2023

Pasture condition guides for the southern rangelands, including the Gascoyne, Murchison and Goldfields-Nullarbor

Peter-Jon A. Waddell
Department of Primary Industries and Regional Development, Western Australia

Philip WE Thomas
Department of Primary Industries and Regional Development, Western Australia

Wayne J. Fletcher
Department of Primary Industries and Regional Development, Western Australia

Kath Ryan
Department of Primary Industries and Regional Development, Western Australia

Joshua E. Foster
Department of Primary Industries and Regional Development, Western Australia

Authors

Peter-Jon A. Waddell, Philip WE Thomas, Wayne J. Fletcher, Kath Ryan, Joshua E. Foster, John K. Stretch, and Jim S. Addison

Department of
Primary Industries and
Regional Development

GOVERNMENT OF
WESTERN AUSTRALIA

Protect
Grow
Innovate

Pasture condition guides for the southern rangelands

Including the Gascoyne, Murchison and Goldfields-Nullarbor

Bulletin 4913

PA Waddell, PWE Thomas, WJ Fletcher, KG Ryan, JE Foster,
JK Stretch and JS Addison

Acknowledgment of Country

The Department of Primary Industries and Regional Development (DPIRD) acknowledges the Traditional Custodians of Country, the Aboriginal peoples of the many lands that we work on and their language groups throughout Western Australia and recognises their continuing connection to the land and waters. DPIRD respects the continuing culture of Aboriginal peoples and the contribution they make to the life of our regions, and we pay our respects to Elders past, present and emerging.

ISSN 1833-7236

Cover: A good mix of palatable low shrubs under the eucalypt grove includes cotton bush, horse mulla mulla and bluebushes, and a scattering of palatable plants among the shrubs between the groves. Litter is plentiful on the soil surface. The site is a eucalypt chenopod shrub plain pasture on an undulating plain in the Pindar land system.

Recommended reference

PA Waddell, PWE Thomas, WJ Fletcher, KG Ryan, JE Foster, JK Stretch and JS Addison (2023) 'Pasture condition guides for the southern rangelands, including the Gascoyne, Murchison and Goldfields-Nullarbor', *Bulletin 4913*, Department of Primary Industries and Regional Development, Western Australian Government.

Disclaimer

Copies of this document are available in alternative formats upon request.

+61 1300 374 731 | enquiries@dpird.wa.gov.au | dpird.wa.gov.au

Contents

Acknowledgements

This publication was compiled and edited by Kath Ryan and Peter-Jon Waddell, Department of Primary Industries and Regional Development.

The production of the final version has been much improved by the generous assistance of:

- Angela Rogerson, DPIRD, style guidance
- Anne Bennett, DPIRD, economics
- Ben and Graham Forsyth, Three Rivers Pastoral, industry review
- Damian Priest, DPIRD, photographs, industry review
- David Bicknell, DPIRD, photograph management, review, web conversion
- David Blood, Coodawa Contracting, industry review
- Harry and Alys McKeough, Carey Downs station, industry review
- Georgina Wilson, Wilson for Words, general review, editing
- Michael Clinch, Nallan station, industry review
- Paul Novelly, formerly DPIRD, initiation of the project, industry review
- Phil Goulding, DPIRD, map production
- Rosemary Bartle, RegenCo, industry review
- Samantha van Wyngaarden, DPIRD, map production
- Sandra Van Vreeswyk, formerly DPIRD, technical review
- Tony Della Bosca, DPIRD, economics
- Valerie Shrubb, DPIRD, assisting with first draft and planning.

These pasture condition guides are based on the accumulated work of rangeland colleagues, past and present, conducted over more than half a century, published in 9 rangeland surveys, and spans most of the Western Australian shrublands. Data and reports from the Western Australian Rangeland Monitoring System (WARMS) at the regional and landscape scale have been used to expand, update and improve on surveyed information.

