecosystems 9.12.5 and 9.12.24 are co-dominant.	9
BN5	Lower slope. Very deep yellowish brown texture-contrast soils. A silica-rich hardpan occurs at depth. Mid-high woodlands of narrow-leaved ironbark with varying proportions of Reid River box, ghost gum, variable-barked bloodwood, poplar gum and long-fruited bloodwood. Regional ecosystem 9.12.1 is predominant, but significant areas of 10.5.4 and small areas of 9.3.5 are also present.	9
BN6	Alluvial fan. Reddish-brown gradational-textured soil profiles are predominant. Tall woodlands of narrow-leaved ironbark predominate with variable proportions of long-fruited bloodwood and silver-leaved ironbark. Reid River box is common in poorly drained areas. Regional ecosystem 10.5.5 is predominant, but small areas of 10.3.28 are also present.	8
BN7	Stream bed and levee. Highly permeable grey gradational-textured soil profiles. Mid-high open forests of poplar gum and long-fruited bloodwood. Areas of slow permeability support mid-high woodlands of narrow-leaved ironbark, ghost gum, Moreton Bay ash and an occasional river red gum or broad-leaved tea-tree. Regional ecosystems 9.3.6 and 9.3.13 are co-dominant.	10
BR1	Backplain. Brown and grey, uniform cracking-clay soils with thin self-mulching topsoils and sodic subsoils. Mid-high woodlands of brigalow with coolabah preferring the lighter, silty clays. Blackbutt, eurah and false sandalwood are common. Regional ecosystem 11.4.8 is predominant, but small areas of 11.3.1, 11.3.3 and 11.3.25 are also present.	12
BR2	Alluvial terrace. Very deep red gradational soils with sandy loam topsoils and light clay subsoils. Tall woodlands of silver-leaved ironbark with desert oak, black spear grass and wire grass. Regional ecosystem 11.3.6 is predominant.	10

Land unit	Description	Land Management Unit
BR3	Current flood plain. Deep, uniform sandy soils with minimal profile development. Vegetation is diverse and variable with mid-tall woodlands of forest red gum, bloodwood and coolabah most common, and a ground cover of forest bluegrass. Regional ecosystem 11.3.4 is predominant.	10
BR4	Streambed and levee. Young sandy deposits with little, or no, profile development. Tall closed woodlands of river red gum and coolabah, with some brigalow where heavy clay soils occur. Regional ecosystem 11.3.25 is predominant.	10
BT1	Plain. Remnants of an old plain with reddish-brown texture-contrast soil profiles. A hardpan occurs below one metre depth. Mid-high open woodlands of narrow-leaved ironbark and variable-barked bloodwood. Regional ecosystem 10.5.4 is predominant.	9
BT2	Plateau margin. Shallow red or brown texture-contrast profiles overlie a ferricrete hardpan at less than 0.5m deep. Sparse mid-high woodlands of applejack, whitewood and native bauhinia. Regional ecosystem 10.7.10 is predominant.	1
BT3	Scarp. A steeply dissected landscape with exposed ferricrete and soils containing abundant ironstone gravel. Shallow gradational-textured soil profiles. Open forests of lancewood and bendee with small areas of Normanton box. Regional ecosystem 10.7.3 is predominant.	1
BT4	Lower slopes and drainage depressions. Brown and yellow gradational-textured profiles and yellow texture-contrast profiles with sodic subsoils. Woodlands of narrow-leaved ironbark and Reid River box, with river red gum, broad-leaved tea-tree and pandanus along the creek beds. Regional ecosystem 11.5.12 predominates, but small areas of 11.3.25 are also present.	10
CA1	Plains, dissected. Brown gradational-textured soil profiles with colour variations in the subsoil according to local drainage characteristics. Mid-high woodlands of narrow-leaved ironbark and silver-leaved ironbark with some ghost gum. Reid River box in the slight depressions and narrow creek lines. Regional ecosystem 10.5.5 is predominant.	9
CA2	Plain. Yellowish-brown gradational-textured soil profiles with grey, sodic, texture-contrast soil in small depressions. Tall open woodlands of silver-leaved ironbark, ghost gum and long-fruited bloodwood with Reid River box in the narrow drainage depressions and poorly drained areas. Regional ecosystem 10.5.5 is predominant, but small areas of 10.3.6 and 10.5.4 are also present.	9
CA3	Plain. A complex of soils and vegetation communities. Sandy gradational-textured profiles support tall woodlands of silver-leaved ironbark, narrow-leaved ironbark, gum-topped bloodwood, ghost gum and long-fruited bloodwood, whereas uniform cracking-clay soils associate with mid-high woodlands of gidgee, brigalow, blackwood and blackbutt. Regional ecosystems 10.5.5 is dominant, but significant areas of 10.4.3 and 10.4.4 are also present.	9
CA4	Plain. Low-lying areas, with poor drainage, slow permeability and grey uniform, cracking clay soils or texture-contrast profiles with brown, sodic subsoils. Mid-high open forests of gidgee with some brigalow and blackwood. Regional ecosystem 10.4.5 is predominant.	12
CA5	Stream bed and levee. Variable soils. Tall woodlands of Reid River box with random occurrences of silver-leaved ironbark or brigalow, depending on the soil type and location along some of the extended drainage depressions. Regional ecosystems 10.3.6 and 10.3.13 are co-dominant, but small areas of 10.4.4 are also present.	6

Land unit	Description	Land Management Unit
CC1	Closed depressions. Very deep, uniform-textured cracking-clay soil profiles with self-mulching topsoils. Mid-high woodlands of blackbutt with brigalow or blackwood. Regional ecosystem 11.4.8 is predominant.	14
CC2	Plain. Very deep, red, gradational-textured soil profiles with some uniform sandy and texture-contrast soils. Tall mixed woodlands of silver-leaved ironbark, poplar box, ghost gum and white cypress pine. Regional ecosystem 11.5.3 is predominant.	8
CC3	Sand plain. A complex area with predominantly young sandy soils interspersed with clayey soil profiles. Tall woodlands of ironbark, poplar box and bloodwoods alternate at random with areas of brigalow, Moreton Bay ash and river red gum. Regional ecosystem 11.5.3 is predominant, but areas of 11.4.8 are also present.	8
CC4	Streambed and levee. Uniform sandy soil profiles. Very tall open woodlands of Clarkson's bloodwood and Moreton Bay ash. Regional ecosystem 11.3.7 is predominant.	10
CE1	Plain, plateau margin. Shallow, uniform, gravely, sandy loams overlie an ironstone hardpan, often exposed. Tall, dense heathlands of slender wattle, fringe myrtle, desert tea-tree and dogwood with a ground layer of gummy spinifex. Regional ecosystem 10.7.7 is predominant.	1
CE2	Scarp. Steep slopes and cliffs of massive ironstone. Reddish-brown gradational soils, shallow and rocky. Dense woodlands of lancewood with occasional narrow-leaved ironbark, napunyah and rusty jacket. Gummy spinifex is the predominant grass species. Regional ecosystem 10.7.3 is predominant, but significant areas of 10.10.4 are also present.	1
CE3	Steep slopes. Shallow gradational soils and exposed sandstone bedrock. Lancewood and narrow-leaved ironbark predominate with scattered bloodwoods, but relative proportions vary according to soil depth. Regional ecosystems 10.10.1, 10.10.3, 10.10.4 and 10.10.5 are all present, to a greater or lesser degree.	1
CE4	Lower slope. Deep reddish-brown gradational and texture-contrast profiles, together with some uniform clay soils. Tall woodlands of silver-leaved ironbark and poplar box, and mid-high woodlands of brigalow. Regional ecosystem 10.5.5 is predominant, but significant areas of 10.10.4 and 10.9.3 are also present.	9
CE5	Drainage depression and alluvial terrace. Fine sandy and silty loam textures in deep, uniform and gradational soil profiles. Tall river red gum along the stream banks and tall mid-dense forests of silver-leaved ironbark and poplar box on adjacent alluvial terraces. Regional ecosystems 10.3.14, 10.3.27 and 10.3.28 are co-dominant.	6
CM1	Crests and steep slopes. Very shallow sandy loams on weathered bedrock. Mid-high woodlands of narrow-leaved ironbark and Reid River box, together with some broad-leaved rustyjacket. Common groundcover species include currant bush, bluegrass, black spear grass and silky oilgrass. Regional ecosystem 9.11.17 is predominant.	1
CM2	Hillslope, mid-slope. Shallow red and brown texture-contrast soil profiles. Mid-high woodlands of narrow-leaved ironbark and Reid River box, with Shirley's silver-leaved ironbark and occasional poplar gum, square-fruited ironbark and brigalow. Regional ecosystem 9.11.17 is predominant, but areas of 10.5.12 are common.	1

Land unit	Description	Land Management Unit
CM3	Scarp. Steeply dissected land, with exposed ferricrete. Shallow, gradational-textured soil profiles containing ironstone gravel. Mid-high open forests of bendee on the steep slopes, and low open mallee woodlands of Normanton box on the moderately deep soils of plateau remnants. Regional ecosystem 10.7.3 is predominant.	1
CM4	Lower slope. Deep, red gradational-textured profiles and brown texture-contrast profiles. Tall woodlands of narrow-leaved ironbark and Reid River box with some ghost gum and bauhinia. Small areas of brown or grey texture-contrast profiles with sodic subsoils support mid-high woodlands of brigalow, gidgee or blackwood. Regional ecosystem 10.5.4 is predominant, but areas of 9.11.17 are common.	9
CM5	Lower slope. Brown uniform-textured, cracking-clay soils and texture-contrast profiles with sodic subsoils. Mid-high woodlands of brigalow with emergents of blackbutt and Reid River box. Regional ecosystems 10.4.1 and 10.4.3 are co-dominant.	12
CM6	Alluvial fan. Brown texture-contrast soil profiles. Mid-high woodlands of narrow-leaved ironbark with current bush, pitted bluegrass and Eragrostis species as the major ground-cover species. Regional ecosystem 10.5.4 is predominant, but small areas of 10.3.6 are also present.	8
CM7	Drainage depression and alluvial terrace. Variable soils. Reid River box, false sandalwood and bauhinia are most common, whereas river red gum, Moreton Bay ash and broad-leaved tea-tree occur at random. Regional ecosystems 10.3.6 and 10.3.13 are co-dominant.	6
CO1	Plateau margin. Shallow, sandy, gradational soils with abundant ironstone gravel. A ferricrete hardpan is often exposed. A diverse shrubland of wattles, melaleucas and isolated occurrences of Normanton box, ghost gum and bloodwood. Regional ecosystems 10.7.2 and 10.7.7 are co-dominant, but small areas of 10.5.2 and 10.5.10 are also present.	1
CO2	Scarp. Shallow, reddish-brown gradational soil profiles. Ferricrete or pallid zone is often exposed. Mid-tall open forests of lancewood and bendee with occasional blackbutt, napunyah and poplar box on the lower slopes. Regional ecosystem 10.7.3 is predominant, but significant areas of 10.10.1 and 11.10.3 are also present.	1
CO3	Footslope. Deep, red-brown, texture contrast soils with sodic clay subsoils. Mid-tall open woodlands of silver-leaved ironbark and poplar box, and some lancewood-bendee. Regional ecosystem 10.5.5 is predominant, but smallareas of 10.7.3 are also present.	9
CO4	Alluvial fan. Very deep uniform sandy soils with weak horizon development. Tall open woodlands of large-fruited bloodwood and silver-leaved ironbark, with some poplar box, ghost gum and Moreton Bay ash, mostly replaced with buffel grass. Regional ecosystem 10.5.11 is predominant, but areas of 10.3.12 are also present.	8
CO5	Drainage depression. Variable soils, with deep uniform sands most common. Tall open woodlands of silver-leaved ironbark, poplar box, Moreton Bay ash and white cypress pine. River red gum on the stream banks and some brigalow on small areas of heavy clays. Regional ecosystems 10.3.12 and 10.3.14 are co-dominant.	10
CP1	Gently undulating plain. Very deep, uniform non-cracking clay soils. Tall woodlands of White's ironbark, fine-leaved ironbark, variable-barked bloodwood and an occasional ghost gum. Regional ecosystem 9.8.1 (to be revised) is predominant, but small areas of 10.5.11 are also present.	12

Land unit	Description	Land Management Unit
CP2	Scarp. Steep slopes. Shallow, brown, uniform, friable clay soils with numerous basalt rocks and exposed bedrock. Low woodlands of gidgee, ampwey and sandalwood, with river red gum and river tea-tree in the bottom of the gorges. Regional ecosystems 9.8.1 (to be revised) and 9.8.6 are co-dominant.	1
CP3	Gently undulating plain. Shallow sandy soils with exposures of basalt. Low sparse woodlands of White's ironbark and a large range of wattles. Regional ecosystem 10.5.11 is predominant, but small areas of 9.8.1 (to be revised) are also present.	8
CP4	Plain. Open grassland of bluegrass and wire grass with occasional mimosa bushes. Deep, black, cracking-clay soils. Regional ecosystem 9.8.5 is predominant.	12
CP5	Footslope. Deep, friable uniform or gradational clayey soils. Low, mixed woodlands of gidgee, whitewood, leopardwood and sandalwood. Regional ecosystem 4.9.7 (to be revised) is predominant.	11
CR1	Upper terrace. Very deep gradational soil profiles with yellow, mottled subsoils. Mid-high woodlands of silver-leaved ironbark with some Reid River box and isolated ghost gum. Regional ecosystem 10.5.5 is predominant, but small areas of 10.3.6 are also present.	8
CR2	Backplain. Prone to inundation for considerable periods of time. Deep, brown uniform-textured clay soils and texture-contrast profiles with sodic subsoils. Tall woodlands of Reid River box with some open woodlands of coolabah, gidgee and Moreton Bay ash. Regional ecosystems 10.3.6 and 10.3.14 are co-dominant, but small areas of 10.4.4 are also present.	14
CR3	Scroll plain. Variable soils; brown texture-contrast profiles, with sodic and non-sodic subsoils and uniform sandy soils. Tall open woodlands of silver-leaved ironbark, Reid River box and ghost gum with some long-fruited bloodwood. Regional ecosystems 10.3.6 and 10.3.12 are co-dominant.	10
CR4	Valley flat. Low-lying areas are prone to salinisation. Brown and grey uniform cracking-clay soils as well as texture-contrast profiles with sodic subsoils. Gidgee, brigalow and blackbutt, in variable proportions, with some Reid River box and bauhinia. Regional ecosystems 10.4.3 and 10.4.5 are predominant, but significant areas of 10.3.6 are also present.	12
CR5	Streambed and levee. Uniform sandy profiles with weak horizonation. Mixed tall woodlands of Reid River box, long-fruited bloodwood and ghost gum. Moreton Bay ash, river red gum and broad-leaved tea-tree. Poplar gum and pandanus are often present in the northern parts of the land system. Regional ecosystems 10.3.6, 10.3.12 and 10.3.13 are co-dominant.	10
DA1	Alluvial fan, upper slope. Moderately deep, texture-contrast soil profiles with sandy loam topsoils over reddish-brown sandy clay subsoils. Open woodlands of silver-leaved ironbark and poplar box. A hardpan is usually present below 0.5m depth. Regional ecosystems 10.5.5 and 10.5.12 are co-dominant.	8
DA2	Alluvial fan, lower slopes. Deep, reddish-brown, texture-contrast soil profiles overlie a hardpan at approximately 1.5m depth. Mid-tall open woodlands of silver-leaved ironbark and poplar box, together with bloodwood, ironwood, white cypress pine. Regional ecosystems 10.3.27 and 10.3.28 are predominant.	8
DA3	Drainage depression. Variable soils with very deep, reddish-brown gradational profiles most common. A complex of vegetation communities ranging from open woodlands of poplar box to woodlands of silver-leaved ironbark and bloodwood, all with a diverse range of understorey species. Regional ecosystems 10.3.27 and 10.3.28 are co-dominant.	6

Land unit	Description	Land Management Unit
DE1	Undulating plain. Moderately deep, brown, uniform clay soils. Mid-tall woodlands of gidgee and boree with Mitchell grass as a ground cover. Regional ecosystems 4.9.1, 4.9.7 and 4.9.11 are co-dominant.	11
DE2	Gently undulating plain. Open grasslands of Mitchell grass on deep, grey cracking-clay soils. Regional ecosystem 4.9.1 is predominant.	13
DE3	Drainage depressions. Very deep, uniform, grey clay soils with some deep uniform sand deposits. Low, sparse woodlands of river red gum and coolabah, with some boree, gidgee and mimosa bush. Regional ecosystems 4.3.3 and 4.3.14 are co-dominant.	10
DR1	Level plain in close proximity to an escarpment. Shallow, gravely soils, with an ironstone hardpan often exposed. White's ironbark and yellow-branched ironbark on the slightly deeper profiles and bush-house paperbark with gummy spinifex on the very shallow soils. Regional ecosystem 10.7.10 is predominant, but small areas of 10.7.7 are also present.	1
DR2	Scarp. Shallow, stony, gradational soils support a mid-tall forest of lancewood. Regional ecosystem 10.7.3 is predominant, but significant areas of 10.10.1 are also present.	1
DR3	Footslope. Normanton box on the upper slopes with shallow, gravely, gradational soils over a hardpan. White's ironbark on the deeper, texture-contrast soils of the lower slopes. Reid River box and spinifex are common throughout. Regional ecosystem 10.7.4 is predominant, but small areas of 10.5.11 are also present.	1
DR4	Alluvial fan. Tall sparse woodlands of White's ironbark together with Reid River box and a diverse range of shrub species. Moderately deep, yellow, texture-contrast soils with deep sandy loam topsoils and a hardpan at approximately one metre deep. Regional ecosystem 10.5.11 is predominant.	8
DR5	Stream bed and levee. Very deep uniform sandy soils. Tall, sparse forests of river red gum, with swamp box and golden parrot tree often present, and an occasional rusty jacket. Regional ecosystem 10.3.14 is dominant.	10
DS1	Gently undulating sand plain. Very deep, texture-contrast profiles with thick loamy sand topsoils over red, clay loam subsoils. Tall sparse woodlands of silver-leaved ironbark and ghost gum with some large-fruited bloodwood and poplar box. Regional ecosystem 10.5.5 is predominant.	8
DS2	Plain, transition zone. Texture-contrast soils with tall open woodlands of poplar box and false sandalwood alternate with uniform, cracking-clay soils supporting mid dense forests of gidgee. Regional ecosystem 10.9.6 is predominant, but significant areas of 10.5.12 are also present.	11
DS3	Level clay plain. Very deep uniform cracking-clay soils with a gilgaied surface micro relief. Mid-tall, mid-dense open forests of gidgee. Regional ecosystem 10.9.6 is predominant.	11
DS4	Drainage depression and levee. Soils vary from uniform clays to young deposits of sandy loams and sandy clay loams. River red gum and coolabah predominate with some mixing of gidgee, false sandalwood and mimosa from the adjacent plains. Regional ecosystem 10.3.14 is predominant, but small areas of 10.9.6 are also present.	10
DT1	Gently undulating plain on a deep sandsheet. Very deep, red sandy soils with gradational and texture-contrast profiles. Mid-tall woodlands of Queensland yellowjacket, Clarkson's bloodwood and applejack, with a pasture dominated by gummy spinifex. Regional ecosystem 10.5.1 is predominant.	3