The participation, patience and vast knowledge of the southern rangelands regional staff, some of whom retired, left or commenced work during the process, has been invaluable in bringing this publication together. The wisdom, customs, practice and concerns of a great number of rangeland managers in the pastoral industry (from the 1950s through to the present day) has influenced rangeland survey recommendations, and any management advice presented here.

Summary

These guides address a recognised gap in readily applicable and easily accessible information on southern rangelands pasture condition and management. The guides build on *Reading the rangeland: a guide to the arid shrublands of Western Australia* (Burnside et al. 1995).

Reading the rangeland says 'Managing the rangelands is complex. Soils and vegetation can vary considerably over short distances in distinct or subtle ways. Separating climatic from management influences on the condition of the land is always difficult. It is vital that we understand and appreciate the unique character and management requirements of the rangelands.'

These guides provide descriptions and images for southern rangelands pastures with similar management requirements for the grazing of native pastures by livestock. Therefore, the focus is on palatability of vegetation to livestock, and the effects of livestock management and external factors on the condition of the vegetation and soils.

The first section provides an overview and map, introduces concepts and terms important to understanding arid shrubland management in general, these guides in particular; and includes an economic analysis of the cost of land degradation specific to the southern rangelands.

The main body of the publication provides descriptions and information on maintenance, improvement and recovery or rehabilitation of each pasture group.

Twenty-three broad pasture groups are described, divided between 3 supergroups of chenopods, shrubs and grasses.
Each description consists of:

- the broad pasture group title
- occurrence statement with estimated areal extent
- vegetation structure and composition description
- pastoral value statement with general management advice
- condition statement describing the likely changes that occur with transition from good condition through to fair and poor condition with photographs where available
- other relevant notes including suggestions for fire management and the reported condition of the pastures if known from department data or other sources
- species list showing relative desirability of common and important species for management and monitoring.

Appendices include maps showing the estimated distribution of each broad pasture group, species lists, grass growth basics and a schematic diagram showing the effect of land degradation on fragile and productive sand sheets. References are provided at the end of the publication.

Eucalypt woodland over a mixed acacia and eremophila shrubland

Introduction

These pasture condition guides are relevant to about 815,000 square kilometres of the rangelands of Western Australia (Figure 1), of which the major land uses in 2020 were pastoral lease (60%), unallocated Crown land (24%) and conservation estate (12%). The area has been the subject of 9 inventory and condition surveys, mainly undertaken by the Department of Primary Industries and Regional Development or its previous constituent departments. In compiling these guides, 402 of the full range of land systems described in rangeland surveys and 272 habitat (or vegetation) types have been considered.

Value of information

This information is for pastoralists, resource managers, government departments and others with an interest in the productivity and maintenance of rangeland plant communities in the Gascoyne, Murchison, Goldfields and Nullarbor, Western Australia.

These guides help users to identify changes in pasture condition, indicate when management changes are needed and how to use some of the key indicators of pasture condition.

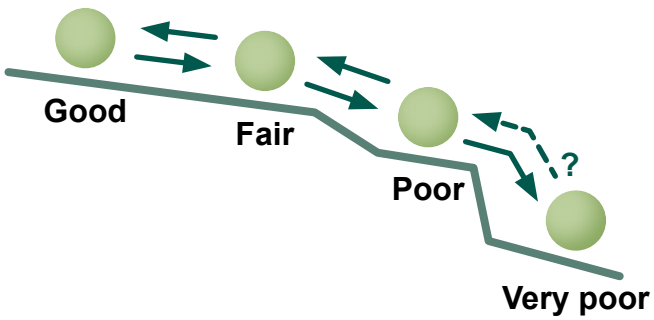
The guides can be used as field references for pasture condition assessments, and as an aid for training interested people.

About pasture condition

Pasture condition is the term for the current condition of the vegetation compared to the optimal condition that could be expected, taking into account the potential of the site (landscape position, soil, climate, vegetation). The term 'health' is sometimes used, meaning that all parts of the whole are present and working well together.

Pasture condition is rated as good, fair or poor, depending on how close the current condition is to the optimal condition. What you expect to see at a site in good, fair or poor condition depends on the pasture type that occurs there.

Not all changes of land condition occur at the same rate, and some changes are not easily reversible. The susceptibility of land to change in condition, and the ease with which changes can be reversed, depends on the land's current condition (Figure 2). The more land condition deteriorates, the more energy and resources must be invested in regeneration. A decline in land condition reduces long-term productivity (Chilcott et al. 2005).



Source: Modified from Chilcott et al. (2005)

Figure 2: Condition decline and reversal difficulty rolling ball model

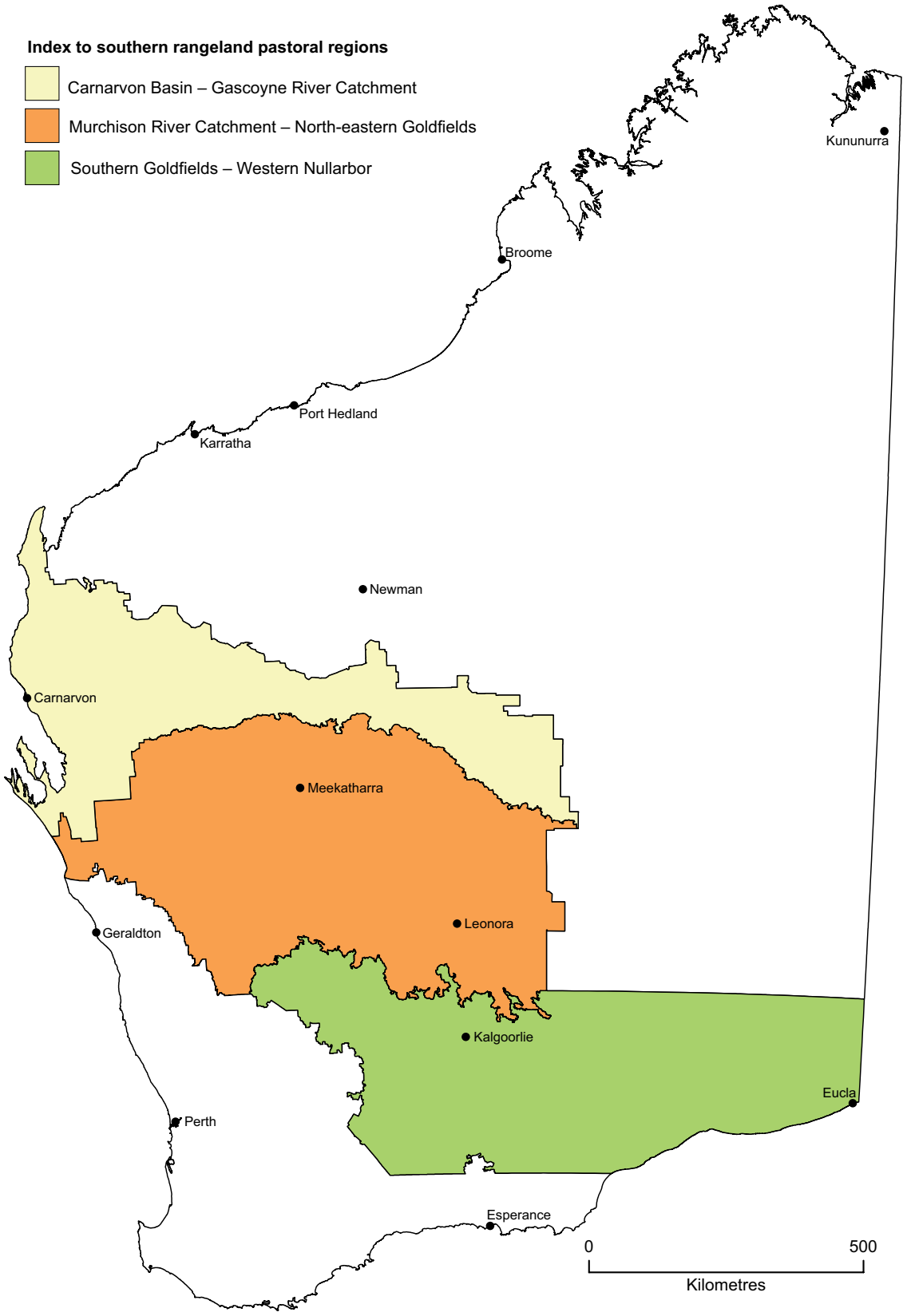


Figure 1: Southern rangelands locality map

The framework for sustainable pastoral management

Sustainable pastoralism involves maintaining the land and vegetation in good condition while running a profitable livestock business.

The Framework for sustainable pastoral management – revised edition (Fletcher 2022; the Framework) is a contemporary, risk-based approach to improving pastoral land monitoring, assessment and management that has been developed by DPIRD and endorsed by State Cabinet. The Framework embodies internationally accepted best practice principles to achieve ecologically sustainable development.

In the Framework, quantitative, regional land condition standards are proposed to make pasture level assessments of land condition and management effectiveness consistent and objective. Standards will be developed for the most pastorally important pasture types (key pastures) for each region.

Key pastures are potentially the most productive and the most palatable pastures on a station. This means they are usually the most heavily grazed pastures, and monitoring these is the most efficient way to assess condition across the lease.

The guides below provide qualitative descriptions of key pastures in good, fair and poor condition for the southern rangelands. These qualitative descriptions of pasture condition form the basis for the development of quantitative measures of condition that will be progressively rolled out across the pastoral rangelands.

Pastoralists wanting to improve pastoral productivity and range condition across a lease can use the guides and knowledge of drivers of pasture condition (grazing pressure, fire and season) to adjust management (principally grazing pressure).

Rangeland regeneration