Land unit	Description	Land Management Unit
DT2	Gently undulating plain. Shallow gradational soil profiles and uniform, sandy soil profiles. Low, sparse woodlands of White's ironbark and applejack with a diverse shrub layer dominated by wattles and grevilleas. Regional ecosystem 10.7.11 is predominant, but small areas of the deeper sandsheet 10.5.1 are also present.	9
DT3	Broad drainage depressions. Dark loamy topsoils on red gradational-textured sandy profiles. Tall closed woodlands of rusty jacket, silver-leaved ironbark, ghost gum and large fruited bloodwood, with a diverse shrub layer. Regional ecosystem 10.5.1 is predominant.	3
DT4	Lakebeds. Small areas, of limited distribution, receive and hold water for several months after a good wet season. Reid River box and coolabah are common on the lakebed while river red gum predominates around the sandy perimeter. Regional ecosystem 10.3.15 is predominant.	14
EN1	Sand ridges. Uniform sand profiles of variable depth overlie a dark sandy clay loam densipan. Giant grey spinifex on the deep sands, with prickly acacia and river red gum common around the margins. Regional ecosystem 10.3.16 is predominant.	4
EN2	Flats. Extensive areas of saline, grey texture-contrast soils, usually devoid of vegetation and scalded by wind erosion, contrast with numerous localised areas watered by natural fresh-water springs, which support black tea tree, sedges, swamp foxtail, water couch and bladderworts. Regional ecosystem 10.3.16 is predominant.	4
EN3	Saline playa. Vegetation is limited to a few hardy salt-tolerant samphires on the blue-grey silty clay soils of the lakebed. Regional ecosystem 10.3.24 is predominant.	15
FR1	Alluvial terrace. Deep silty loam topsoils over sandy alluvium. Low open woodlands of bauhinia, false sandalwood and White's ironbark. Regional ecosystem 4.3.6 (to be revised) is predominant.	8
FR2	Stream bed and levee. Very deep, dark brown, texture-contrast soils with deep sandy soils on the levees. Tall woodlands of river red gum along the riverbanks, with isolated ghost gum, desert bloodwood, corkwood wattle on the flood plain. Regional ecosystem 4.3.2 is predominant.	10
GK1	Hillcrest and upper slope. Shallow to very shallow gradational soil profiles overlying an ironstone hardpan. Open woodlands of White's ironbark with occasional Reid River box, ghost gum or applejack. A diverse shrub layer and a spinifex-wire grass ground cover. Regional ecosystem 10.7.10 is predominant.	1
GK2	Scarp. Very shallow, reddish-brown, gravely, gradational soil profiles with scattered rocks, boulders and exposures of ferricrete. Mid-tall, dense woodlands of lancewood with a sparse spinifex ground cover. Regional ecosystem 10.7.3 is predominant.	1
GK3	Plain. Very deep, red sandy texture-contrast soils. Mid-tall, sparse woodlands of applejack with wattles and gummy spinifex. Regional ecosystem 10.5.1 is predominant.	3
GK4	Plain, lower slope. Moderately deep, red-brown gradational soil profiles with gravely clay loam, hard-setting topsoils. An ironstone hardpan occurs at a depth of approximately one metre. Mid-tall open woodlands of White's ironbark. Regional ecosystem 10.5.11 is predominant, but areas of 10.7.10 are common.	9
GK5	Drainage depression and backplain. Deep, uniform grey, cracking-clay soils with weakly, self-mulching topsoils. Tall woodlands of blackwood or gidgee. Regional ecosystems 10.3.1 and 10.3.4 are co-dominant.	12

Land unit	Description	Land Management Unit
GS1	Plain. Slightly elevated areas a gently undulating clay plain. Grey, uniform cracking-clay, with brown and red variants appearing in areas that have slightly better drainage. Remnant stands of brigalow and gidgee with some Reid River box and an occasional blackbutt. Regional ecosystem 9.3.9 is predominant.	12
GS2	Plain, gentle slope. Very deep, brown and grey texture-contrast profiles with sodic subsoils. Tall woodlands of narrow-leaved ironbark with isolated occurrences of Reid River box, ghost gum and gidgee. Regional ecosystem 9.5.3 is predominant.	9
GS3	Drainage depression. The soils are extremely variable in depth and texture, although texture-contrast profiles with mottled, sodic subsoils are most common. Tall woodlands of river red gum and broad-leaved tea-tree with some gum-topped bloodwood, poplar gum, bauhinia and pandanus. Regional ecosystem 10.3.13 is predominant.	10
GT1	Plain. Very deep, red, sandy uniform and gradational-textured profiles. Mid-tall woodlands of yellowjacket and gum-topped bloodwood with a diverse shrub layer of wattles, grevilleas, cassias and hakeas, with a ground layer dominated by gummy spinifex. Regional ecosystem 10.5.1 is predominant.	3
GT2	Plain, gentle slope. Shallow to moderately deep, red-brown gradational soil profiles, often gravely overlie a hardpan. Mid-tall woodlands of silver-leaved ironbark with occasional ghost gum and applejack. Minor areas of heathland on shallow soils. Gummy spinifex dominates the ground layer. Regional ecosystem 10.7.11 is predominant, but areas of 10.5.5 are common.	9
GT3	Drainage depression. Deep, red sandy gradational soils profiles with a high organic matter content in the topsoils. Tall, closed woodlands of ghost gum and bloodwoods, including rusty jacket, and a diverse range of plant species in the understorey. Regional ecosystem 10.5.1 is predominant.	3
GT4	Alluvial fan. Very deep, pale red, sandy uniform-textured soil profiles. Tall woodlands of ghost gum, rusty jacket, other bloodwoods and yellowjacket. Regional ecosystem 10.5.1 is predominant.	3
JC1	Upper terrace. Deep, sandy, reddish-brown, gradational and texture-contrast soils. Tall woodlands of poplar box with Moreton Bay ash, ironwood and wilga. Regional ecosystem 10.5.12 is predominant.	8
JC2	Backplains. Very deep, grey, uniform cracking-clay soils. Mid-dense forests of gidgee and brigalow with false sandalwood. Regional ecosystem 10.4.5 is predominant.	12
JC3	Alluvial plain. A complex of very deep soils on sand plains and clayey depressions. Tall sparse woodlands of silver-leaved ironbark, poplar box, bloodwoods and beefwood communities alternate with gidgee-brigalow dense woodlands. Regional ecosystem 10.4.5 is predominant, but significant areas of 10.5.5 are also present.	12
JC4	Streambed and levees. Very deep, texture-contrast soils with sodic, calcareous, clay subsoils. Tall woodlands of poplar box, bloodwoods and bauhinia, with river red gum along the stream channels. Regional ecosystems 10.3.14 and 10.3.27 are co-dominant.	10
JJ1	Upper slopes. Deep, red, loamy sand gradational soils. Low open woodlands, often in groves, of yellowjacket with occasional applejack. A diverse shrub layer is common and spinifex dominates the ground cover. Regional ecosystem 10.5.1 is predominant.	3
JJ2	Crests and upper slopes. Shallow, red to yellowish brown texture contrast soils with sandy loam topsoils and an ironstone hardpan within 0.5m of the surface. Mid-tall open woodlands of silver-leaved ironbark with occasional ghost gum and poplar box. Regional ecosystem 10.7.11 is predominant, but significant areas of 10.5.5 are also present.	1

Land unit	Description	Land Management Unit
JJ3	Scarps. Shallow, stony, red-brown gradational soils. An ironstone hardpan is often exposed. Mid-tall forests of lancewood and gummy spinifex provide a sparse ground cover. Regional ecosystem 10.7.3 is predominant.	1
JJ4	Lower slopes. Deep, texture-contrast profiles with sandy loam topsoils and yellowish-brown clayey subsoils. Tall woodlands of silver-leaved ironbark. Regional ecosystem 10.5.5 is predominant.	9
JJ5	Drainage depressions. Texture-contrast profiles with sodic, mottled clay subsoils. A sandy wash layer may be present. Tall woodlands of poplar box, but river red gum is common and brigalow usually occurs on the lower reaches where heavy clay soils appear. Regional ecosystems 10.3.14 and 10.3.27 are predominant.	6
JJ6	Alluvial fans. Very deep, reddish-brown, uniform sandy loams overlie a buried clay soil. Woodlands of silver-leaved ironbark, poplar box and ghost gum. Regional ecosystem 10.5.5 is predominant, but significant areas of 10.3.12 are also present.	8
KN1	Hillslopes. Red texture-contrast profiles of variable soil depth. Mid-high open woodlands of narrow-leaved ironbark and variable-barked bloodwood with common occurrences of long-fruited bloodwood and ghost gum. Regional ecosystem 9.12.1 is predominant.	9
KN2	Plains, level - gently undulating. Deep, reddish-brown texture-contrast profiles, usually with mottled, sodic subsoils. Mid-high woodlands of narrow-leaved ironbark with some Reid River box and an understory of false sandalwood and currant bush. Regional ecosystem 9.12.1 is predominant.	9
KN3	Drainage depressions. The creek beds and adjacent narrow floodplain have young coarse sandy profiles. Tall woodlands of river red gum. Regional ecosystem 9.3.1 is predominant.	10
LB1	Beach ridges. Deep, uniform-textured profiles, with no horizon development, overlie sodic clays, and grey texture-contrast profiles with thick sandy topsoils and high levels of carbonates and soluble salts in the sodic subsoil. Low woodlands of sally wattle, beefwood and coastal boobialla. Regional ecosystem 10.3.17 is predominant.	2
LB2	Plains. Texture-contrast profiles with subsoils that are mottled and sodic, and contain high levels of carbonate and soluble salts. Isolated low trees of ironwood, sally wattle, long-fruited bloodwood, beefwood or bootlace oak. Regional ecosystem 10.3.21 is predominant.	5
LB3	Drainage depressions. Grey, sodic gradational-textured soil profiles containing high levels of salt. Tall open woodlands of blackbutt or Reid River box, false sandalwood and an occasional brigalow. River red gum occurs along the streambanks. Regional ecosystems 10.3.5 and 10.3.14 are co-dominant.	4
LB4	Swales and shorelines. Deep, sodic grey clay soils. A sparse, low groundcover of salt-tolerant plants includes Fimbristylis, Halosarcia, Myoporum, Sida, Suaeda, Sclerolaena, Sporobolus virginicus (marine couch) and Lawrencia buchananensis. Regional ecosystem 10.3.22 is predominant.	5
LB5	Saline playas. These areas are devoid of vegetation because of the high salt content in the silty clay soils, the saturated anaerobic conditions for 2-3 months, or more, per year in most years, and the long periods of inundation by water. Regional ecosystem 10.3.24 is predominant.	15
LC1	Alluvial plains. Reddish brown gradational-textured profiles with minor occurrences of texture-contrast and uniform clay profiles. Very tall sparse woodlands of desert bloodwood with some ghost gum. Some poplar box, Moreton Bay ash and brigalow occur with changes in soil type. Regional ecosystems 10.3.12 and 10.3.27 are co-dominant, but small areas of 10.4.2 are also present.	8

Land unit	Description	Land Management Unit
LC2	Backplains. Brown, uniform cracking-clay soils, with pronounced gilgai micro relief. Tall sparse woodlands of blackbutt with a lower tree storey of brigalow. Regional ecosystem 10.4.3 is predominant.	14
LC3	Drainage depressions. Variable soils. Uniform sandy loam profiles are most common. Tall open woodlands of river red gum with poplar box and desert bloodwood on the adjacent levees and interfluves. Regional ecosystems 10.3.12, 10.3.14 and 10.3.27 are co-dominant.	10
LD1	Lunettes. Deep, uniform, red, loamy sand soil profiles. Tall woodlands of desert bloodwood, ghost gum and silver-leaved ironbark; the latter becomes dominant where thin aeolian deposits overlie the lakebed clays. Regional ecosystem 10.3.20 is predominant.	2
LD2	Plains. Moderately deep, sandy loam gradational soils. Tall woodlands of silver-leaved ironbark and Reid River box. Numerous hollows and drainage depressions, scattered at random throughout, have cracking-clay soils and gidgee. Regional ecosystem 10.5.5 is predominant, but small areas of 10.4.5 are also present.	8
LD3	Clay plains. Uniform cracking-clay soils with self-mulching topsoils and red-brown to grey subsoils - colour variants relate to localised drainage conditions. Gilgai micro-relief is common and quite pronounced. Mid-tall woodlands of gidgee with an occasional blackbutt. Regional ecosystem 10.4.5 is predominant.	12
LD4	Clay plains. Uniform, grey, sodic, cracking-clay soils with massive, hard-setting topsoils and acidic subsoils with a high salt content. Tall forests of blackwood with a ground cover of annual species such as 'rice grass', rare paspalidium and copperburr. Regional ecosystem 10.4.1 is predominant.	14
LD5	Drainage depressions. Variable depths of sandy and silty loams over clayey subsoils. Woodlands of Reid River box with a mixture of river red gum and gidgee. Regional ecosystems 10.3.6 and 10.3.14 are co-dominant, but small areas of 10.5.5 are also present.	6
LD6	Lakebeds. Deep silty clay soils are permanently covered with fresh water. Coolabah and river red gum occupy the shoreline and the wetland areas that become inundated after a good wet season. Regional ecosystem 10.3.15 is predominant.	14
LE1	Plains. A level plain with shallow to very shallow, red gradational and texture-contrast soils overlying an ironstone hardpan of cemented gravels. Mid-tall woodlands of White's ironbark, with a ground cover of spinifex. Regional ecosystem 10.7.10 is predominant.	1
LE2	Plains. A very gently undulating plain with deep texture-contrast soils overlying an ironstone hardpan of cemented gravels. Tall woodlands of White's ironbark and ghost gum with a diverse shrub layer. Regional ecosystem 10.5.11 is predominant.	9
LE3	Plains. Broad shallow depressions and low-lying areas with clayey soils, often grey, cracking-clays. Vegetation varies with location from open grasslands of Mitchell grass and/or native couch grass to woodlands of gidgee, coolabah, eurah and mimosa bush in varying proportions. White's ironbark and Reid River box occur on the fringes. Regional ecosystem 10.3.15 is predominant.	14
LE4	Gentle slopes along the margin of the plain. Shallow, reddish-brown gradational soils overlying an ironstone hardpan. Tall woodlands of White's ironbark, ghost gum and Reid River box, in various proportions depending on location. Regional ecosystem 10.5.11 is predominant.	1

Land unit	Description	Land Management Unit
LE5	Steep slopes, usually adjacent to incised drainage depressions. Very shallow, uniform sandy soils with areas of exposed hardpan. Diverse vegetation with common occurrences of White's ironbark, ghost gum, napunyah and mulga. Regional ecosystem 10.7.4 is predominant, but significant areas of 10.5.11 are also present.	1
LE6	Drainage depressions. Variable soil textures and depth. Mid-tall woodlands of Eucalyptus whitei with an understory of false sandalwood, currant bush and wire grasses. River red gum is common on the banks of the incised streambeds. Regional ecosystem 10.5.11 is predominant, but small areas of 10.3.14 are also present.	6
LG1	Lunettes. Sandy, brown gradational soils with clay loam subsoils. Open woodlands of silver-leaved ironbark with a sparse shrub layer of waxy wattle and a sparse ground cover of buck spinifex and wire grass. Regional ecosystem 10.3.20 is predominant.	2
LG2	Clay plains. A relict lakebed of grey and brown cracking-clay soils with pronounced gilgai micro relief. Tall forests of brigalow and gidgee with false sandalwood, boobialla and currant bush forming the understorey and copperburr pigweed and Mitchell grass providing a very sparse ground cover. Regional ecosystem 10.4.5 is predominant.	12
LG3	Dissected plains. A localised area of brown cracking-clay soils with extreme gilgai micro relief. Mid-high, dense woodlands of belah. Ground cover is very sparse with annual species present. Regional ecosystem 10.4.7 is predominant.	12
LG4	Lunettes. Deep uniform sandy soils, underlain by lakebed clays. Open woodlands of ironwood, whitewood and beefwood with an understorey of bauhinia, supplejack and false sandalwood. Ground cover is very sparse. Regional ecosystem 10.3.17 is predominant.	2
LG5	Swales. A level, open depression seasonally inundated with water. Uniform grey, sodic, cracking-clay soils. Sparse woodlands of coolabah, with occasional false sandalwood and lignum bush. Regional ecosystem 10.3.15 is predominant.	14
LG6	Lunettes. Red, calcareous, sodic, texture-contrast soils. Dense, mid-high woodlands of gidgee with false sandalwood, wilga, sandalwood and currant bush. Regional ecosystem 10.3.19 is predominant.	2
LG7	Playas. Grey, uniform, sodic clay soils. Isolated occurrences of river cooba and parkinsonia in a low chenopod shrubland of samphire and other salt-tolerant minor species. Regional ecosystem 10.3.23 is predominant.	15
LG8	Saline playas. Blue-grey silty, saline clays devoid of vegetation. Regional ecosystem 10.3.24 is predominant.	15
LH1	Elevated plain. Texture-contrast soils with brown, sodic subsoils. Very sparse woodlands of beefwood, ironwood and ghost gum accompanied by a sparse shrub layer of gundabluie, woodland paperbark, boobialla and currant bush. Regional ecosystem 10.5.7 is predominant.	7
LH2	Lunette. Dense, mid-high woodlands of gidgee on the upper slopes, which have reddish-brown, texture-contrast profiles with sodic, calcareous subsoils. On the lower slopes tall woodlands of blackwood on texture-contrast soils with grey, sodic subsoils. Regional ecosystem 10.3.19 is predominant, but small areas of 10.9.1 are also present.	2
LH3	Lakebed. Open tussock grasslands of Mitchell grass-bluegrass are predominant on grey, uniform, cracking-clay soils where periods of inundation with water are less than 2-3 months. Areas with longer, or more frequent periods of inundation, are usually devoid of vegetation. Regional ecosystem 10.3.15 is predominant, but small areas of 10.9.1 are also present.	14

Land unit	Description	Land Management Unit
LH4	Lunettes. Dense thickets of black sally wattle with a sparse ground cover of wiregrass. Deep sandy soils of uniform texture. Regional ecosystem 10.3.17 is predominant.	2
LH5	Alluvial plains. Open tussock grasslands of handsome lovegrass with an occasional eurah or boobialla bush. Moderately deep sands of uniform texture overlie olive-grey sodic clays. Regional ecosystem 10.3.16 is predominant.	5
LH6	Streambeds, levees and interfluves. Tall woodlands of river red gum and broad-leaved tea-tree. Very deep, sandy soils of uniform texture. Regional ecosystem 10.3.13 is predominant.	10
LM1	Alluvial fan, upper slopes. Deep, texture-contrast soils with thick, loamy sand topsoils over reddish-yellow, sodic clay loams and a hardpan at approximately 1.2m. Gradational-textured profiles are common. Tall woodlands of silver-leaved ironbark with shrub layers of desert oak and bauhinia, and a ground layer of gummy spinifex, black spear grass and wiregrasses. Regional ecosystem 10.5.5 is predominant.	8
LM2	Alluvial fan, lower slopes. Very deep texture-contrast soils with thick sandy loam topsoils and mottled, sodic, sandy-clay subsoils. Tall woodlands of poplar box with some silver-leaved ironbark and an understory of beefwood, silver oak, currant bush, black spear grass and wiregrass. Regional ecosystems 10.5.5 and 10.5.12 are co-dominant.	6
LM3	Drainage depressions. Deep, texture-contrast profiles and uniform sandy loam profiles. Tall open woodlands of blackbutt, together with large-fruited bloodwood and poplar box, and with river red gum along the actual creek banks. Buffel grass, black spear grass, desert bluegrass and kangaroo grass. Regional ecosystem 10.4.3 is predominant, but significant areas of 10.3.10 and 10.3.14, and small areas of 10.5.12 are also present.	6
LN1	Alluvial fan, upper slopes. Deep, yellowish-brown, gradational-textured profiles and bleached, uniform-textured profiles with weak horizon development. Tall open woodlands of narrow-leaved ironbark, silver-leaved ironbark and ghost gum, although the density, height and proportions of these species varies between sites. Regional ecosystem 10.5.5 is predominant.	8
LN2	Alluvial fan, young deposits. Very deep, yellowish-brown gradational-textured profiles, bleached uniform-textured profiles with weak horizon development and sandy uniform sandy profiles with no horizon development, indicate considerable soil variability. Tall open woodlands of long-fruited bloodwood, ghost gum and narrow-leaved ironbark. Regional ecosystem 10.3.10 is predominant, but significant areas of 10.5.5 are also present.	8
LN3	Alluvial fan, lower slopes. Very deep, brown texture-contrast profiles and bleached uniform-textured sandy profiles. Tall woodlands of Reid River box with a small proportion of silver-leaved ironbark, long-fruited bloodwood and ghost gum. Blackwood is usually present where thin alluvium overlies the heavy clays of the adjacent Teewarrina land system. Regional ecosystem 10.5.12 is predominant.	6
LN4	Drainage depressions. Variable soils. Mid-high woodlands of Reid River box with minor occurrences of narrow-leaved ironbark, ghost gum and long-fruited bloodwood. Regional ecosystem 10.3.6 is predominant.	6
LR1	Alluvial fans. Very deep, uniform-textured loamy sands overlying a buried clay or a ferricrete hardpan. Tall sparse woodlands of desert bloodwood, ghost gum and ironbark. Regional ecosystems 10.5.2, 10.5.5 and 10.5.12 are co-dominant.	8

Land unit	Description	Land Management Unit
LR2	Plain and depressions. Very deep, uniform-textured, grey clay soils with gilgaied micro-relief. Thin, sandy clay loam topsoils may be present. Mid-tall, forests of gidgee and false sandalwood. Regional ecosystem 10.9.6 is predominant.	11
LR3	Plain, saline flats. Very deep, texture-contrast soils with sand topsoils and sodic, saline clay subsoils. Open grasslands of giant grey spinifex with occasional ellangowan and boobialla. Bare, scalded, saline areas are common. Regional ecosystem 10.3.16 is predominant.	4
LR4	Drainage depressions. Young sand or sandy loam profiles of variable depth alternate with uniform clay soils. Tall open woodlands of Moreton Bay ash and river red gum. Regional ecosystems 10.3.12 and 10.3.14 are co-dominant.	10
LW1	Alluvial terraces. Deep, gradational-textured profiles and reddish-brown texture-contrast profiles. Mid-high woodlands of Moreton Bay ash and poplar gum with an occasional bloodwood. Regional ecosystem 9.3.3 is predominant.	8
LW2	Lakes. Permanent and ephemeral wetlands occur along the length of Lolworth Creek, and contain a diverse vegetation community that differs from the adjacent landscape and attracts an equally diverse bird population. Regional ecosystem 9.3.4 is predominant.	14
LW3	Streambeds and levees. Soils of variable depth include sandy, uniform-textured profiles with weak horizon development and black gradational-textured profiles. Tall woodlands of forest red gum, broad-leaved tea-tree and Moreton Bay ash on the well-drained levees, and mid-high open forests of coolabah and Reid River box in poorly drained areas. Regional ecosystem 9.3.1 is predominant.	10
MD1	Alluvial fans. Very deep, sandy-textured soils deposited over the uniform clay soils of an old lakebed. Tall woodlands of Reid River box and poplar box. Some areas of gidgee and brigalow. Regional ecosystem 10.5.12 is predominant, but significant areas of 10.4.5 are also present.	6
MD2	Lunettes. Deep, sandy, uniform-textured soils on the northwestern margin of the old lakebed. Tall woodlands of silver-leaved ironbark, desert bloodwood and ghost gum. Some areas of gidgee and brigalow. Regional ecosystem 10.3.20 is predominant, but small areas of 10.4.5 are also present.	2
MD3	Clay plains. A relict lakebed with very deep, uniform-textured, grey cracking-clay soils. Mid-tall, dense forests of gidgee, with some brigalow, false sandalwood and wilga. Regional ecosystem 10.4.5 is predominant.	12
MD4	Drainage depressions. Sandy alluvial deposits of variable depth over the lakebed clays. Coolabah is predominant on the clayey soils while river red gum prefers the deep sandy loams. Regional ecosystem 10.3.14 is predominant.	10
MH1	Plains. Deep, brown texture-contrast soils. Tall, mid-dense forests of White's ironbark. A hardpan is usually present within 2m. Regional ecosystem 10.5.11 is predominant, but small areas of 10.4.5 are also present	9
MH2	Plain. Open grasslands of Mitchell grass and bluegrass on brown cracking-clay soils, with occasional coolabah and gidgee trees around the margins where sandy topsoils occur. Regional ecosystem 10.4.8 is predominant, but small areas of 10.4.5 are also present.	12
MH3	Plain. A complex area containing the soils and vegetation of both land units MH1 and MH2. Mid-high woodlands of gidgee with Mitchell grass and bluegrass on grey self-mulching clay soils. Regional ecosystems 10.4.5 and 10.4.8 are predominant, but significant areas of 10.4.1 and 10.5.11 are common.	12

Land unit	Description	Land Management Unit
MH4	Streambeds and levees. Variable soils. Tall woodlands of river red gum and coolabah. Regional ecosystem 10.3.14 is predominant, but small areas of 10.4.1, and 10.4.88 are also present	10
NP1	Crests and upper slopes. Shallow, red gradational and texture-contrast soils or uniform sandy soils overlying an ironstone hardpan. Sparse, mid-tall woodlands of silver-leaved ironbark with small areas of bush house paperbark, wattles and heaths, or Normanton box. Regional ecosystem 10.7.11 predominates, but small areas of 10.7.2 and 10.7.7 are also present.	1
NP2	Mid and upper slopes. Very deep, red sandy gradational soils. Mid-tall woodlands of Queensland yellowjacket and applejack with gummy spinifex as the dominant grass species. Regional ecosystem 10.5.1 is predominant.	3
NP3	Lower slope. Very deep, yellowish brown, texture-contrast soils. Tall woodlands of Reid River box and silver-leaved ironbark. An ironstone hardpan may be present within 1- 2m of the surface. Regional ecosystem 10.5.5 is predominant.	6
NP4	Drainage depressions. Variable soils, but yellow, sodic, mottled, texture-contrast profiles are most common. Tall woodlands of Reid River box are confined to the shallow drainage depressions. Regional ecosystem 10.3.6 is predominant.	6
OE1	Gently undulating plain. Shallow gradational-textured soils with some shallow, uniform sandy profiles. An ironstone hardpan occurs throughout at less than 0.5m depth. Sparse, stunted woodlands of silver-leaved ironbark, Reid River box and ghost gum. Regional ecosystem 10.7.11 is predominant, but small areas of 10.3.6 are also present.	1
OE2	Scarps. Exposed laterite and shallow, gravely, red gradational soils. Tall open forests of lancewood and bendee with a sparse ground cover of buck spinifex and neverfail. Regional ecosystem 10.7.3 is predominant.	1
OE3	Undulating plains. Very deep, red, sandy, gradational soils. Mid-high woodlands of Queensland yellow jacket and gum-topped bloodwood. Desert oak, red ash, buck spinifex, kangaroo grass and wiregrass are common. Regional ecosystem 10.5.1 is predominant.	3
OE4	Gentle slopes. Moderately deep, red gradational soils with an ironstone hardpan at approximately one metre depth. Open woodlands of silver-leaved ironbark and large-fruited bloodwood. Regional ecosystem 10.5.5 is predominant, but small areas of 10.7.11 are also present.	9
OE5	Drainage depressions. Texture-contrast profiles with thick sandy loam topsoils over sodic, mottled grey clays. Tall open woodlands of Reid River box and river red gum. Regional ecosystems 10.3.6 and 10.3.14 are co-dominant.	6
PK1	Plains. Remnants of a plain overlying folded sandstones and mudstones. Deep, yellowish-brown gradational-textured profiles. Mid-high to tall woodlands of silver-leaved ironbark with occasional Reid River box and ghost gum. Regional ecosystem 10.5.5 is predominant.	9
PK2	Hills - crests and upper slopes. Shallow, gradational soils alternating with sandy variants down slope. Mid-high woodlands of narrow-leaved ironbark with an understorey of false sandalwood, various wattles, black spear grass and wiregrass. Buffel grass has been introduced to cleared areas. Regional ecosystems 11.11.9 and 11.11.15 are co-dominant.	1

Land unit	Description	Land Management Unit
PK3	Lower slopes. Deep, dark, gradational and texture-contrast profiles with sodic subsoils on weathered mudstones. Mid-high open woodlands of narrow-leaved ironbark or silver-leaved ironbark. Small areas of blackwood with false sandalwood and bauhinia. Black speargrass, wiregrass and buffel grass as ground cover. Regional ecosystem 10.5.5 is predominant, but areas of 11.11.13 and 11.11.15 are common.	9
PK4	Plain, flats and low-lying areas. Dark grey, uniform, cracking clay and brown gradational soil profiles with structured subsoils. Mid-high open forests and woodlands of blackwood and brigalow, with occasional Reid River box. Regional ecosystems 10.4.1 and 10.4.2 are co-dominant.	12
PK5	Drainage depressions and associated floodplains. Deep clay soils with variable depths of sandy alluvium. Tall open woodlands of river red gum and broad-leaved tea-tree. Black speargrass and buffel grass as ground cover. Regional ecosystem 11.3.25 is predominant.	10
PP1	Plains with elongated, low sandy bars (ridges). Deep, texture-contrast soils are dominant and uniform sands are common, both overlie a hardpan at 1.0 - 1.5m depth. Tall woodlands of White's ironbark with ghost gum, desert bloodwood and large-fruited bloodwood. Regional ecosystem 11.5.11 is predominant, but small areas of 10.4.8 are also present.	9
PP2	Plains. Open tussock grasslands of Mitchell grass and bluegrass with isolated mimosa bushes and gundabluie. Very deep, uniform grey and black cracking-clay soils. Regional ecosystem 10.4.8 is predominant.	12
PP3	Plains. A complex area involving the soils and vegetation of land units PP1 and PP2. Regional ecosystems 10.4.8 and 10.5.11 are co-dominant.	12
PP4	Plains - backplains and low-lying areas, subject to inundation with water. Very deep, uniform-textured clay soils. Open woodlands of gidgee, coolabah, Reid River box and mimosa bush. Regional ecosystem 10.4.5 (west subtype) and 10.4.8 are co-dominant, but small areas of 10.3.14 are also present.	14
PP5	Streambeds and levees. Variable soils. Tall open woodlands of river red gum. Regional ecosystem 10.3.14 is predominant.	10
PT1	Undulating plains. Shallow, brown texture-contrast soils. Mid-high, open woodlands of White's ironbark, ghost gum and some desert bloodwood. Narrow-leaved wattle, woodland paperbark and currant bush dominate the shrub layer and gummy spinifex the ground layer. Regional ecosystem 10.7.10 is predominant.	1
PT2	Playas and associated lunettes. Saline lakebeds are often seasonally wet and devoid of vegetation except for a sparse, random cover of salt-tolerant species (samphires). The fringing narrow lunettes have sandy gradational soil profiles with White's ironbark and ghost gum common. Regional ecosystem 10.3.15 is predominant.	15
PT3	Hillslopes. Mid-tall woodlands of White's ironbark with mulga and false sandalwood. Gummy spinifex and wiregrass are the dominant grasses. Shallow, reddish-brown gradational and texture-contrast soils over an ironstone hardpan. Regional ecosystem 10.7.10 is predominant.	1
PT4	Scarps. Shallow, gradational and texture-contrast soil profiles overlie and ironstone hardpan. Open woodlands of Normanton box, mulga, and lancewood. Gummy spinifex is the dominant grass species. Regional ecosystems 10.7.2 and 10.7.3 are co-dominant.	1
PT5	Lower slopes. Deep to very deep, brown, texture-contrast soil profiles, gradational profiles and uniform cracking-clay soils. Tall closed woodlands of blackwood. Regional ecosystem 10.9.1 is predominant, but significant areas of 10.7.10 are also present.	11

Land unit	Description	Land Management Unit
PT6	Drainage depressions. Variable soils with bedrock or hardpan exposed in places and deep sandy sediments in others. Mid-high woodlands of coolabah and river red gum. Regional ecosystem 10.3.14 is predominant, but small areas of 10.9.1 are also present.	10
RC1	Upper terraces. Very deep, sandy uniform soil profiles overlying truncated older soils. Tall open woodlands of Clarkson's bloodwood, ghost gum, White's ironbark, Reid River box, ironwood, beefwood and false sandalwood. Regional ecosystem 10.5.7 is predominant.	8
RC2	Scroll plains. A complex of terraces, interfluves and drainage depressions. The soils and vegetation of land units RC1 and RC4 occur in close proximity to each other. Regional ecosystem 10.5.7 is predominant, but significant areas of 10.3.14 are also present.	10
RC3	Lakebeds. Heavy grey sodic clay soils with a high salt content. Low shrublands of samphire with occasional river cooba or a saline playa, devoid of vegetation. Regional ecosystems 10.3.23 and 10.3.24 are co-dominant.	15
RC4	Drainage depressions. Tall open woodlands of river red gum. Very deep, uniform silty loam soils. Regional ecosystem 10.3.14 is predominant, but small areas of 10.5.7 are also present.	10
RD1	Alluvial fan, upper slopes. Very deep, gradational profiles with brown sandy loam topsoils and yellowish red sandy clay loam subsoils. Tall sparse woodlands of Reid River box with gidgee and dead finish. Some poplar box in minor depressions. False sandalwood, silver cassia, bluegrass, mountain wanderrie grass and wire grass in the understory. Regional ecosystem 10.5.12 is predominant, but small areas of 10.9.6 are also present.	8
RD2	Plains. Very deep, brown, uniform clay soils. Mid-tall, forests of gidgee with false sandalwood, wiregrass and various annual species. Regional ecosystem 10.9.6 is predominant.	11
RD3	Clay plain. An extension of the gently undulating, "Downs" country. Grey uniform cracking-clays with self-mulching topsoils. Open grasslands of Mitchell grass and bluegrass with occasional gidgee or boree. Regional ecosystem 4.9.7 is predominant.	11
RD4	Alluvial fan, lower slopes. Deep, grey-brown, texture-contrast profiles with sodic subsoils that have high salt contents and a calcrete hardpan within 1.0m. Sparse dwarf woodlands of dead finish predominate, with variable proportions of whitewood, bauhinia and false sandalwood. Ground cover of kerosene grass, woolly mantle, winged windmill grass and introduced buffel grass. Regional ecosystem 10.9.8 is predominant.	4
RD5	Drainage depressions. Variable soils with uniform sands and silty loams deposited over heavy clays. Tall open woodlands of river red gum with some gidgee and false sandalwood associating with clay variants. Regional ecosystem 10.3.14 is predominant.	10
SC1	Plain, elevated areas. Deep, red and brown gradational-textured soil profiles with yellow variants where ironstone gravel reduces the permeability. Mid-high woodlands of narrow-leaved ironbark and silver-leaved ironbark with some long-fruited bloodwood, ghost gum, and poplar gum. Regional ecosystem 10.5.4 is predominant.	9
SC2	Plains. A complex of moderately deep soil types and vegetation common to land units SC1 and SC3. Regional ecosystems 10.5.4 and 10.7.12 are co-dominant.	9

Land unit	Description	Land Management Unit
SC3	Plain, areas adjacent to a scarp. Shallow, red gradational-textured profiles, usually with abundant ironstone gravel and an ironstone hardpan. Lancewood and bendee prefer the shallow soils with ironstone, whereas Reid River box, ghost gum and the occasional broad-leaved rustyjacket occur on the slightly deeper soils. Regional ecosystem 10.7.3 is predominant.	1
SC4	Scarps. Moderate to very steep slopes and shallow, red gradational-textured profiles. Mid-high open forests of bendee on the deeper soil profiles and lancewood as a tall woodland on the shallow profiles, often with abundant ironstone gravel or an ironstone hardpan in the profile. Regional ecosystem 10.7.3 is predominant.	1
SC5	Footslopes. Deep, yellowish-brown texture-contrast profiles, often with sodic subsoils. Mid-high, open woodlands of narrow-leaved ironbark and ghost gum with narrow bands of river red gum. Regional ecosystems 10.5.4 and 9.12.1 are co-dominant.	9
SC6	Drainage depressions. Yellow texture-contrast profiles of variable depth. Tall open forests of river red gum, broad-leaved tea-tree and pandanus. Regional ecosystem 10.3.13 is predominant.	10
SD1	Lakebed, elevated clay plain. A relict lakebed with brown, self-mulching, uniform cracking-clay soils. Only isolated remnants remain of the original gidgee-boree woodland. Regional ecosystems 10.4.5 and 10.4.8 are co-dominant.	12
SD2	Lakebed, lower slopes. Very deep, dark grey and black, uniform cracking-clay soils. Remnant vegetation indicates mid-high to tall woodlands of blackwood, brigalow and yellow wood once covered this area. Regional ecosystem 10.4.1, 10.4.5 and 10.4.8 are co-dominant.	12
SD3	Drainage depressions. Very deep, grey and black, uniform cracking-clay soils. Remnant vegetation indicates that mid-high open forests of blackwood, coolabah and yellow wood once predominated. Regional ecosystem 10.3.1 is predominant.	12
SN1	Cone, volcanic. The volcanic plug of a basalt extrusion point. Pockets of clay loam between rocky outcrops. Low open woodlands of bloodwood, silver-leaved ironbark and 'snappy gum', with prickly pine and turkey bush. Regional ecosystem 11.8.4 is predominant.	1
SN2	Plains. Moderately deep, red-brown, gradational-textured soils overlying ferricrete at approximately 1m depth. Tall open woodlands of silver-leaved ironbark with ghost gum and a dense pasture of bluegrass, kangaroo grass and wiregrass. Regional ecosystem 11.8.4 is predominant.	9
SN3	Plains. Uniform, grey, cracking-clay soils with self-mulching topsoils. Tall, very sparse woodlands of gum-topped bloodwood with isolated shrubs of mimosa and a ground layer of desert bluegrass, red Flinders grass and silky browntop. Regional ecosystem 11.8.11 is predominant.	12
SN4	Lower plains. Very deep, dark grey and black, uniform, cracking-clay soils, often with pronounced linear gilgai micro relief. Sparse, low woodlands of brigalow with an understorey of forest bluegrass and Flinders grass. Regional ecosystem 11.8.11 (to be revised) is predominant.	12
SN5	Drainage depressions. Very deep, grey cracking-clay soils with silty clay topsoils. Mid-tall open woodlands of coolabah. Regional ecosystem 11.3.3 is predominant.	1
SP1	Crests and upper slopes. Shallow uniform sands and sandy loams with a ferricrete hardpan at less than 0.5 m depth. Tall sparse woodlands of silver-leaved ironbark, ghost gum and poplar box. Applejack and white cypress pine are common and gummy spinifex dominates the ground cover. Regional ecosystems 10.7.7 and 10.7.11 are predominant, but small areas of 10.5.5 and 10.5.12 are also present.	