The main principles of regenerative agriculture in the rangelands are to keep the soil covered, minimise soil disturbance, retain roots, increase species diversity and integrate livestock. The overall objectives of regenerative agriculture are to foster soil and land health and provide environmental, economic and social benefits to the wider community: these ideas are not new in the rangelands, and a wealth of empirically based literature supports the principles and objectives behind practices that can lead to rehydration, rehabilitation and regeneration of degraded land. Many producers are already applying these well-founded principles, and conservation land management practices, to their business model and agroecosystems.

Rangeland regeneration starts with reducing total grazing pressure on sensitive or degraded areas, to allow natural or assisted revegetation to occur. This may provide an opportunity for ‘carbon farming’ in the southern rangelands. Carbon sequestration in the southern rangelands faces significant cost, price and biophysical uncertainties. These are discussed by Sudmeyer et al. (2014), and plant productivity and soil organic carbon can be expected to decline if rainfall declines in future.

Direct measurements of soil health and soil carbon are generally non-repeatable (Khangura 2021); therefore, it is more practical and repeatable to measure and monitor vegetation health (e.g. pasture condition, land condition, range condition), because soil health is directly related to pasture quality and diversity.

Long-term empirical trials to compare conventional and regenerative agriculture practices have been recommended to build knowledge of the benefits and mechanisms at a regional scale. This will provide producers with the evidence base to make informed decisions about adoption of practices and systems (whether these are considered 'conventional' or 'regenerative') to realise social and economic benefits and resilience under dry times and climate change.

Identifying broad pasture groups

The first step to assess pasture condition is to identify the pasture. These guides provide descriptions and photographs of good, fair and poor pasture condition for 23 of the most common broad pasture groups in the southern rangelands. A list of described habitat and vegetation types that make up each broad group is provided at Appendix A.

Each pasture group has its own section, which includes a list of common and important plant species for that pasture group, with desirable, intermediate and undesirable species identified. The density and diversity of palatable species (often called desirables or decreasers) largely determines pasture condition in the shrublands. More detailed information on many of the common species found in the southern rangelands, including indicator values, is available in *Arid shrubland plants of Western Australia* (Mitchell and Wilcox 1994).