Land unit	Description	Land Management Unit
SP2	Plains. Very deep, texture-contrast soils with thick sandy loam topsoils over red to reddish brown clays. Tall, sparse woodlands of silver-leaved ironbark and ghost gum with an equally sparse shrub layer of desert oak, prickly pine, ironwood and quinine tree. Gummy spinifex and wiregrass are the main grass species. Regional ecosystem 10.5.5 is predominant.	9
SP3	Drainage depressions and low-lying areas. Young sandy soils of variable depth with poplar box and river red gum on the current floodplain, and deep uniform, cracking-clay soils in the closed depressions with coolabah, gidgee, waterbush and false sandalwood. Regional ecosystems 10.3.14, 10.3.15 and 10.3.27 are co-dominant.	6
SS1	Plain, plateau margins. Very shallow, gravely, gradational soil profiles overlying a lateritic hardpan, often exposed. Shrublands of broombush, bush house paperbark, and gummy spinifex with some Normanton box. Regional ecosystems 10.7.7 and 10.7.10 are co-dominant.	1
SS2	Scarps. Shallow, stony, red-brown gradational soils. Mid-tall, dense forests of lancewood with a sparse ground layer of gummy spinifex. Regional ecosystem 10.7.3 is predominant.	1
SS3	Footslopes. Very deep, brown, uniform clay soils with a moderate-strong structure, Mid-tall woodlands of bastard gidgee and napunyah. A sparse ground cover of annual grasses and forbs. Regional ecosystem 10.9.2 is predominant, but small areas of 10.7.3 and 10.7.5 are also present.	11
SS4	Plains. Very deep, uniform-textured, red clay soils. Tall, dense stands of blackwood with a sparse understorey of leopardwood, whitewood and false sandalwood, and a ground cover dominated by brigalow and bottlewasher grasses. Regional ecosystem 10.9.1 is predominant.	11
SS5	Drainage depressions. Very deep, brown uniform clay soils. Mid-tall, open woodlands of gidgee and boree. Mimosa and prickly acacia are usually present. Regional ecosystem 10.3.4 is predominant.	11
TA1	Lakebed, elevated positions. Grey and brown uniform-textured, cracking-clay soils, usually with calcium carbonate and gypseous crystals in the upper and lower profile, respectively. Mid-high open forests of blackwood and brigalow mix with low closed forests of gidgee with some belah. Regional ecosystems 10.4.1, 10.4.2 and 10.4.4 are co-dominant.	12
TA2	Lakebed, plain. Very deep, grey, uniform cracking-clay soils with calcareous segregations and/or gypseous crystals. Mid-high to tall open woodlands of brigalow and bauhinia with occasional blackbutt and Reid river box. Regional ecosystems 10.4.2 and 10.4.3 are co-dominant.	12
TA3	Lakebed, plain. Grey and black, uniform, cracking-clay soils, with calcareous segregations or gypseous crystals in the soil profile. Open tussock grasslands of bull Mitchell grass, hoop Mitchell grass, curley Mitchell grass, Queensland blue grass and red Flinders grass. Regional ecosystem 10.4.8 is predominant.	12
TA4	Lakebed, plain. Shallow, reddish-brown, calcareous, gradational and uniform-textured profiles with structured subsoils and texture-contrast profiles with grey sodic subsoils, overlie sedimentary bedrock or a calcrete hardpan. Mid-high open woodlands of desert bloodwood with some silver-leaved ironbark, bauhinia and ghost gum. Regional ecosystem 10.4.9 is predominant.	1
TA5	Drainage depressions. Variable depths of sandy loam, brought in from adjacent landscape, cover the underlying grey and black clay soils. The common tree species, in varying proportions and combinations, include coolabah, blackwood and Reid River box. Regional ecosystem 10.3.1 is predominant.	6

Land unit	Description	Land Management Unit
TC1	Alluvial terraces. Elongated, low sandy bars (ridges) with very deep, reddish-brown texture-contrast soils. Tall, sparse woodlands of bloodwoods, grevilleas and wattles. Regional ecosystem 10.3.10 is predominant, but significant areas of 10.4.8 are also present.	8
TC2	Backplains. Very deep, grey, uniform cracking-clay soils. Open grasslands of Mitchell grass and desert bluegrass with occasional bauhinia, gidgee and desert bloodwood. Regional ecosystem 10.4.8 is predominant.	12
TC3	Levees. Very deep, texture-contrast soil profiles with silty loam topsoils overlying structured, sodic, reddish-brown clays. Dense woodlands of gidgee once covered these levees, small areas of remnant vegetation remain. Regional ecosystem 10.4.5 is predominant, but significant areas of 10.3.14 are also present.	12
TC4	Streambeds. River red gum and coolabah are predominant on the young sandy alluvial soils of variable texture and depth. Regional ecosystem 10.3.14 is predominant.	10
TF1	Alluvial fans. Deep, reddish-brown, sandy, texture-contrast soils with occasional uniform sandy or clayey profiles. Tall forests of White's ironbark with some ghost gum and desert bloodwood. Regional ecosystems 10.3.9 and 10.3.10 are co-dominant.	8
TF2	Alluvial fans. A complex area with White's ironbark on very deep sandy soils (land unit TF1) alternating with Reid River box on brown, sodic, texture-contrast soils. The soil type and drainage characteristics of the site determine the vegetation community. Regional ecosystems 10.3.6 and 10.3.9 are co-dominant.	8
TF3	Alluvial fans, variable depth. A complex soil-vegetation association. Variable depths of sandy alluvium overlie an older soil profile or hardpan. Mid-high woodlands of White's ironbark and desert oak on shallow sandy profiles, with bloodwoods and wattles on the deep sandy profiles, and river red gum confined to the narrow drainage depressions. Regional ecosystems 10.5.2 and 10.5.11 are co-dominant, but small areas of 10.3.14 are also present.	8
TF4	Streambed and associated levees. Very deep, reddish-brown uniform sands. Tall woodlands of ghost gum and desert bloodwood. Regional ecosystems 10.3.10 and 10.3.14 are co-dominant.	10
TK1	Level plain. Very deep, grey cracking-clays with self-mulching topsoils. Open grasslands of Mitchell grass, Flinders grass, wiregrass and bluegrass. Regional ecosystem 10.9.4 is predominant.	13
TK2	Level plain. Very deep, grey, uniform clay soils and texture-contrast soils, both with dense, hard-setting topsoil. Mid-high, open woodlands of coolabah with some blackwood in low-lying areas prone to inundation with water. Regional ecosystem 10.3.1 is predominant.	14
TK3	Gently undulating plains. Low, sparse woodlands of boree with Mitchell grass on brown, self-mulching, cracking-clay soils, grading into blackwood and annual ground-cover species on grey cracking-clay soils in the slightly lower positions of the landscape. Regional ecosystem 10.9.1 is predominant.	11
TK4	Streambed and drainage depressions with associated levees and interfluves. Variable soils. Open woodlands of river red gum and coolabah with the occasional blackwood, false sandalwood and river cooba. Regional ecosystem 10.3.14 is predominant.	10
TM1	Low ridge. Narrow, sinuous rocky ridges on basalt plains. Very shallow, red gradational-textured profiles with numerous, rounded basalt boulders exposed on the soil surface. Mid-high woodlands of narrow-leaved ironbark, variable-barked bloodwood and ghost gum. Regional ecosystem 9.8.1 is predominant.	1

Land unit	Description	Land Management Unit
TM2	Plains. Moderately deep, reddish-brown soil profiles, lacking strong texture contrast, with a high free iron oxide content in the subsoil. Mid-high open woodlands of ghost gum with varying proportions of narrow-leaved ironbark, variable-barked bloodwood and Reid River box. Regional ecosystem 9.8.1 is predominant.	9
TM3	Plains, slight depressions and low-lying areas. Moderately deep, brown gradational-textured soil profiles and dark grey, uniform-textured clay profiles. Both soil types experience prolonged periods of wetness. Mid-high woodlands of Reid River box. Regional ecosystem 9.8.1 (to be revised) is predominant.	14
TM4	Ridge. Soil formation is non-existent, or minimal at best. Tall closed forests of helicopter tree, Burdekin plum, kurrajong and yellow wood, and a sub-strata including scrub turpentine, myrtle tree and lolly bush. Regional ecosystem 9.8.7 is predominant.	1
TM5	Plain, uneven, rocky surfaces. A complex of soil-vegetation associations normally belonging to land units TM3, TM4 and TM6. Regional ecosystems 9.8.1 and 9.8.7 are co-dominant, but small areas of 10.3.11are also present.	1
TM6	Lakes, wetlands and drainage depressions. The soil profiles experience saturated conditions for at least 2-3 months each year in most years. Mid-high open forests of river red gum and Reid River box predominate in the ephemeral wetlands and around the margins of permanent lakes. Regional ecosystems 9.3.1 and 9.3.11 are co-dominant.	14
TS1	Alluvial fan, upper and middle slopes. Deep, texture-contrast soils with sandy loam topsoils and yellowish brown, mottled sandy clay subsoils. Tall open woodland of silver-leaved ironbark with Reid River box in the northern section and poplar box in the southern section. Regional ecosystems 10.5.5 and 10.5.12 are co-dominant.	8
TS2	Alluvial fan, lower slopes. Very deep, texture-contrast soils with deep sandy loam topsoils over brown mottled, sodic clays. Tall woodlands of Reid River box in the north and poplar box in the south. Small areas of gidgee on dark clay soils, with or without thin sandy loam topsoils. Regional ecosystem 10.5.12 is predominant, but small areas of 10.4.5 are also present.	6
TS3	Drainage depressions. Deep, variable soils. Tall woodlands of Reid River box (northern section) or poplar box (southern section). River red gum is common on the larger watercourses. Hardpans are often exposed in the creek bed. Regional ecosystems 10.3.6, 10.3.14 and 10.3.27 are co-dominant.	6
UH1	Gentle crests and upper slopes. A very limited area of shallow, red texture-contrast soils derived from calcareous bedrock. Tall, open woodlands of silver-leaved ironbark and large-fruited bloodwood are predominant. Regional ecosystem 10.9.5 is predominant.	1
UH2	Lower slopes. Deep, brown and grey, uniform cracking-clays and red, uniform non-cracking-clays. Mid-high, dense woodlands of brigalow, gidgee and blackwood occur in varying proportions. Napunyah may be present on the upper slopes and blackbutt on the lower slopes adjacent to the drainage depressions. Regional ecosystems 10.9.2 and 10.9.3 are co-dominant.	11
UH3	Plains. Grey, uniform cracking-clay soils. Open grasslands of barley Mitchell grass with scattered bauhinia or coolabah. Soft roly-poly and woolly copperburr are common annuals. Regional ecosystems 10.3.7 and 10.9.4 are co-dominant.	12
UH4	Drainage depressions. A complex area of uniform cracking-clay soils in the channels with gidgee and false sandalwood, alternating with red, sodic texture-contrast soils on the interfluves with a tall woodland of blackbutt. Regional ecosystems 10.3.4 and 10.3.5 are co-dominant.	12

Land unit	Description	Land Management Unit
VA1	Plains. Remnants of the original plateau surface. Very deep, reddish-brown gradational and uniform-textured soils. Mid-high woodlands of silver-leaved ironbark, ghost gum and long-fruited bloodwood. Regional ecosystem 11.5.3 is predominant, but small areas of 11.7.3 (to be revised) are also present.	9
VA2	Plain, adjacent to edge of scarps. Shallow brown texture-contrast and gradational profiles. Low open woodlands of silver-leaved ironbark with some ghost gum, bush house paperbark, tea-tree and applejack. Normanton box and lancewood may be present. Exposures of ferricrete. Regional ecosystems 11.7.2 and 11.7.3 (to be revised) are co-dominant.	1
VA3	Scarps - moderate to very steep slopes. Shallow reddish-brown gradational-textured profiles with variable proportions of gravel, stones and boulders on the soil surface, and exposed ferricrete. Open forests of lancewood and bendee. Regional ecosystems 11.7.2 and 11.7.3 (to be revised) are co-dominant.	1
VA4	Footslopes. Deep, yellowish-brown texture-contrast profiles, with very deep sandy topsoils and sodic subsoils. Mid-high woodlands of Reid River box, with some Normanton box on the gravely upper slopes and silver-leaved ironbark, poplar gum and bloodwoods predominate on the sandier lower slopes. Regional ecosystem 11.5.3 (to be revised) is predominant, but small areas of 11.3.8 (to be revised) and 11.7.3 are also present.	9
VA5	Drainage depression. The soils vary considerably in texture, depth and colour, although sandy uniform and gradational-textured profiles are co-dominant. Tall woodlands of river red gum and Reid River box predominate, and are often accompanied by blackbutt, pandanus and Cape River fan palm. Regional ecosystems 11.3.4 and 11.3.25 are co-dominant.	10
WE1	Undulating plains. Deep, yellowish-brown texture-contrast soils with a hardpan at approximately 1.5m deep. Mid-tall woodlands of White's ironbark, ghost gum and applejack. Regional ecosystems 10.5.8 and 10.5.11 are co-dominant.	9
WE2	Plains - gentle slopes. Very shallow, uniform sandy or texture-contrast soils with a hardpan at less than 0.25m depth. Low, sparse woodlands of ghost gum, applejack and White's ironbark with desert oak, woodland paperbark, black spear grass and wiregrass. Regional ecosystem 10.7.10 is predominant.	1
WE3	Drainage depressions. Clay soils and young sandy profiles are common with river red gum, Reid River box, White's ironbark and gidgee, depending on location. Regional ecosystems 10.3.6, 10.3.14 and 10.3.15 are co-dominant.	6
WE4	Scarps. Moderate to very steep slopes with shallow soils, ironstone hardpan often exposed. Lancewood is dominant with a sparse ground cover of spinifex. Regional ecosystem 10.7.3 is predominant.	1
WE5	Stream beds and scroll plains. Deep sandy alluvial soils. Tall woodlands of river red gum. Regional ecosystem 10.3.14 is predominant.	10
WL1	Plains. Sandy lunettes and plains separating drainage depressions and lakes. Very deep, uniform, sandy-textured soil profiles. Tall isolated trees of long-fruited bloodwood with scattered sally wattle, beefwood and false sandalwood. Regional ecosystem 10.3.10 is predominant.	2
WL2	Drainage depressions. River red gum, blackbutt and Reid River box are both present, however Reid River box prefers the non-saline soils, whereas river red gum and blackbutt can tolerate soils with low salinity levels. Regional ecosystems 10.3.6 and 10.3.15 are co-dominant.	14

Land unit	Description	Land Management Unit
WL3	Lakebeds. The silty clay soils, saturated for at least 2-3 months in most years, show gley colours (olive-green) in the profile. Following heavy seasonal rains the lakebeds become inundated with water, providing a habitat and source of food for a variety of bird life. Regional ecosystem 10.3.15 is predominant.	14
WM1	Narrow crests and very steep slopes. Shallow to very shallow, yellow texture-contrast and gradational soil profiles. Mid-tall, dense woodlands of lancewood with isolated bloodwood and fine-leaved ironbark. Regional ecosystem 10.10.1 and 10.10.2 are co-dominant.	1
WM2	Plain. Small areas of the original plateau that have escaped severe erosion. Variable soils, mostly deep, sandy uniform profiles. Tall woodlands of fine-leaved ironbark, rustyjacket and shiny-leaved bloodwood. Regional ecosystems 10.10.4 and 10.10.5 are co-dominant, but small areas of 10.9.7 are also present.	9
WM3	Streambed and levees. The narrow valleys and gorges carry large volumes of water during peak flows. Tall woodlands with river red gum, spotted gum and swamp box. Regional ecosystem 10.3.11 and 1.3.14 are co-dominant.	10
WR1	Hillcrests and hillslopes. Very shallow soils with a low water-holding capacity, or no soil at all. Low open woodlands of Shirley's silver-leaved ironbark with some broad-leaved rustyjacket on the lower portion of the steep slopes. Regional ecosystem 9.11.1 is predominant.	1
WR2	Hillslopes. Undulating rises with variable slopes adjacent to land unit WR1. Moderately deep, yellow texture-contrast soils, with an ironstone hardpan within the profile. Mid-high woodlands of narrow-leaved ironbark and long-fruited bloodwood with some broad-leaved rustyjacket and ghost gum. Regional ecosystem 10.5.4 is predominant, but small areas of 9.11.2 are also present.	9
WR3	Plains. Deep, reddish-brown, gradational-textured soil profiles. Mid-high woodlands of Reid River box with substrata of mostly beefwood and tea-tree. Regional ecosystem 10.3.6 is predominant.	9
WV1	Plain - gently undulating. An ironstone or silcrete hardpan underlies the whole area and soils range from uniform sands to moderately deep texture-contrast profiles. Dense heathlands and mid-tall, open woodlands of White's ironbark and ghost gum. Regional ecosystem 10.5.11 and 10.7.10 are co-dominant.	9
WV2	Hillslopes. Shallow, yellow texture-contrast soils. Tall, open woodlands of White's ironbark and ghost gum. Normanton box occupies areas of shallow gravely soils and exposed silcrete hardpan. Regional ecosystem 10.7.1 is predominant.	1
WV3	Scarps. Very deep, reddish-brown, uniform clay soils with bastard gidgee. The upper slopes have stony clays with bendee and napunyah in amongst the gidgee, while the lower slopes merge into land unit WV4 with cracking-clay soils and a mixture of gidgee and boree. Regional ecosystem 10.9.2, 10.9.6 and 4.9.11 are co-dominant, but small areas of 10.7.3 are also present.	11
WV4	Lower footslopes. Very deep, brown, uniform cracking-clays. Sparse mid-tall woodlands of boree and gidgee with a ground cover of Mitchell grass and Flinders grass. Regional ecosystem 4.9.7 is predominant.	11
WV5	Streambed and levees. A diverse range of soils, which are the product of erosion processes within the catchment. River red gum and coolabah are dominant, with common occurrences of gidgee, false sandalwood and bauhinia. Regional ecosystems 4.3.3, 4.3.8 and 10.3.14 are co-dominant.	10