The common pasture groups are distinguished by their vegetation, soil type and position in the landscape. Projected foliar cover (PFC), where known, is used to describe the extent of perennial shrub vegetation and hummock grass (spinifex) cover (see Projected foliar cover subsection).

PFC terms are inconsistent between surveys, reflecting differences in the structure of plant communities across the regions. For further detail on the expected PFC in a locality, refer to the relevant rangeland survey.

Each pasture description represents a broad group of similar vegetation associations which have similar management requirements for pastoralism. The 'pasture group' is not strictly a botanical classification because, in determining such a class of pastoral lands, the perennial plant species that contribute to stock production have an overriding importance.

A number of pastures in the area covered by this guide are minor in a regional context but are important at the district level, or locally in the management of individual stations. For the sake of simplicity and brevity these have not been given separate descriptions. Some pastures of the Carnarvon Basin survey area are only found on a few stations and the pasture condition guides for the Pilbara provides advice for these. These include spinifex hill pastures on the Winning, Cooralya and Mardathuna leases; Mitchell grass pastures on Mia Mia, Lyndon River and Yanrey leases; and Roebourne plains grass pastures on leases adjoining the Ashburton River catchment survey area.

Pastures in the southern rangelands can be stratified into 3 major groups: those dominated by chenopods, other shrubs and grasses. About 47,400 km^2 in the Wiluna area has not been surveyed to date at the land system detail. Pasture types in this area were attributed to broad vegetation descriptions by Beard (1976). The broad pastures within these groups and relevant regions are shown in Table 1.

Most of the southern rangelands supports chenopod pastures and other shrub pastures. Grass pastures are locally important: buffel grasses have changed riparian landscapes in parts of the Gascoyne and Murchison and may change Goldfields-Nullarbor landscapes in the future. Ribbon grass pastures are no longer present in the Carnarvon area because of historical degradation and are not included. Breakaway footslope pastures have been described together with mixed chenopod shrub plain pastures; riverine mixed shrub and river frontage have been described together as riparian association pastures.

Appendix B contains maps of estimated distribution for each pasture group. Appendix C contains a list of common and scientific names for species mentioned in these guides.

Eucalypt woodland over a chenopod shrubland

Table 1: Pasture groups and regional locations

Pasture groups	Occurrence		
Chenopods	**Gascoyne[1]**	**Murchison[2]**	**Goldfields-Nullarbor[3]**
Bluebush	✔	✔	✔
Eucalypt chenopod	✗	✔	✔
Greenstone stony plain	✗	✔	✔
Mixed chenopod shrub plain	✔	✔	✔
Nullarbor	✗	✗	✔
Riparian association	✔	✔	✔
Saltbush	✔	✔	✔
Samphire	✔	✔	✔
Snakewood	✔	✔	✗
Stony mixed chenopod	✔	✔	✔
Shrubs			
Acacia hardpan	✔	✔	✔
Acacia–cassia short grass forb	✔	✔	✔
Currant bush mixed shrub	✔	✗	✗
Eucalypt–acacia–eremophila shrubland plain	✗	✔	✔
Heath[4]	✔	✔	✔
Sandplain acacia	✔	✔	✔
Sandy granitic acacia	✗	✔	✔
Stony acacia–cassia–eremophila	✔	✔	✔
Grasses			
Buffel grass	✔	?[5]	?
Hard spinifex	✔	✔	✔
Soft spinifex	✔	✗	✗
Speargrass/wallaby grass	✗	✗	✔
Wanderrie grass	✔	✔	✔

1 Gascoyne includes the Gascoyne catchment and Carnarvon Basin survey areas.

2 Murchison includes the Murchison River catchment, the Lower Murchison River catchment and the Wiluna–Meekatharra survey areas, plus most of the Sandstone, Yalgoo and Paynes Find and the North-eastern Goldfields survey areas.

3 Goldfields–Nullarbor includes the southern Goldfields and Nullarbor survey areas, plus part of the Sandstone, Yalgoo and Paynes Find and the North-eastern Goldfields survey areas.

4 Heath has been considered because of the areal extent across the regions, but is not described further in the print version of this publication.

5 Not yet significant or widespread in the Murchison, but isolated stands and individuals are present, mostly confined to run-on areas and road verges.

Pastoral value

For this bulletin, 6 categories of pastoral value or potential are used, based on estimated carrying capacity of pastures in good condition (Table 2).

Suggested stocking levels for sustainable grazing – expressed as carrying capacities (per annum) in hectares per dry sheep equivalent (ha/DSE), hectares per animal equivalent (ha/AE) or hectares per cattle unit (ha/CU) – for 3 levels of pasture condition, are available on request from DPIRD for pastures relevant to each lease.

Variation in productivity

Carrying capacities in Table 2 are a guide to land capability and productive potential and are not intended to be rigidly applied by managers or used as the sole basis for legislative controls (Curry et al. 1994; Pringle 1994; Van Vreeswyk and Godden 1998; Van Vreeswyk et al. 2004b; Cotching 2005; Hennig 2009; Waddell et al. 2010).

Practical long-term carrying capacities can be estimated from the pastoral potential, with discounts applied for pasture condition and other factors (Box 1). Generally, fair condition pastures in the southern rangelands are two-thirds as productive as good condition pastures, and poor condition pastures are less than half as productive as good condition pastures (Curry et al. 1994, Wilcox and McKinnon 1974, Mitchell et al. 1979, Van Vreeswyk and Godden 1998, Van Vreeswyk et al. 2004b, Hennig 2009).

Table 2: Pastoral potential categories for pastures in good condition

Pastoral potential	Carrying capacity (ha/DSE)	Carrying capacity (ha/AE)	Carrying capacity (ha/CU)
Very high	<5	≤42	≤35
High	5.1–9.9	43–83	36–69
Moderately high	10–14.9	84–125	70–104
Moderate	15–19.9	126–167	105–139
Low	20–29.9	168–251	140–209
Very low	≥30	≥252	≥210

ha/DSE = hectares per dry sheep equivalent; ha/AE = hectares per animal equivalent; ha/CU = hectares per cattle unit

The actual grazing value and appropriate stocking of particular pastures at any time varies with seasonal conditions, fire history, perennial pasture condition and degree of recent use. Browse and herbage accruing from periods of growth will, in practice, be eaten by stock and many other herbivores. These factors mean that an inflexible adherence to suggested stocking rates is not recommended. Rather, the aim is to match the stocking rate with the variation in pasture production as closely as possible. Fixed year-round stocking rates result in either underuse or overuse at most times (Payne et al. 1987, Hennig 2009, Bartle pers. comm. 2022); however, research has found that conservative set-stocking according to pasture condition and water availability may be appropriate for some arid zone pastures (Holm 1994, Fletcher 1995, Yan et al. 1996, Morrissey and O'Connor 1988, Hall et al. 2011).

The *Pastoral profits guide – A paddock guide to achieving sustainable livestock productivity* provides basic steps to simplify the process of managing the feed supply, equipping pastoral managers with the tools to make decisions and to critically assess the outcomes (Alchin et al. 2008). Beyond profitability, good land management is an essential element of the pastoral industry's social licence to operate (Pastoral Lands Board 2021).

Remnant mulga groves aligned transverse to water flow (2007 aerial photograph provided by Landgate)

Carrying capacity

Definitions for the WA rangelands

It's about land capability: stocking rate is a management decision

Potential carrying capacity (PCC)

This estimate assumes that all of the managed area is in good range condition, is fully watered, and is able to be grazed throughout the whole year under average climatic conditions.

It is the estimated average number of livestock (in AE or CU or DSE) that can sustainably graze a unit of area (sq.km or ha) at maintenance (not gaining or losing weight) for a year if ALL pastures are in good condition and accessible. Note that the case described above is unattainable in practice for a pastoral business.