Land unit	Description	Land Management Unit
WW1	Plains. Moderately deep, yellow, sandy gradational soils with an ironstone hardpan at a depth of approximately 1.0m. Mid-tall woodlands of Whites ironbark predominate with patches of yellowjacket and applejack, and a diverse range of shrubs. Regional ecosystem 10.5.11 is predominant, but small areas of 10.5.1 and 10.7.7 are also present.	3
WW2	Plains - gently undulating. Very deep, reddish-brown, texture-contrast soils overlying an ironstone hardpan at approximately 2m deep. Tall woodlands of White's ironbark, ghost gum and desert bloodwood. Regional ecosystem 10.5.11 is predominant.	9
WW3	Plains. Very deep, red gradational soils. Mid-high woodlands of Queensland yellowjacket with a wide range of other species in varying proportions, including applejack, Clarkson's bloodwood and gum-topped bloodwood. The understorey contains a very large, diverse range of species. Regional ecosystem 10.5.1 is predominant.	3
WW4	Hillslope. Moderately deep, yellowish-brown, texture-contrast and gradational-textured soil profiles. Mid-high woodlands of silver-leaved ironbark and narrow-leaved ironbark with some ghost gum, applejack or rustyjacket. Regional ecosystem 10.5.4 is predominant, but small areas of 10.3.6 and 10.7.11 are also present.	9
WY1	Hillcrests and upper slopes. Shallow red gradational soils overlie sandstone bedrock or an ironstone hardpan. Tall woodlands of silver-leaved ironbark with occasional Reid River box and ghost gum. A mid-strata of emu apple, western rosewood and brush hovea and a ground cover of bluegrass and buffel grass. Shallow red gradational soils overlie sandstone bedrock or an ironstone hardpan. Regional ecosystem 10.7.3 is predominant.	1
WY2	Lakebed, gently undulating plain. Very deep, reddish-brown, uniform, cracking-clay soils. Mid-tall closed forests of gidgee with a sparse understorey of false sandalwood, annual forbs and grasses. Areas cleared of the native vegetation support a dense sward of buffel grass. Regional ecosystem 11.4.6 is predominant.	12
WY3	Lakebed, plain. Very deep, grey, cracking-clay soils. Tall closed forests of brigalow with some gidgee intermixed. A very sparse ground layer of gidgee burr, fairy grass and sidas. Extensive areas have been cleared and replaced with buffel grass. Regional ecosystem 11.4.9 is predominant.	12
WY4	Drainage depressions. Young sandy soils of variable depth overlie the lakebed clays. River red gum is confined to the sandy deposits in the narrow drainage lines. Regional ecosystem 11.3.25 is predominant, but significant areas of 11.4.9 are also present.	14

Appendix 10 Site codes on the DUSLARA map sheets cross-linked to the site codes from other land resource studies in the Desert Uplands

DUSLARA*		Buchanan _ Galilee*		WARLUS*		CORVEG*		Dalrymple*		Herbarium*	
DUSLARA site code	Original DUSLARA* site code	DUSLARA site code	Original site code	DUSLARA site code	Original site code	DUSLARA site code	Original site code	DUSLARA site code	Original site code	DUSLARA site code	Original site code
1	1	2001	B01	3001	CWA4	4001	158	5001	33	7001	1
2	2	2002	B02	3002	CWA9	4002	159	5002	34	7002	2
3	3	2003	B03	3003	CWA10	4003	160	5003	35	7003	3
4	4	2004	B04	3004	CWA11	4004	165	5004	36	7004	4
5	5	2005	B05	3005	CWA12	4005	166	5005	37	7005	5
6	6	2006	B06	3006	CWA19	4006	167	5006	38		
7	7	2007	B07	3007	CWA20	4007	168	5007	39		
8	8	2008	B08	3008	CWA23	4008	169	5008	40		
9	9	2009	B09	3009	CWA32	4009	170	5009	41		
10	10	2010	B10	3010	CWA33	4010	171	5010	42		
11	11	2011	B11	3011	CWA34	4011	176	5011	43		
12	12	2012	B12	3012	CWA35	4012	180	5012	44		
13	13	2013	B13	3013	CWA36	4013	181	5013	45		
14	14	2014	B14	3014	CWA37	4014	182	5014	46		
15	15	2015	B15	3015	CWA38	4015	183	5015	47		
16	16	2016	B16	3016	CWA39	4016	184	5016	48		
17	17	2017	B17	3017	CWA40	4017	185	5017	49		
18	18	2018	B18	3018	CWA44	4018	186	5018	50		
19	19	2019	B19	3019	CWA45	4019	187	5019	51		
20	20	2020	B20	3020	CWA46	4020	188	5020	52		
21	21	2021	B21	3021	CWA47	4021	189	5021	53		
22	22	2022	B22	3022	CWA48	4022	190	5022	54		
23	23	2023	B23	3023	CWA49	4023	191	5023	55		
24	24	2024	B24	3024	CWA50	4024	192	5024	56		
25	25	2025	B25	3025	CWA57	4025	193	5025	57		
26	26	2026	B26	3026	CWA58	4026	194	5026	68		
27	27	2027	B27	3027	CWA59	4027	195	5027	69		
28	28	2028	B28	3028	CWA60	4028	196	5028	70		
29	29	2029	B29	3029	CWA68	4029	197	5029	71		
30	30	2030	B30	3030	CWA72	4030	198	5030	72		
31	31	2031	B31	3031	CWA74	4031	199	5031	73		
32	32	2032	B32	3032	CWA75	4032	200	5032	74		
33	33	2033	B33	3033	CWA76	4033	201	5033	75		
34	34	2034	B34	3034	CWA77	4034	202	5034	76		
35	35	2035	B35	3035	CWA162	4035	203	5035	77		
36	36	2036	B36	3036	CWA163	4036	204	5036	78		

DUSLARA*		Buchanan – Galilee*		WARLUS*		CORVEG*		Dalrymple*		Herbarium*
37	37	2037	B37	3037	CWA247	4037	205	5037	79	
38	38	2038	B38	3038	CWA248	4038	206	5038	86	
39	39	2039	B39	3039	CWA249	4039	207	5039	87	
40	40	2040	B40	3040	CWA250	4040	208	5040	88	
41	41	2041	B41	3041	CWA251	4041	209	5041	89	
42	42	2042	B42	3042	CWA252	4042	210	5042	90	
43	43	2043	B43	3043	CWA253	4043	211	5043	92	
44	44	2044	B44	3044	CWA254	4044	212	5044	93	
45	45	2045	B45	3045	CWA255	4045	213	5045	94	
46	46	2046	B46	3046	CWA256	4046	214	5046	95	
47	47	2047	B47	3047	CWA257	4047	215	5047	96	
48	48	2048	B48	3048	CWA258	4048	216	5048	97	
49	49	2049	B49	3049	CWA259	4049	217	5049	99	
50	50	2050	B50	3050	CWA260	4050	218	5050	100	
51	51	2051	B51	3051	CWA261	4051	219	5051	123	
52	52	2052	B52	3052	CWA262	4052	220	5052	135	
53	53	2053	B53	3053	CWA263	4053	221	5053	136	
54	54	2054	B54	3054	CWA264	4054	222	5054	137	
55	55	2055	B55	3055	CWA265	4055	223	5055	138	
56	56	2056	B56	3056	CWA266	4056	224	5056	139	
57	57	2057	B57	3057	CWA268	4057	225	5057	140	
58	58	2058	B58	3058	CWA269	4058	226	5058	141	
59	59	2059	B59	3059	CWA270	4059	227	5059	142	
60	60	2060	B60	3060	CWA273	4060	228	5060	151	
61	61	2061	B61	3061	CWA274	4061	229	5061	152	
62	62	2062	B62	3062	CWA275	4062	230	5062	184	
63	63	2063	B63	3063	CWA276	4063	231	5063	187	
64	64	2064	B64	3064	CWA277	4064	232	5064	188	
65	65	2065	B65	3065	CWA278	4065	233	5065	189	
66	66	2066	B66	3066	CWA280	4066	234	5066	252	
67	67	2067	B67	3067	CWA281	4067	236	5067	253	
68	68	2068	B68	3068	CWA282	4068	237	5068	254	
69	69	2069	B69	3069	CWA283	4069	238	5069	315	
70	70	2070	B70	3070	CWA284	4070	269	5070	316	
71	71	2071	B71	3071	CWA285	4071	270	5071	317	
72	72	2072	B72	3072	CWA286	4072	271	5072	328	
73	73	2073	B73	3073	CWA288	4073	273	5073	329	
74	74	2074	B74	3074	CWA200	4074	274	5074	330	
75	75	2075	B75	3075	CWA201	4075	275	5075	331	
76	76	2076	B76	3076	CWA213	4076	276	5076	332	
77	77	2077	B77	3077	CWA294	4077	277	5077	336	
78	78	2078	B78	3078	CWA296	4078	278	5078	337	
79	79	2079	B79	3079	CWA297	4079	279	5079	339	
80	80	2080	B80	3080	CWA298	4080	280	5080	341	
81	81	2081	B81	3081	CWA299	4081	281	5081	343	
82	82	2082	B82	3082	CWA300	4082	282	5082	344	
83	83	2083	B83	3083	CWA301	4083	283	5083	345	
84	84	2084	B84	3084	CWA302	4084	284	5084	346	
85	85	2085	B85	3085	CWA303	4085	285	5085	347	

DUSLARA*		Buchanan _ Galilee*		WARLUS*		CORVEG*		Dalrymple*		Herbarium*
86	86	2086	D01	3086	CWA304	4086	286	5086	348	
87	87	2087	D02	3087	CWA305	4087	287	5087	352	
88	88	2088	D03	3088	CWA306	4088	288	5088	353	
89	89	2089	D04	3089	CWA311	4089	294	5089	354	
90	90	2090	D05	3090	CWA312	4090	299	5090	355	
91	91	2091	D06	3091	CWA313	4091	300	5091	356	
92	92	2092	D07	3092	CWA314	4092	301	5092	357	
93	93	2093	D08	3093	CWA315	4093	302	5093	358	
94	94	2094	D09	3094	CWA316	4094	303	5094	359	
95	95	2095	D10	3095	CWA317	4095	304	5095	360	
96	96	2096	D11	3096	CWA318	4096	305	5096	361	
97	97	2097	D12	3097	CWA319	4097	306	5097	386	
98	98	2098	D13	3098	CWA320	4098	307	5098	387	
99	99	2099	D14	3099	CWA321	4099	308	5099	388	
100	100	2100	D15	3100	CWA322	4100	309	5100	389	
101	101	2101	D16	3101	CWA323	4101	310	5101	390	
102	102	2102	D17	3102	CWA324	4102	311	5102	391	
103	103	2103	D18	3103	CWA325	4103	312	5103	392	
104	104	2104	D19	3104	CWA326	4104	313	5104	393	
105	105	2105	D20	3105	CWA327	4105	314	5105	394	
106	106	2106	D21	3106	CWA328	4106	315	5106	395	
107	107	2107	D22	3107	CWA329	4107	316	5107	396	
108	108	2108	G01	3108	CWA330	4108	317	5108	397	
109	109	2109	G02	3109	CWA331	4109	318	5109	398	
110	110	2110	G03	3110	CWA352	4110	325	5110	399	
111	111	2111	G04	3111	CWA353	4111	326	5111	400	
112	112	2112	G05	3112	GWA1	4112	327	5112	408	
113	113	2113	G06	3113	GWA2	4113	328	5113	409	
114	114	2114	G07	3114	GWA3	4114	329	5114	410	
115	115	2115	G08	3115	GWA4	4115	330	5115	411	
116	116	2116	G09	3116	GWA5	4116	331	5116	412	
117	117	2117	G10	3117	GWA7	4117	332	5117	420	
118	118	2118	G11	3118	GWA8	4118	333	5118	421	
119	119	2119	G12	3119	GWA9	4119	334	5119	422	
120	120	2120	G13	3120	GWA14	4120	336	5120	423	
121	121	2121	G14	3121	GWA134	4121	337	5121	427	
122	122	2122	G15	3122	GWA135	4122	338	5122	428	
123	123	2123	G16	3123	GWA136	4123	339	5123	429	
124	124	2124	G17	3124	GWA137	4124	340	5124	430	
125	125	2125	G18	3125	GWA139	4125	341	5125	431	
126	126	2126	G19	3126	GWA140	4126	342	5126	432	
127	127	2127	G20	3127	GWA141	4127	343	5127	433	
128	128	2128	G21	3128	GWA142	4128	344	5128	434	
129	129	2129	G22	3129	GWA143	4129	345	5129	435	
130	130	2130	G23	3130	GWA154	4130	346	5130	436	
131	131	2131	G24	3131	GWA156	4131	347	5131	437	
132	132	2132	G25	3132	GWA157	4132	348	5132	438	
133	133	2133	G26	3133	GWA158	4133	349	5133	439	
134	134	2134	G27	3134	GWA159	4134	350	5134	440	

DUSLARA*		Buchanan _ Galilee*		WARLUS*		CORVEG*		Dalrymple*		Herbarium*
135	135	2135	G28	3135	GWA160	4135	351	5135	441	
136	136	2136	G29	3136	GWA161	4136	352	5136	442	
137	137	2137	G30	3137	GWA162	4137	353	5137	443	
138	138	2138	G31	3138	GWA163	4138	354	5138	444	
139	139	2139	G32	3139	GWA164	4139	355	5139	445	
140	140	2140	G33	3140	GWA165	4140	356	5140	446	
141	141	2141	G34	3141	GWA166	4141	357	5141	447	
142	142	2142	G35	3142	GWA167	4142	358	5142	448	
143	143	2143	G36	3143	GWA168	4143	359	5143	449	
144	144	2144	G37	3144	GWA169	4144	360	5144	450	
145	145	2145	G38	3145	GWA170	4145	361	5145	451	
146	146	2146	G39	3146	GWA171	4146	362	5146	452	
147	147	2147	G40	3147	GWA172	4147	363	5147	453	
148	148	2148	G41	3148	GWA173	4148	364	5148	454	
149	149	2149	G42	3149	GWA174	4149	365	5149	455	
150	150	2150	G43	3150	GWA175	4150	366	5150	456	
151	151	2151	G44	3151	GWA182	4151	367	5151	457	
152	152	2152	G45	3152	GWA185	4152	368	5152	458	
153	153			3153	GWA186	4153	369	5153	459	
154	154			3154	GWA187	4154	370	5154	460	
155	155			3155	GWA188	4155	371	5155	461	
156	156			3156	GWA189	4156	372	5156	462	
157	157			3157	GWA190	4157	373	5157	463	
158	158			3158	GWA191	4158	374	5158	464	
159	159			3159	GWA192	4159	375	5159	465	
160	160			3160	GWA193	4160	376	5160	466	
161	161			3161	GWA194	4161	377	5161	467	
162	162			3162	GWA195	4162	430	5162	468	
163	163			3163	GWA196	4163	469	5163	538	
164	164			3164	GWA197	4164	495	5164	540	
165	165			3165	GWA198	4165	496	5165	541	
166	166			3166	GWA199	4166	509	5166	543	
167	167			3167	GWA202	4167	696	5167	544	
168	168			3168	GWA203	4168	697	5168	545	
169	169			3169	GWA204	4169	698	5169	546	
170	170			3170	GWA205	4170	717	5170	547	
171	171			3171	GWA206	4171	718	5171	552	
172	172			3172	GWA207	4172	719	5172	553	
173	173			3173	GWA208	4173	720	5173	554	
174	174			3174	GWA209	4174	721	5174	555	
175	175			3175	GWA210	4175	722	5175	556	
176	176			3176	GWA211	4176	723	5176	667	
177	177			3177	GWA214	4177	726	5177	668	
178	178			3178	GWA215	4178	728	5178	669	
179	179			3179	GWA216	4179	730	5179	670	
180	180			3180	GWA217	4180	731	5180	671	
181	181			3181	GWA218	4181	732	5181	677	
182	182			3182	GWA219	4182	733	5182	678	
183	183			3183	GWA220	4183	749	5183	679	

DUSLARA*		Buchanan – Galilee*	WARLUS*		CORVEG*		Dalrymple*		Herbarium*
84	184		3184	GWA221	4184	750	5184	722	
185	185		3185	GWA222	4185	751	5185	723	
186	186		3186	GWA223	4186	752	5186	724	
187	187		3187	GWA224	4187	753	5187	739	
188	188		3188	GWA225	4188	754	5188	746	
189	189		3189	GWA200	4189	756	5189	750	
190	190		3190	GWA201	4190	819	5190	752	
191	191		3191	GWA213	4191	824	5191	753	
192	192				4192	825	5192	754	
193	193				4193	826	5193	755	
194	194				4194	829	5194	756	
195	195				4195	830	5195	757	
196	196				4196	831	5196	758	
197	197				4197	832	5197	759	
198	198				4198	844	5198	760	
199	199				4199	845	5199	761	
200	200				4200	846	5200	762	
201	201				4201	847	5201	763	
202	202				4202	848	5202	764	
203	203				4203	849	5203	765	
204	204				4204	850	5204	766	
205	205				4205	851	5205	767	
206	206				4206	852	5206	768	
207	207				4207	853	5207	769	
208	208				4208	854	5208	770	
209	209				4209	855	5209	771	
210	210				4210	856	5210	772	
211	211				4211	857	5211	773	
212	212				4212	858	5212	774	
213	213				4213	859	5213	775	
214	214				4214	869	5214	776	
215	215				4215	894	5215	777	
216	216				4216	895	5216	778	
217	217				4217	896	5217	779	
218	218				4218	897	5218	780	
219	219				4219	898	5219	781	
220	220				4220	938	5220	782	
221	221				4221	939	5221	783	
222	222				4222	961	5222	784	
223	223				4223	962	5223	785	
224	224				4224	963	5224	786	
225	225				4225	964	5225	787	
226	226				4226	965	5226	788	
227	227				4227	966	5227	789	
228	228				4228	967	5228	790	
229	229				4229	968	5229	791	
230	230				4230	969	5230	792	
231	231				4231	970	5231	793	
232	232				4232	971	5232	794	