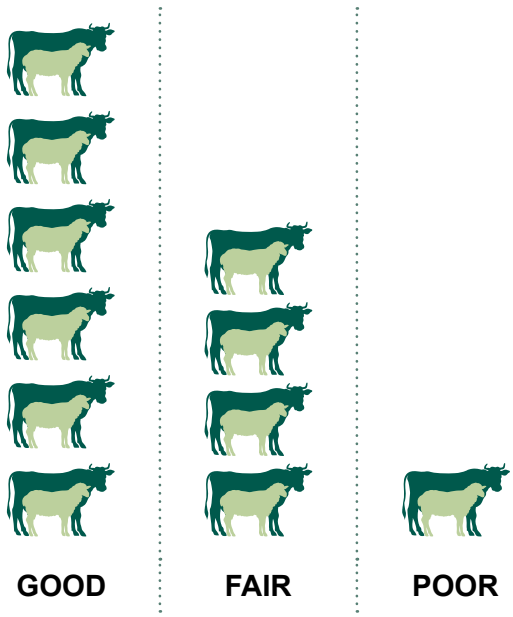
The estimated PCC is used by the valuer-general in calculating pastoral lease rents (along with a number of other factors), and by real estate agents.

Current carrying capacity (CCC)

This estimate applies a discount for the parts of the managed area that are in fair or poor range condition, while still assuming all parts are fully watered and able to be grazed throughout the whole year under average climatic conditions. The CCC is estimated by DPIRD when rangeland condition is assessed on a pastoral lease.

It is the estimated average number of livestock (in AE or CU or DSE) that can sustainably graze a unit of area (sq.km or ha) at maintenance (not gaining or losing weight) for a year discounted for range condition, if all pastures are accessible. A discount for grazing radius has not been applied.

As a general rule: fair condition pastures are two-thirds as productive as good condition pastures, and poor condition pastures are less than half as productive as good condition pastures in the southern and arid rangelands.

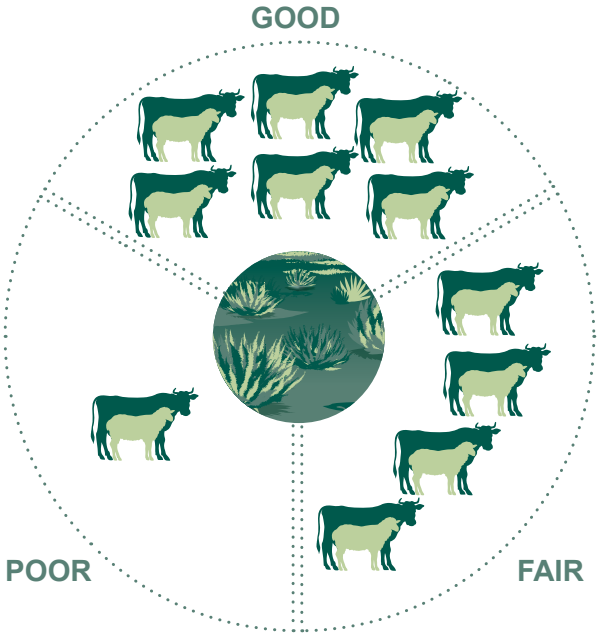


Box 1: Definitions for carrying capacity in the WA rangelands

Seasonal carrying capacity

This short-term estimate is the amount of feed available for grazing by stock, sometimes called feed on offer (FOO), over a planning horizon (e.g. days, months, or until the next key decision date).

Seasonal carrying capacity (SCC) estimates are made by the land manager around key decision dates based on long-term climate data, and take into account the current season, the condition of the pastures, grazing radius, amount of residual feed required and practical management considerations, such as infrastructure, labour, supplementation, boats (timing and availability), etc. SCC may be higher than CCC estimates at times due to a good season, but will most often be lower due to supplementation and residual feed needs.