DUSLARA*		Buchanan – Galilee*		WARLUS*		CORVEG*		Dalrymple*		Herbarium*	
233	233					4233	972	5233	795		
234	234					4234	973	5234	796		
235	235					4235	974	5235	797		
236	236					4236	975	5236	798		
237	237					4237	976	5237	799		
238	238					4238	977	5238	800		
239	239					4239	979	5239	801		
240	240					4240	980	5240	802		
241	241					4241	981	5241	803		
242	242					4242	982	5242	804		
243	243					4243	986	5243	805		
244	244					4244	1004	5244	806		
245	245					4245	1006	5245	807		
246	246					4246	1007	5246	808		
247	247					4247	1008	5247	809		
248	248					4248	1090	5248	810		
249	249					4249	1091	5249	811		
250	250					4250	1092	5250	812		
251	251					4251	1093	5251	813		
252	252					4252	1094	5252	814		
253	253					4253	1095	5253	815		
254	254					4254	1097	5254	816		
255	255					4255	1098	5255	817		
256	256					4256	1099	5256	818		
257	257					4257	1100	5257	819		
258	258					4258	1101	5258	820		
259	259					4259	1102	5259	821		
260	260					4260	1104	5260	822		
261	261					4261	1105	5261	823		
262	262					4262	1106	5262	824		
263	263					4263	1108	5263	825		
264	264					4264	1109	5264	826		
265	265					4265	1110	5265	827		
266	266					4266	1111	5266	828		
267	267					4267	1112	5267	829		
268	268					4268	1117	5268	830		
269	269					4269	1118	5269	831		
270	270					4270	364001	5270	832		
271	271					4271	364002	5271	833		
272	272					4272	364003	5272	834		
273	273					4273	364004	5273	835		
274	274					4274	364005	5274	836		
275	275					4275	364006	5275	837		
276	276					4276	367001	5276	838		
277	277					4277	367002	5277	839		
278	278					4278	367003	5278	840		
279	279					4279	367004	5279	841		
280	280					4280	367005	5280	842		
281	281					4281	367006	5281	843		

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
282	282			4282	367007	5282	844	
283	283			4283	367008	5283	845	
284	284			4284	367009	5284	846	
285	285			4285	367010	5285	847	
286	286			4286	367011	5286	848	
287	287			4287	367012	5287	849	
288	288			4288	367013	5288	850	
289	289			4289	367014	5289	851	
290	290			4290	367015	5290	852	
291	291			4291	367016	5291	853	
292	292			4292	367017	5292	854	
293	293			4293	367018	5293	855	
294	294			4294	367019	5294	856	
295	295			4295	367020	5295	857	
296	296			4296	367021	5296	858	
297	297			4297	367022	5297	859	
298	298			4298	368001	5298	860	
299	299			4299	368002	5299	861	
300	300			4300	368003	5300	862	
301	301			4301	368004	5301	863	
302	302			4302	368005	5302	905	
303	303			4303	368006	5303	906	
304	304			4304	368007	5304	907	
305	305			4305	368008	5305	908	
306	306			4306	368009	5306	910	
307	307			4307	368011	5307	911	
308	308			4308	368012	5308	923	
309	309			4309	368013	5309	924	
310	310			4310	368015	5310	925	
311	311			4311	368016	5311	926	
312	312			4312	368017	5312	927	
313	313			4313	368018	5313	928	
314	314			4314	368019	5314	929	
315	315			4315	368020	5315	930	
316	316			4316	368021	5316	931	
317	317			4317	368022	5317	932	
318	318			4318	368023	5318	933	
319	319			4319	368024	5319	934	
320	320			4320	368025	5320	935	
321	321			4321	368026	5321	936	
322	322			4322	368027	5322	937	
323	323			4323	368028	5323	938	
324	324			4324	368029	5324	939	
325	325			4325	368034	5325	940	
326	326			4326	368035	5326	941	
327	327			4327	368036	5327	943	
328	328			4328	368037	5328	945	
329	329			4329	368038	5329	946	
330	330			4330	368039	5330	947	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
331	331			4331	368040	5331	953	
332	332			4332	368041	5332	954	
333	333			4333	368042	5333	955	
334	334			4334	368043	5334	956	
335	335			4335	368044	5335	957	
336	336			4336	368045	5336	958	
337	337			4337	368046	5337	959	
338	338			4338	368047	5338	960	
339	339			4339	368048	5339	961	
340	340			4340	368049	5340	962	
341	341			4341	368050	5341	963	
342	342			4342	368051	5342	969	
343	343			4343	368052	5343	970	
344	344			4344	368053	5344	971	
345	345			4345	368054	5345	972	
346	346			4346	368055	5346	973	
347	347			4347	368057	5347	974	
348	348			4348	368058	5348	975	
349	349			4349	368059	5349	976	
350	350			4350	368060	5350	977	
351	351			4351	368061	5351	978	
352	352			4352	368062	5352	979	
353	353			4353	368063	5353	980	
354	354			4354	368064	5354	981	
355	355			4355	368065	5355	982	
356	356			4356	368066	5356	983	
357	357			4357	368067	5357	984	
358	358			4358	368068	5358	985	
359	359			4359	368069	5359	986	
360	360			4360	368070	5360	987	
361	361			4361	368071	5361	988	
362	362			4362	368072	5362	989	
363	363			4363	368076	5363	990	
364	364			4364	368077	5364	991	
365	365			4365	368078	5365	992	
366	366			4366	368079	5366	993	
367	367			4367	368080	5367	994	
368	368			4368	368087	5368	995	
369	369			4369	368088	5369	996	
370	370			4370	368089	5370	997	
371	371			4371	368090	5371	998	
372	372			4372	368091	5372	999	
373	373			4373	368092	5373	1026	
374	374			4374	368093	5374	1027	
375	375			4375	368094	5375	1037	
376	376			4376	368095	5376	1038	
377	377			4377	368096	5377	1039	
378	378			4378	368098	5378	1040	
379	379			4379	368099	5379	1041	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
380	380			4380	368100	5380	1042	
381	381			4381	368101	5381	1043	
382	382			4382	368102	5382	1044	
383	383			4383	368103	5383	1045	
384	384			4384	368104	5384	1046	
385	385			4385	368109	5385	1047	
386	386			4386	368110	5386	1048	
387	387			4387	368111	5387	1049	
388	388			4388	368112	5388	1050	
389	389			4389	368113	5389	1055	
390	390			4390	368114	5390	1056	
391	391			4391	368115	5391	1057	
392	392			4392	368116	5392	1065	
393	393			4393	368117	5393	1066	
394	394			4394	368118	5394	1067	
395	395			4395	368119	5395	1068	
396	396			4396	368120	5396	1069	
397	397			4397	368121	5397	1074	
398	398			4398	368122	5398	1075	
399	399			4399	368123	5399	1078	
400	400			4400	368124	5400	1079	
401	401			4401	368125	5401	1080	
402	402			4402	368126	5402	1124	
403	403			4403	368127	5403	1125	
404	404			4404	368128	5404	1126	
405	405			4405	368129	5405	1127	
406	406			4406	368130	5406	1128	
407	407			4407	393001	5407	1129	
408	408			4408	397002	5408	1130	
409	409			4409	397007	5409	1131	
410	410			4410	397020	5410	1138	
411	411			4411	397025	5411	1167	
412	412			4412	397038	5412	1168	
413	413			4413	397042	5413	1169	
414	414			4414	397048	5414	1170	
415	415			4415	400270	5415	1171	
416	416			4416	400273	5416	1172	
417	417			4417	400276	5417	1173	
418	418			4418	400277	5418	1174	
419	419			4419	400278	5419	1175	
420	420			4420	400279	5420	1176	
421	421			4421	400301	5421	1177	
422	422			4422	400302	5422	1178	
423	423			4423	400305	5423	1179	
424	424			4424	400306	5424	1180	
425	425			4425	400321	5425	1181	
426	426			4426	400322	5426	1182	
427	427			4427	400323	5427	1183	
428	428			4428	400324	5428	1184	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
429	429			4429	400339	5429	1185	
430	430			4430	400340	5430	1186	
431	431			4431	400506	5431	1187	
432	432			4432	400507	5432	1345	
433	433			4433	400508	5433	1346	
434	434			4434	400509	5434	1358	
435	435			4435	400510	5435	1370	
436	436			4436	400511	5436	1371	
437	437			4437	400512	5437	1390	
438	438			4438	400513	5438	1391	
439	439			4439	400514	5439	1392	
440	440			4440	400515	5440	1393	
441	441			4441	400517	5441	1394	
442	442			4442	400518	5442	1395	
443	443			4443	400519	5443	1396	
444	444			4444	400520	5444	1397	
445	445			4445	400521	5445	1398	
446	446			4446	400522	5446	1399	
447	447			4447	400524	5447	1400	
448	448			4448	400525	5448	1401	
449	449			4449	400526	5449	1402	
450	450			4450	400527	5450	1403	
451	451			4451	400528	5451	1404	
452	452			4452	400531	5452	1405	
453	453			4453	400532	5453	1406	
454	454			4454	400533	5454	1407	
455	455			4455	400534	5455	1408	
456	456			4456	400535	5456	1409	
457	457			4457	400538	5457	1410	
458	458			4458	400539	5458	1411	
459	459			4459	400540	5459	1412	
460	460			4460	400541	5460	1413	
461	461			4461	400554	5461	1414	
462	462			4462	400555	5462	1415	
463	463			4463	400556	5463	1423	
464	464			4464	400557	5464	1424	
465	465			4465	400558	5465	1425	
466	466			4466	400559	5466	1426	
467	467			4467	400560	5467	1427	
468	468			4468	400567	5468	1428	
469	469			4469	400568	5469	1429	
470	470			4470	400569	5470	1430	
471	471			4471	400570	5471	1431	
472	472			4472	400571	5472	1432	
473	473			4473	400572	5473	1433	
474	474			4474	400573	5474	1434	
475	475			4475	400574	5475	1435	
476	476			4476	400575	5476	1436	
477	477			4477	400576	5477	1437	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
478	478			4478	400577	5478	1438	
479	479			4479	400578	5479	1439	
480	480			4480	400579	5480	1440	
481	481			4481	400580	5481	1441	
482	482			4482	400581	5482	1442	
483	483			4483	400582	5483	1443	
484	484			4484	400583	5484	1444	
485	485			4485	400584	5485	1445	
486	486			4486	400585	5486	1446	
487	487			4487	400586	5487	1447	
488	488			4488	400587	5488	1448	
489	489			4489	400609	5489	1449	
490	490			4490	400921	5490	1450	
491	491			4491	400922	5491	1451	
492	492			4492	400923	5492	1452	
493	493			4493	400927	5493	1453	
494	494			4494	400928	5494	1454	
495	495			4495	401056	5495	1455	
496	496			4496	401058	5496	1456	
497	497			4497	401059	5497	1457	
498	498			4498	401060	5498	1458	
499	499			4499	401075	5499	1459	
500	500			4500	401079	5500	1460	
501	501			4501	401080	5501	1461	
502	502			4502	401081	5502	1462	
503	503			4503	401082	5503	1463	
504	504			4504	401084	5504	1464	
505	505			4505	401085	5505	1465	
506	506			4506	401086	5506	1466	
507	507			4507	401087	5507	1467	
508	508			4508	401088	5508	1468	
509	509			4509	401089	5509	1469	
510	510			4510	401090	5510	1470	
511	511			4511	401091	5511	1471	
512	512			4512	401092	5512	1472	
513	513			4513	401093	5513	1473	
514	514			4514	401094	5514	1474	
515	515			4515	401105	5515	1475	
516	516			4516	401109	5516	1476	
517	517			4517	401110	5517	1477	
518	518			4518	401111	5518	1478	
519	519			4519	401112	5519	1479	
520	520			4520	401113	5520	1480	
521	521			4521	401114	5521	1481	
522	522			4522	401115	5522	1482	
523	523			4523	401116	5523	1483	
524	524			4524	401117	5524	1484	
525	525			4525	401118	5525	1485	
526	526			4526	401119	5526	1486	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
527	527			4527	401120	5527	1487	
528	528			4528	401121	5528	1488	
529	529			4529	401122	5529	1489	
530	530			4530	401123	5530	1490	
531	531			4531	401124	5531	1491	
532	532			4532	401125	5532	1492	
533	533			4533	401126	5533	1493	
534	534			4534	401127	5534	1494	
535	535			4535	401128	5535	1495	
536	536			4536	401129	5536	1496	
537	537			4537	401130	5537	1497	
538	538			4538	401132	5538	1498	
539	539			4539	401135	5539	1499	
540	540			4540	401136	5540	1503	
541	541			4541	401137	5541	1504	
542	542			4542	401138	5542	1505	
543	543			4543	420001	5543	1506	
544	544			4544	422001	5544	1507	
545	545			4545	423001	5545	1508	
546	546			4546	423002	5546	1509	
547	547			4547	423004	5547	1510	
548	548			4548	423005	5548	1511	
549	549			4549	447001	5549	1512	
550	550			4550	447002	5550	1513	
551	551			4551	448001	5551	1514	
552	552			4552	859001	5552	1515	
553	553			4553	859002	5553	1516	
554	554			4554	859003	5554	1517	
555	555			4555	859021	5555	1518	
556	556			4556	859022	5556	1519	
557	557			4557	859023	5557	1520	
558	558			4558	859024	5558	1521	
559	559			4559	859025	5559	1522	
560	560			4560	859026	5560	1523	
561	561			4561	859027	5561	1524	
562	562			4562	859028	5562	1525	
563	563			4563	859029	5563	1526	
564	564			4564	859030	5564	1527	
565	565			4565	859031	5565	1528	
566	566			4566	859032	5566	1529	
567	567			4567	863002	5567	1530	
568	568			4568	863003	5568	1531	
569	569			4569	863004	5569	1532	
570	570			4570	863005	5570	1533	
571	571			4571	863006	5571	1534	
572	572			4572	863007	5572	1535	
573	573			4573	863008	5573	1536	
574	574			4574	863009	5574	1537	
575	575			4575	863010	5575	1538	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
576	576			4576	863011	5576	1539	
577	577			4577	863012	5577	1540	
578	578			4578	863013	5578	1541	
579	579			4579	863020	5579	1542	
580	580			4580	863021	5580	1543	
581	581			4581	863026	5581	1544	
582	582			4582	863027	5582	1545	
583	583			4583	863028	5583	1546	
584	584			4584	863029	5584	1547	
585	585			4585	863030	5585	1548	
586	586			4586	863031	5586	1549	
587	587			4587	863032	5587	1550	
588	588			4588	863033	5588	1551	
589	589			4589	863034	5589	1552	
590	590			4590	863035	5590	1553	
591	591			4591	863036	5591	1554	
592	592			4592	863037	5592	1555	
593	593			4593	863038	5593	1556	
594	594			4594	863039	5594	1557	
595	595			4595	863040	5595	1558	
596	596			4596	863041	5596	1559	
597	597			4597	863042	5597	1560	
598	598			4598	863043	5598	1561	
599	599			4599	863044	5599	1562	
600	600			4600	863045	5600	1563	
601	601			4601	864008	5601	1564	
602	602			4602	864010	5602	1566	
603	603			4603	864011	5603	1567	
604	604			4604	864012	5604	1568	
605	605			4605	864013	5605	1569	
606	606			4606	864014	5606	1570	
607	607			4607	864015	5607	1571	
608	608			4608	864016	5608	1572	
609	609			4609	864017	5609	1581	
610	610			4610	864019	5610	1582	
611	611			4611	867001	5611	1583	
612	612			4612	867002	5612	1584	
613	613			4613	867003	5613	1585	
614	614			4614	867005	5614	1586	
615	615			4615	867007	5615	1587	
616	616			4616	867009	5616	1588	
617	617			4617	867010	5617	1589	
618	618			4618	867011	5618	1590	
619	619			4619	867012	5619	1591	
620	620			4620	867013	5620	1592	
621	621			4621	867014	5621	1605	
622	622			4622	867015	5622	1606	
623	623			4623	867016	5623	1607	
624	624			4624	867017	5624	1620	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
625	625			4625	867018	5625	1621	
626	626			4626	867019	5626	1622	
627	627			4627	867021	5627	1623	
628	628			4628	867022	5628	1624	
629	629			4629	867023	5629	1625	
630	630			4630	867024	5630	1626	
631	631			4631	867025	5631	1627	
632	632			4632	867026	5632	1628	
633	633			4633	867027	5633	1629	
634	634			4634	867028	5634	1630	
635	635			4635	867029	5635	1631	
636	636			4636	867030	5636	1632	
637	637			4637	867031	5637	1633	
638	638			4638	867032	5638	1634	
639	639			4639	867033	5639	1635	
640	640			4640	867034	5640	1636	
641	641			4641	867035	5641	1637	
642	642			4642	867036	5642	1638	
643	643			4643	867037	5643	1643	
644	644			4644	867038	5644	1644	
645	645			4645	867039	5645	1645	
646	646			4646	867040	5646	1646	
647	647			4647	867041	5647	1647	
648	648			4648	867042	5648	1648	
649	649			4649	867043	5649	1649	
650	650			4650	867044	5650	1691	
651	651			4651	867045	5651	1692	
652	652			4652	867046	5652	1693	
653	653			4653	867047	5653	1694	
654	654			4654	867048	5654	1695	
655	655			4655	867049	5655	1696	
656	656			4656	867050	5656	1697	
657	657			4657	867051	5657	1698	
658	658			4658	867052	5658	1699	
659	659			4659	867053	5659	1700	
660	660			4660	867054	5660	1701	
661	661			4661	867055	5661	1702	
662	662			4662	867056	5662	1703	
663	663			4663	867057	5663	1704	
664	664			4664	867058	5664	1705	
665	665			4665	867059	5665	1706	
666	666			4666	867060	5666	1707	
667	667			4667	867061	5667	1708	
668	668			4668	867062	5668	1709	
669	669			4669	867063	5669	1710	
670	670			4670	867064	5670	1711	
671	671			4671	867065	5671	1712	
672	672			4672	868001	5672	1713	
673	673			4673	868002	5673	1714	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
674	674			4674	871001	5674	1715	
675	675			4675	871002	5675	1716	
676	676			4676	871003	5676	1717	
677	677			4677	871004	5677	1718	
678	678			4678	871005	5678	1719	
679	679			4679	871007	5679	1720	
680	680			4680	871008	5680	1721	
681	681			4681	871009	5681	1722	
682	682			4682	871010	5682	1723	
683	683			4683	871012	5683	1724	
684	684			4684	871013	5684	1725	
685	685			4685	872001	5685	1726	
686	686			4686	872002	5686	1727	
687	687			4687	872003	5687	1728	
688	688			4688	872004	5688	1734	
689	689			4689	872005	5689	1735	
690	690			4690	872006	5690	1736	
691	691			4691	872007	5691	1737	
692	692			4692	872008	5692	1738	
693	693			4693	872009	5693	1740	
694	694			4694	872010	5694	1741	
695	695			4695	872014	5695	1742	
696	696			4696	872016	5696	1743	
697	697			4697	872017	5697	1744	
698	698			4698	872018	5698	1745	
699	699			4699	872019	5699	1746	
700	700			4700	872020	5700	1747	
701	701			4701	872021	5701	1748	
702	702			4702	872022	5702	1749	
703	703			4703	872024	5703	1750	
704	704			4704	872025	5704	1751	
705	705			4705	872026	5705	1752	
706	706			4706	872027	5706	1753	
707	707			4707	892001	5707	1754	
708	708			4708	892002	5708	1755	
709	709			4709	892004	5709	1756	
710	710			4710	892005	5710	1757	
711	711			4711	892006	5711	1758	
712	712			4712	892007	5712	1759	
713	713			4713	892008	5713	1760	
714	714			4714	892009	5714	1761	
715	715			4715	892010	5715	1762	
716	716			4716	103	5716	1785	
717	717			4717	324	5717	1786	
718	718			4718	401	5718	1787	
719	719			4719	409	5719	1788	
720	720			4720	411	5720	1789	
721	721			4721	412	5721	1790	
722	722			4722	413	5722	1835	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
723	723			4723	414	5723	1836	
724	724			4724	415	5724	1837	
725	725			4725	416	5725	1842	
726	726			4726	417	5726	1845	
727	727			4727	418	5727	1851	
728	728			4728	419	5728	1852	
729	729			4729	420	5729	1853	
730	730			4730	421	5730	1854	
731	731			4731	422	5731	1855	
732	732			4732	423	5732	1856	
733	733			4733	424	5733	1857	
734	734			4734	425	5734	1859	
735	735			4735	426	5735	1860	
736	736			4736	427	5736	1861	
737	737			4737	428	5737	1862	
738	738			4738	429	5738	1866	
739	739			4739	431	5739	1867	
740	740			4740	433	5740	1868	
741	741			4741	434	5741	2039	
742	742			4742	435	5742	2040	
743	743			4743	436	5743	2041	
744	744			4744	437	5744	2082	
745	745			4745	438	5745	2083	
746	746			4746	439	5746	2084	
747	747			4747	441	5747	2085	
748	748			4748	460	5748	2086	
749	749			4749	463	5749	2151	
750	750			4750	465	5750	2152	
751	751			4751	466	5751	2166	
752	752			4752	467	5752	2167	
753	753			4753	468	5753	2168	
754	754			4754	472	5754	2169	
755	755			4755	473	5755	2506	
756	756			4756	474	5756	2507	
757	757			4757	475	5757	2519	
758	758			4758	476	5758	2520	
759	759			4759	478	5759	2521	
760	760			4760	479	5760	2522	
761	761			4761	480	5761	2523	
762	762			4762	481	5762	2524	
763	763			4763	482	5763	2525	
764	764			4764	483	5764	2526	
765	765			4765	484	5765	2527	
766	766			4766	485	5766	2528	
767	767			4767	487	5767	2529	
768	768			4768	488	5768	2530	
769	769			4769	489	5769	2531	
770	770			4770	490	5770	2532	
771	771			4771	491	5771	2541	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
772	772			4772	492	5772	2542	
773	773			4773	493	5773	2543	
774	774			4774	494	5774	2544	
775	775			4775	501	5775	2545	
776	776			4776	510	5776	2546	
777	777			4777	511	5777	2547	
778	778			4778	512	5778	2548	
779	779			4779	513	5779	2549	
780	780			4780	514	5780	2550	
781	781			4781	515	5781	2551	
782	782			4782	516	5782	2552	
783	783			4783	517	5783	2553	
784	784			4784	518	5784	2554	
785	785			4785	519	5785	2555	
786	786			4786	520	5786	2556	
787	787			4787	521	5787	2557	
788	788			4788	522	5788	2558	
789	789			4789	525	5789	2559	
790	790			4790	526	5790	2560	
791	791			4791	546	5791	2561	
792	792			4792	547	5792	2562	
793	793			4793	548	5793	2563	
794	794			4794	549	5794	2564	
795	795			4795	550	5795	2565	
796	796			4796	552	5796	2570	
797	797			4797	553	5797	3000**	
798	798			4798	554	5798	3001**	
799	799			4799	555	5799	3002*	
800	800			4800	563	5800	3003	
801	801			4801	566	5801	3004	
802	802			4802	572	5802	3005	
803	803			4803	573	5803	3006	
804	804			4804	574	5804	3007	
805	805			4805	575	5805	3008	
806	806			4806	576	5806	3009	
807	807			4807	577	5807	3010	
808	808			4808	578	5808	3011	
809	809			4809	585	5809	3012	
810	810			4810	586	5810	3013	
811	811			4811	587	5811	3014	
812	812			4812	589	5812	3015	
813	813			4813	590	5813	3016	
814	814			4814	591	5814	3017	
815	815			4815	592	5815	3018	
816	816			4816	593	5816	3019	
817	817			4817	594	5817	3020	
818	818			4818	595	5818	3021	
819	819			4819	596	5819	3037	
820	820			4820	597	5820	3038	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
821	821			4821	598	5821	3039	
822	822			4822	599	5822	3040	
823	823			4823	600	5823	3041	
824	824			4824	601	5824	3042	
825	825			4825	602	5825	3043	
826	826			4826	603	5826	3044	
827	827			4827	604	5827	3045	
828	828			4828	605	5828	3046	
829	829			4829	607	5829	3047	
830	830			4830	608	5830	3048	
831	831			4831	609	5831	3049	
832	832			4832	611	5832	3050	
833	833			4833	612	5833	3051	
834	834			4834	613	5834	3052	
835	835			4835	614	5835	3053	
836	836			4836	619	5836	3054	
837	837			4837	622	5838	61	
838	838			4838	623	5839	62	
839	839			4839	624	5840	64	
840	840			4840	625	5841	65	
841	841			4841	626	5842	66	
842	842			4842	627	5843	67	
843	843			4843	628	5844	98	
844	844			4844	629	5845	124	
845	845			4845	630	5846	125	
846	846			4846	631	5847	185	
847	847			4847	632	5848	186	
848	848			4848	633	5849	273	
849	849			4849	634	5850	277	
850	850			4850	635	5851	278	
851	851			4851	636	5852	279	
852	852			4852	637	5853	280	
853	853			4853	638	5854	281	
854	854			4854	639	5855	282	
855	855			4855	640	5856	314	
856	856			4856	641	5857	334	
857	857			4857	642	5858	338	
858	858			4858	643	5859	340	
859	859			4859	644	5860	342	
860	860			4860	645	5861	351	
861	861			4861	646	5862	401	
862	862			4862	647	5863	402	
863	863			4863	648	5864	403	
864	864			4864	649	5865	404	
865	865			4865	650	5866	405	
866	866			4866	651	5867	406	
867	867			4867	652	5868	407	
868	868			4868	662	5869	419	
869	869			4869	674	5870	424	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
870	870			4870	675	5871	425	
871	871			4871	676	5872	426	
872	872			4872	689	5873	489	
873	873			4873	690	5874	537	
874	874			4874	755	5875	539	
875	875			4875	757	5876	546	
876	876			4876	758	5877	548	
877	877			4877	759	5878	640	
878	878			4878	760	5879	718	
879	879			4879	761	5880	725	
880	880			4880	762	5881	727	
881	881			4881	763	5882	748	
882	882			4882	764	5883	885	
883	883			4883	765	5884	886	
884	884			4884	766	5885	909	
885	885			4885	767	5886	912	
886	886			4886	768	5887	913	
887	887			4887	769	5888	914	
888	888			4888	770	5889	915	
889	889			4889	771	5890	916	
890	890			4890	772	5891	917	
891	891			4891	773	5892	918	
892	892			4892	774	5893	919	
893	893			4893	788	5894	920	
894	894			4894	789	5895	921	
895	895			4895	790	5896	922	
896	896			4896	791	5897	942	
897	897			4897	792	5898	944	
898	898			4898	806	5899	948	
899	899			4899	820	5900	949	
900	900			4900	822	5901	950	
901	901			4901	978	5902	951	
902	902			4902	983	5903	952	
903	903			4903	984	5904	967	
904	904			4904	985	5905	968	
905	905			4905	987	5906	1028	
906	906			4906	988	5907	1054	
907	907			4907	989	5908	1058	
908	908			4908	998	5909	1070	
909	909			4909	999	5910	1071	
910	910			4910	1000	5911	1072	
911	911			4911	1001	5912	1073	
912	912			4912	1002	5913	1076	
913	913			4913	1003	5914	1077	
914	914			4914	1014	5915	1122	
915	915			4915	1015	5916	1123	
916	916			4916	1016	5917	1188	
917	917			4917	1017	5918	1189	
918	918			4918	1018	5919	1357	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
919	919			4919	1019	5920	1359	
920	920			4920	1020	5921	1360	
921	921			4921	1021	5922	1363	
922	922			4922	1022	5923	1364	
923	923			4923	1039	5924	1365	
924	924			4924	1040	5925	1366	
925	925			4925	1041	5926	1368	
926	926			4926	1042	5927	1369	
927	927			4927	1096	5928	1372	
928	928			4928	1129	5929	1373	
929	929			4929	1130	5930	1416	
930	930			4930	1135	5931	1417	
931	931			4931	1136	5932	1418	
932	932			4932	1137	5933	1419	
933	933			4933	1239	5934	1420	
934	934			4934	1240	5935	1421	
935	935			4935	1242	5936	1422	
936	936			4936	1243	5937	1500	
937	937			4937	1244	5938	1501	
938	938			4938	1245	5939	1502	
939	939			4939	1246	5940	1565	
940	940			4940	1247	5941	1573	
941	941			4941	1248	5942	1574	
942	942			4942	1249	5943	1575	
943	943			4943	1251	5944	1576	
944	944			4944	1252	5945	1577	
945	945			4945	1253	5946	1578	
946	946			4946	1254	5947	1579	
947	947			4947	1255	5948	1580	
948	948			4948	1256	5949	1763	
949	949			4949	1257	5950	1764	
950	950			4950	1259	5951	1765	
951	951			4951	1268	5952	1766	
952	952			4952	1269	5953	1767	
953	953			4953	1274	5954	1784	
954	954			4954	1275	5955	1838	
955	955			4955	1277	5956	1839	
956	956			4956	1301	5957	1840	
957	957			4957	368010	5958	1841	
958	958			4958	368014	5959	1843	
959	959			4959	368030	5960	1844	
960	960			4960	368031	5961	1846	
961	961			4961	368032	5962	1847	
962	962			4962	368033	5963	1848	
963	963			4963	368073	5964	1849	
964	964			4964	368074	5965	1850	
965	965			4965	368075	5966	1858	
966	966			4966	368081	5967	1863	
967	967			4967	368082	5968	1864	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
968	968			4968	368083	5969	1865	
969	969			4969	368084	5970	1965	
970	970			4970	368085	5971	1967	
971	971			4971	368086	5972	2015	
972	972			4972	368097	5973	2030	
973	973			4973	368105	5974	2031	
974	974			4974	368106	5975	2036	
975	975			4975	368107	5976	2037	
976	976			4976	368108	5977	2038	
977	977			4977	397001	5978	2042	
978	978			4978	397003	5979	2043	
979	979			4979	397004	5980	2057	
980	980			4980	397005	5981	2058	
981	981			4981	397006	5982	2074	
982	982			4982	397008	5983	2075	
983	983			4983	397009	5984	2100	
984	984			4984	397010	5985	2101	
985	985			4985	397011	5986	2102	
986	986			4986	397012	5987	2103	
987	987			4987	397013	5988	2104	
988	988			4988	397014	5989	2105	
989	989			4989	397015	5990	2150	
990	990			4990	397016	5991	2153	
991	991			4991	397017	5992	2154	
992	992			4992	397018	5993	2155	
993	993			4993	397019	5994	2156	
994	994			4994	397021	5995	2157	
995	995			4995	397022	5996	2158	
996	996			4996	397023	5997	2159	
997	997			4997	397024	5998	2160	
998	998			4998	397026	5999	2161	
999	999			4999	397027	6000	2162	
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1001	1001			3501	397029	6002	2171	
1002	1002			3502	397030	6003	2172	
1003	1003			3503	397031	6004	2173	
1004	1004			3504	397032	6005	2174	
1005	1005			3505	397033	6006	2175	
1006	1006			3506	397034	6007	2176	
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1008	1008			3508	397036	6009	2178	
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1010	1010			3510	397039	6011	2181	
1011	1011			3511	397040	6012	2182	
1012	1012			3512	397041	6013	2183	
1013	1013			3513	397043	6014	2427	
1014	1014			3514	397044	6015	2428	
1015	1015			3515	397045	6016	2429	
1016	1016			3516	397046	6017	2430	

DUSLARA*		Buchanan – Galilee*	WARLUS*	CORVEG*		Dalrymple*		Herbarium*
1017	1017			3517	397047	6018	2431	
1018	1018			3518	397049	6019	2432	
1019	1019			3519	397050	6020	2433	
1020	1020			3520	397051	6021	2434	
1021	1021			3521	397052	6022	2435	
1022	1022			3522	397053	6023	2436	
1023	1023			3523	397054	6024	2437	
1024	1024			3524	397055	6025	2438	
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1027	1027			3527	397058			
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1041	1041			3541	859009			
1042	1042			3542	859010			
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1048	1048			3548	859016			
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1065	1065			3565	860028			

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Buchanan – Galilee*: Lorimer 1998

CORVEG*: EPA Herbarium database

DUSLARA*: Lorimer 2003

Dalrymple*: Rogers *et al*. 1999

Herbarium*: Various opportunistic Herbarium survey sites

WARLUS*: Turner *et al*. 1978, Turner *et al*. 1993

8. Glossary and abbreviations

A

ACCESS	An abbreviation for a computer database program
Acidic	When the pH (1:5 H_2O) is less than 5.5
Aeolian	Of wind-blown origin
AGD84	An abbreviation for Australian Geodetic Datum 1984
Aggrading	The deposition of unconsolidated deposits by aeolian, marine or fluvial processes, when the quantity or caliber of the load is greater than the competence of the transporting medium to carry it, or as a result of mass movement
Aggregate	A mass of soil particles held together by organic gums and molecular bonds
AHD	An abbreviation for Australian Height Datum
Alluvial apron	An alluvial plain, of gentle gradient, formed by several alluvial fans coalescing
Alluvial fan	A fan shaped body of alluvium typically built up where a stream leaves a steep mountain valley
Alluvium	Sediment deposited by streams and rivers in non-marine environments
AMG	An abbreviation for Australian Map Grid
Amphibole	A common mineral found in rocks
Ancestral	Linked to the past
ANUSPLIN	An abbreviation for a computer climate model run by the Australian National University
Aquifer	Stratum or zone below the surface of the earth capable of producing water, as from a well
Arenaceous	Sandy in texture, or applied to rocks composed of cemented, usually quartz, sand.
Arenic	A term to describe a loose, or weakly coherent sandy soil layer (<10% clay) that may have aeolian cross bedding and <2% gravel
Argillaceous sandstone	A term for sediments with a high proportion of clay laid down under water
Artesian	Groundwater with sufficient hydrostatic head (pressure) to rise above the ground surface
Artiscope	A piece of equipment that allows lines or points of information on maps or photographs at a specific scale to be traced or transferred to another map at a different scale, using a series of adjustable lights and mirrors
ASL	An abbreviation for Above Sea Level
Average	The sum of all values divided by the number of items providing those values

B

Badlands	Landform pattern of low to extremely low relief (less than 90m) and steep to precipitous slopes, typically with numerous fixed erosional stream channels that form a non-directional integrated tributary network. There is continuously active erosion by collapse, landslide, sheet flow, creep and channel stream flow.
Basalt	A fine grained volcanic rock with the composition of a gabbro
Base status	The sum of the basic cations (Ca, K, Mg, Na) expressed in cmol per kg clay multiplied by 100 and divided by the clay percentage of the sample
Basic	Soil materials that are not calcareous and not strongly acid

Beach ridge	Very long, nearly straight low ridge, built up by waves and usually modified by wind
Bedrock	The continuous mass of solid rock that makes up the earth's crust
Biomass	The total mass of living organisms
Bioregion	An area with a unique geology, geomorphology, climate and arrangement of soil-vegetation associations
Biota	Animal and plant life of a region
Bitterlich stick	A simple apparatus used to estimate the basal area (or volume) of tree species at a site
Bleach	Soil horizons that are white, near white or much paler than adjacent horizons
Bolus	Soil (or other) material pressed together to form a round coherent mass
BOM	An abbreviation for Bureau of Meteorology
Buffer strips	Varying width vegetative strips retained around an area of particular interest or value to provide protection from a perceived degradation process

C

Calcarosol	A soil that is calcareous throughout the solum – the A1 or Ap horizon may be non-calcareous, and there is no clear or abrupt textural boundary to the B horizon
Calcrete	A solid almost impervious layer of calcium carbonate in a soil profile, also referred to as caliche
Cation	An ion, usually with a positive charge, that would move towards a cathode
Cation exchange capacity (CEC)	The total of exchangeable cations that a soil can absorb being made up of calcium, magnesium, potassium, sodium, aluminium and hydrogen. CEC affects soil properties and behaviour, stability of structure, the availability of some nutrients for plant growth, and soil pH
CD-ROM	An abbreviation for Compact Disc with Read Only Memory – used to store digital information
CEC	An abbreviation for cation exchange capacity
Chromosol	A soil with a clear or abrupt textural boundary to the B horizon, and in which the major part of the upper 0.2m of the B horizon is not sodic or strongly acid
Cladode	A photosynthetic branch, or specialized stem structure, that resemble and perform the functions of a leaf - also called a cladophyll, e.g. prickly pear (*Opuntia* sp.)
Clastic	Fragments of rocks
cm	An abbreviation for centimetre
cmol	An abbreviation for centi-mole, or one hundredth part of the molecular weight
Columnar	Soil particles arranged around a vertical axis and bounded by well defined, relatively flat faces with much accommodation to the faces of surrounding peds and a domed top
Colluvium	Sediment mass deposited from transport down a slope by gravity (scree), landslide, mudflow, creep, or sheet flow but not by stream flow
Conglomerate	A sedimentary rock composed of fragments of rounded gravel set in a finer grained matrix
Consistence	A measure of the force required to break down an air-dried lump of soil (approx. 2cm diameter) between thumb and forefinger
Cracking clay	Soil containing 35 percent or more, clay sized particles, and cracks at least 5mm wide extending upwards to the surface or to the base of any plough layer or thin (< 0.03m) surface horizon
CRC	An abbreviation for Cooperative Research Centre

Cretaceous	A period in geological time (145myBP - 65myBP), the third and latest of the periods in the Mesozoic Era
Cryptophyte	The thin organic crust or membrane on a soil surface formed by the growth of algae, bacteria, cyanobacteria, fungi, lichen, liverworts and mosses
CSIRO	An abbreviation for Commonwealth Scientific and Industrial Research Organisation

D

DCDB	An abbreviation for Digital Cadastral DataBase provided and updated by the Department of Natural Resources and Mines
Delta	An alluvial deposit, usually triangular, at the mouth of a river
Dermosol	A soil profile with a structured B horizon, but lacking strong texture contrast between the A and B horizons
Dieback	The death or lack of vigour in the extremities of a tree canopy
Dispersion	Soil aggregate breakdown in water leaving clay particles forming a cloud around the aggregate.
Distributary	Branch of a river flowing from the main river and not rejoining it, as in a delta
DNRM	An abbreviation for Department of Natural Resources and Mines
Downs	Abbreviation for the Mitchell Grass Downs country in central Queensland, comprising extensive, open grasslands on heavy clay soils
DPIF	An abbreviation for Department of Primary Industries and Fisheries
DUBDSC	An abbreviation for Desert Uplands Build-Up and Development Strategy Committee
Dune	A moderately inclined to very steep ridge or hillock built up by the wind.
Duplex	A term used by Northcote (1979), describing a sharp change in soil texture between the A and B horizons of a soil profile
Duricrust	Hard layers formed in the weathering zone at or near the land-surface as a consequence of the accumulation of particular components the most important of which are iron and aluminium oxides and hydroxides, silica, calcium carbonate and gypsum
DUSLARA	An abbreviation for the Desert Uplands Strategic Land Resource Assessment project
Dystrophic	A base status of less than 5 cmol per kg clay

E

E	An abbreviation for east
EC	An abbreviation for electrical conductivity
ECse	An abbreviation for electrical conductivity of the saturated extract
Electrical conductivity	A measure of the quantity of electricity transferred across a unit area per unit time at a specified temperature and indicates the level of salt (sodium and others) in soil or water, the higher the salt content the higher the conductivity
Endemic	Native or confined naturally to a particular and unusually restricted area or region; biologically a relic of once wide distribution
Endohypersodic	Soils in which some horizon below 0.5m has an exchangeable sodium percentage of 15 or greater
EPA	An abbreviation for Environmental Protection Agency
Epihypersodic	When some subsurface horizon within the upper 0.5m of the solum has an exchangeable sodium percentage of 15 or greater

Epipedal	A moderate to strong structure of clearly evident soil aggregates within a mass of soil
Episodic	When the upper 0.1m of a solum is sodic
Escarpment	A steep face terminating high lands abruptly
ERDAS	An abbreviation for computer software used for processing satellite image data
ESP	An abbreviation for Exchangeable sodium percentage
ESRI	An abbreviation for Environmental Systems Research Institute (US GIS software company)
Evapotranspiration	The combination of water that is evaporated and transpired by plants as a part of their metabolic processes
EXCEL	A computer spreadsheet program
Exotic	A non-native plant

F

Fans	Large gently inclined to level landform element with radial slope lines inclined away from a point, resulting from aggradation, or occasionally from erosion, by channeled, often braided, stream flow, or possibly sheet flow
Feldspars	A group of minerals commonly found in rocks
Ferricrete	A soil zone more or less cemented with iron oxide
Ferrosol	Soils other than Vertosols, Hydrosols, and Calcarosols that have >5% free iron oxide in the fine earth fraction of the B horizon, and do not have a clear or abrupt textural change to the B horizon, or any vertic properties in the upper 0.3m of the B horizon
Ferruginous	Descriptive of red rocks, which contain iron, but not necessarily in abnormal amounts
Flood plain	Alluvial plain characterised by frequently active erosion and aggradation by channeled or over-bank stream flow. Average recurrence interval of 50 years or less.
Fluvial	Derived from, or connected with, rivers

G

GBA	An abbreviation for Grass Basal Area
GDA94	An abbreviation for Geocentric Datum of Australia 1994
Genera	Plural of genus
Gently undulating	Plains with relief of less than 9m and slopes of 1% to 3%
Genus	A group of species believed to have descended from a common ancestor
Geomorphology	The study of the nature and history of landforms and the processes which create them
Gilgai	Surface relief associated with soils containing shrink-swell clays. Consist of mounds and depressions of various dimensions.
GIS	An abbreviation for Geographic information system
Gley	A term applied to soils that are poorly drained and experience anaerobic (lack of oxygen) conditions most of the time.
GPS	An abbreviation for Global Positioning System
Gradational	A term defined in Northcote (1979), used to describe those profiles where the clay content increases gradually with depth
Granite	A coarse plutonic rock containing quartz and feldspar

Granodiorite	A coarse grained plutonic rock resembling a granite but with plagioclase more abundant than potassium feldspar
Great Artesian Basin	A large groundwater resource underlying 1.7 million square kilometres (about one-fifth) of Australia, extending across the arid and semi-arid regions of Queensland, New South Wales, South Australia and the Northern Territory
Groundwater	Water occurring below the surface of the landscape, at greater pressure than atmospheric, occupying cavities and spaces in regolith and bedrock. The upper surface of the groundwater is the water table
Gully erosion	An open incised erosion channel down which water flows during or immediately after rain. Generally deeper than 30 cm.
Gypsum	A chemical sedimentary rock; the mineral hydrated calcium sulphate

H

Ha	An abbreviation for hectare
Halobionts	Salt-loving organisms that are restricted to inland, salt waters
Halophylic	A preference for salty or saline conditions
Halophytic plants	Plants adapted morphologically and/or physiologically to grow in saline conditions
Haplic	When the major part of the B2 horizon is whole coloured
Hardpan	A hard impervious layer, composed chiefly of clay, cemented by relatively insoluble materials, does not become plastic when mixed with water, and definitely limits the downward movement of water and roots
Hill	Landform pattern of high relief (90 - 300m) with gently inclined to precipitous slopes
Horizon	A layer within the soil profile having morphological characteristics and properties different from those layers which occur below and/or above it
Hr	An abbreviation for hour
Hydromorphic	The soil structure and associated drainage and water holding capacity of a profile
Hydrosol	A soil profile (other than Organosols, Podosols and Vertosols) in which the greater part is saturated for at least 2-3 months in most years
Hypernatric	Soil in which the major part of the upper 0.2m of the B2 horizon has an exchangeable sodium percentage greater than 25
Hypersaline	Water with a salt content greater than that of sea water

I

Igneous rock	Rock that has formed by the cooling and consolidation of magma. It may be intrusive (plutonic) or extrusive (volcanic)
	In its original place

J

Jurassic	The middle of the three periods of the Mesozoic Era (200 – 145myBP)

K

Kandosol	A soil profile, other than Hydrosol, with all of the following: a massive or weak structure and a clay content exceeding 15% in the major part of the B horizon, not calcareous, no clear or abrupt textural boundaries between horizons, and no tenic B horizons
kg	An abbreviation for kilogram
km	An abbreviation for kilometre
km^2	An abbreviation for square kilometre (km x km)
Kurosols	A soil profile with a strong texture contrast between the A horizon and a strongly acid B horizon

L

Lacustrine	Pertaining to, produced by, or formed in a lake
Landform	A portion of the landscape that can be observed in its entirety, and has consistence of form, for example, a river delta, hill, escarpment or dunefield
Landform element	A section or area within a specific landform that can be described in terms of its position, slope or morphology, for example, a crest, ridge, upper slope or drainage depression
Landform pattern	An assemblage of the same landforms resulting in a specific landscape, for example, hills, rolling rises or alluvial plains
Landsat imagery	Images derived from visible and non-visible wavelength sensors aboard a Landsat satellite approx 705 km above the earth
Land system	An area of land with similar attributes of topography, local climate and lithology, and proportional occurrence and arrangement of soil-vegetation associations
Land unit	A specific soil-vegetation association occurring in a particular landscape position at one or several locations within a land system
Land zone	An area in which the landforms are similar in nature, origin and function. Land zones are summary units, which provide a general picture of the main geology and landforms of a bioregion. Twelve are described for Queensland.
Laterite	A hardened soil horizon characterised by extreme weathering that has led to concentrations of secondary oxides of iron and aluminium. Laterite is relatively soft *in situ,* but hardens rapidly when exposed to air
Lateritisation	A weathering process that forms laterite
Lenticular	A lens-shaped soil ped
Leptic	Soils that are underlain within 0.5m of the surface by a calcrete pan; hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite
Levees	Very long, very low, nearly level sinuous ridge immediately adjacent to a stream channel, built up by over-bank flow
Lithic	Consisting of rock fragments
Lithology	The physical characteristics of a rock
Loam	A textural term applied to soils – a coherent, spongy bolus, no obvious sandy or ‘silky’ feel, about 25% clay
Low hill	Hill of 30 - 90m relief
Lunette	A ridge, often crescent-shaped, on the lee side of shallow lakes and swamps, composed of wind-blown fine sand, silt and/or clay particles, depending on the material on the lake bed surface

M

m	An abbreviation for metre
Map sheets	1:100,000 map sheet series for the Desert Uplands bioregion
Median	The middle number in a sequence of numbers arranged in order
Mesa	An isolated, flat topped, steep sided, desert landform (larger than a butte), which is formed by the erosion of nearly horizontal strata
Mesonatric	Soil in which the major part of the upper 0.2m of the B horizon has an exchangeable sodium percentage of between 15 and 25
Mesotrophic	Soil in which the base status is between 5 and 15cmol per kg of clay
Mesozoic	An era of geological time (250 – 65myBP) comprising the Triassic, Jurassic and Cretaceous periods
metamorphic rock	Rocks whose original compounds and textures have been transformed to new compounds and textures as a result of high temperature, high pressure or both. Grades of meta-morphism range from low to high depending on temperature and or pressure during formation
mm	millimetres
moisture holding capacity	Total moisture content of soil remaining following saturation and free drainage - other term field capacity. Moisture availability is the difference between field capacity and wilting point
morphological	Relating to the form of things, such as plants and animals
mudstone	A sedimentary rock with mineral fragments smaller than those in a siltstone
myBP	million years before present

N

N	North
NHT	Natural Heritage Trust
NRM	Natural Resource Management

O

orthic	Soils with a tenic B horizon; a B2 horizon with 15% clay (SL-) or less, or a transition horizon occurring in the fissures of the parent rock or saprolite, which contains up to 50% of B horizon material
outlier	Portions of any stratified group, which lie detached, or out from the main body, the intervening or connecting portion having been removed by denudation

P

paleo-channels	Older non active stream lines
paleosol	A buried soil
Paleozoic	An era of geological time (545 –245myBP) comprising the Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian periods
pallid	Pale to white coloured
pallid zone	A bleached, kaolinised layer of rock, from which all the iron minerals have been removed
ped	An individual natural soil aggregate consisting of a cluster of primary particles and separated from adjoining clusters by surfaces of weakness, which are recognisable as natural voids, or by the occurrence of cutans.

pediment	A sloping surface cut across bedrock and thinly or discontinuously veneered with alluvium that slopes away from the base of a highland in an arid or semiarid environment
pediplains	Level to very gently inclined landform pattern with extremely low relief and no stream channels, eroded by barely active sheet flow and wind
pedogenic	Relating to soil formation
pedological	Relating to the genesis and classification of soils
peneplains	Level to gently undulating landform pattern with extremely low relief and sparse slowly migrating alluvial stream channels, which form a non-directional, integrated tributary pattern. It is eroded by barely active stream flow, creep, channeled, and over-bank stream flow
perennial	Herbaceous or woody plant species that continue to grow from year to year
permeability	The potential of a soil to transmit water internally
Permian	A period of geological time (295 – 245myBP) in the Paleozoic era
pers. comm.	personal communication
petiole	The slender stalk joining leaf-blade to stem
pH	A measure of acidity
phyllode	The flattened petiole resembling a leaf
pivot table	An interactive table in a spreadsheet or database that can be used to quickly summarize large amounts of data
plateau	A relatively elevated area of comparatively flat land, which is commonly limited on at least one side by an abrupt descent to lower land
playa	A shallow central basin of a desert plain, in which water gathers after a rain and is evaporated.
pores	Avery small opening in a surface, through which fluid may pass
pyroxines	A group including some of the most common rock-forming minerals

Q

quartzite	A granulose metamorphic rock consisting largely of quartz
Quaternary	A period of geological time from 1.8myBP to the present time, comprising the Pleistocene and Holocene (Recent) epochs

R

rain shadow	A region shielded from rain by mountains or other causes
RE	An abbreviation for Regional Ecosystem
recharge areas	Areas where the net movement of water is into the groundwater. Relatively permeable areas of the landscape, usually on the upper slopes and on shallow soils, act as recharge areas.
regional ecosystem	A combination of plant species associated with a particular bioregion and combination of geology, landform and soil type.
regolith	The irregular covering of soil including loose un-cemented rock particles, and weathered parent material, whatever the origin, that covers the land surface and overlies the hard bedrock
relict	An object or formation now existing in an environment that is different from that in which it formed

remote sensing	The science and art of obtaining information about an area or phenomenon through the analysis of data acquired by a device, or sensor, that is not in contact with the area or phenomenon under investigation
riparian	Living or located on the bank of a river or a body of water
rises	A landform pattern of very low relief (9-30m) and very gentle to steep slopes.
root zone	The depth of soil from which plant roots obtain moisture and nutrients for growth
Rudosol	A soil profile with negligible pedologic organisation (horizon differentiation) apart from (a) minimal development of an A1 horizon, or (b) less than 10% of B horizon material or pedogenic carbonate in the fissures of the parent rock or saprolite

S

S	South
SALI	An abbreviation for Soil and Land Information database
saline	Salty – possessing a high concentration of total dissolved salts
salinity	A measure of the quantity of soluble salts, especially sodium chloride, in water (and soil water). High salt levels in the soil water increase the osmotic pressure and reduce a plant's ability to take up moisture. Salinity in the profile can come from rising saline ground waters and by addition of water, which has generally low to moderate levels of salt, which is concentrated as the water evaporates.
salting	The process of salt accumulation, usually with reference to the upper portion and surface of a soil profile
samphire	A dense succulent shrub with numerous woody stems and short segmented branchlets occurring on saline flats
sand sheet	A layer of sandy material, often extensive, of variable depth depending on the relief of the original land surface and the degree of subsequent erosion
sandstone	A medium grained clastic sedimentary rock consisting mainly of sand sized particles
savanna	A grassland region with scattered trees, usually in subtropical and tropical regions
scald	A flat area, bare of vegetation, from which soil has been eroded or excavated by surface wash or wind
scarp	An escarpment, cliff, or steep slope of some extent along the margin of a plateau, mesa, terrace or bench
scleromorphy	A term describing plants that have developed, or are in the process of developing, toughened leaves as a means of reducing moisture loss. This is a feature of many plants that occur in low rainfall areas.
sedimentary rock	Any rock formed by chemical precipitation, biogenic processes or by sedimentation and cementation of mineral grains transported to a site of deposition by water, wind, ice or gravity. Sedimentary rocks result from the lithification of sediment.
self-mulching	A condition of surface soils, notably clays, in which a high degree of pedality is exhibited with the peds falling apart, naturally, as the soil dries to form a loose surface mulch
semi-arid	A term used to describe a region of low annual rainfall, but which receives sufficient quantity of rain for specific crops and cultivation. Rainfall is usually quite variable from year to year.
shale	A fine grained clastic sedimentary rock
sheet erosion	The relatively uniform removal of soil from an area without the development of conspicuous channels
silcrete	A silica rich duricrust

silica	Silicon dioxide, a chemical compound. It is insoluble in water, slightly soluble in alkalis, and soluble in dilute hydrofluoric acid. Pure silica is colourless to white. It occurs in several forms and is widely and abundantly distributed throughout the earth, both in the pure state and in silicates, e.g., in quartz (agate, amethyst, chalcedony, flint, jasper, onyx, and rock crystal), opal, sand, sandstone, clay, granite, and many other rocks
siltstone	A sedimentary rock composed mainly of silt sized fragment
skeletal soils	Very shallow stony soils overlying bedrock or a hardpan
slake	The macroscopic breakdown of an unsaturated aggregate on immersion in water
slate	A metamorphic rock of low grade which splits readily
SLATS	State Land and Tree Survey (Queensland DNRM project)
slickenside	A polished and striated surface that results from friction along a fault plane
sodic	A high percentage of sodium ions (in soluble or exchangeable form
Sodosol	A soil profile with a clear or abrupt textural B horizon and in which the major part of the upper B horizon (or the major part of the entire B2 horizon if it is less than 0.2m thick) is sodic and not strongly acid. Hydrosols are excluded
soil permeability	The ability of a soil profile to transmit water
soil reaction trend	The change in pH with depth. Four soil reaction trends are as follows: • strong acid trend - when the surface soil pH >7.0 and the deep subsoil pH <6.5 • acid trend - when the surface soil pH <7.0 and the deep subsoil pH <6.5 • neutral trend - when the surface soil pH value is between pH 5.0 and pH 8.0, and the deep subsoil has a pH value between pH 6.5 and pH 8.0 • alkaline trend - when the surface soil pH >5.0 and the deep subsoil pH >8.0
solum	That portion of the soil profile influenced by current soil processes, including biotic, and consists of either the A + B horizons or the A horizon alone when no B horizon is present
sp.	An abbreviation commonly used when the full botanical name of a plant is unknown, as in *Eucalyptus* sp.
spp.	An abbreviation commonly used when the full botanical name of several plants within one genus are unknown, as in *Eucalyptus* spp.
sq.km	An abbreviation of square kilometres
steep	Slopes between 32% and 56%
structure	Soil structure refers to the distinctness, size and shape of peds. A ped is an individual natural soil aggregate consisting of a cluster of primary particles and separated from adjoining peds by surfaces of weakness which are recognisable as natural voids, or by the occurrence of cutans.
subnatric	Soils in which the major part of the upper 0.2m of the B2 horizon has an exchangeable sodium percentage of between 6 and 15
subregion	A subdivision of a region based on geomorphic and/or climatic criteria
swale	A linear, level-floored open depression excavated by wind, or left relict between ridges built up by wind or waves

T

tectonic	Pertaining to, or designating, the rock structure and external forms resulting from the deformation of the earth's crust, as applied to earthquakes

tenic	A weakly developed B horizon in terms of texture, colour, structure and/or segregations of pedogenic origin (including carbonate)
Tenosol	A soil profile (other than Hydrosols, Calcarosols and Organosols) with generally weak pedologic organization apart from the A horizon
Tertiary	A period in geological time (65myBP to 1.8myBP) occurring in the earlier period of the Cenozoic Era
texture contrast	See duplex
TM	Thematic Mapper – a type of satellite imaging sensor
topsoil	The surface layer of the soil including most of the organic matter content of the soil profile. Technically, this layer is considered the dark coloured A horizon of the soil profile
transpiration	A process whereby plants extract moisture from the soil to meet the metabolic, growth and photosynthetic needs of the plant, after which water vapour is released through the leaf stomata to the atmosphere
Triassic	A period in geological time (24myBP to 205myBP) occurring in the earliest period of the Mesozoic Era
Tropical Savannas CRC	Tropical Savannas Cooperative Research Centre
tussock grass	A grass that forms discrete but open tufts usually with distinct individual shoots, or if not, then forming a hummock

U

uniform-textured	Refers to a soil profile in which the texture grade or texture group remains the same throughout the solum

V

Vertosol	A soil profile with all of the following features: • a clay texture (>35% clay) throughout the solum except for thin crusty surface horizons 0.03m or less thick; **and** • when dry, open cracks occur at some time in most years. These are at least 5mm wide and extend upward to the surface, or at least to the base of any plough layer, self-mulching horizon, or thin, surface crusty horizon; **and** • slickensides, and/or lenticular peds occur at some depth in the solum
vertic	Soil material with a heavy clay texture and the characteristic features of a Vertosol

W

W	West
wind erosion	Refers to the removal and transportation of soil or rock particles from a specific area

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