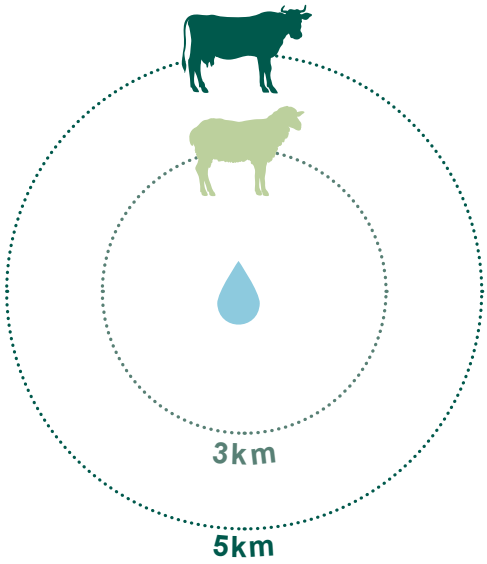


Discount for grazing radius

Sheep normally graze within a radius of 3 km of a watering point, and cattle within a radius of 5 km.

Stock requiring more water due to climate, lactation, salinity or dry feed may need to drink more than once a day. This will reduce their foraging radius and the area of the paddock being used. The further the animals walk, the less weight they're putting on.

The estimated PCC discounted for grazing radius is most commonly used by financial institutions when considering applications for business loans.



Improving productivity benchmark

Combining the discount for grazing radius with the current carrying capacity is recommended to provide a benchmark ceiling for stocking rates that are light enough to achieve improvements in range condition at the paddock or property scale.

The consequences of frequently or continually exceeding the improving productivity benchmark (IPB) is pasture condition decline, which leads to reduced drought resilience, soil loss, animal productivity declines and economic losses. The stocking rate must be below the IPB over the long term to improve range condition and productivity.

Pasture condition decline

Condition declines when any of the following changes occur:

- desirable species are replaced by less desirable species
- reduced plant cover increases the proportion of bare soil
- erosion accelerates
- production of palatable perennial species declines
- any combination of these changes.

Fertile patches and tree-based clumps

Presence in arid rangelands

Arid landscapes commonly consist of fertile patches within larger resource-poor areas or interpatches (Tongway 1994). Fertile patches assist to regulate and retain scarce resources in these typically resource-poor landscapes. Fertile patches are zones of water and soil accumulation that often support greater species density and diversity than the surrounding landscape. Such patches are critical as ecological refugia from which plant re-establishment can occur after extended dry periods or disturbance. They are important in buffering arid landscapes in extremely dry conditions, providing forage during dry periods. Arid landscapes with many fertile patches are extremely efficient at capturing, recycling and utilising scarce resources (water and nutrients).

Rangeland landscapes in good functional condition retain resources which are cycled within the local system. They are generally stable, capable of responding positively to disturbance and resist accelerated erosion. They have improved water-holding capacity. In comparison, dysfunctional rangeland landscapes struggle to retain resources. They have a reduced capacity to maintain existing nutrients, utilise incident rainfall or capture replacement materials.

Fertile patches

Tree groves, bush clumps and wanderrie banks are fertile patches and are important in patch-interpatch water and nutrient capture processes. As a result, there is generally more floristic diversity within groved habitats or under tree-based clumps (Figure 3). Tree-based clumps develop from bird-dispersed shrub thickets, typically around and beneath the canopy of ‘perch’ trees and large shrubs, but also around rock outcrops and termite mounds.

Conditions within fertile patches can be advantageous for new plants compared with those germinating in exposed interpatches. Shelter from the canopy and the microhabitat below the sub-canopy can improve germinant survival. Branch and leaf litter accrete around tree and shrub bases within groves and obstruct ground surface winds and water flow. Wind, water and animal-dispersed material (e.g. leaf litter, seeds, animal scats, general debris) accumulate within and immediately upslope of the grove or clump. This enriches soil with nutrients, particularly nitrogen, increases microbial activity and contributes to greater soil moisture (Garner and Steinberger 1988), and creates improved conditions for germination and establishment. The higher plant species richness in healthy fertile patches provide enhanced landscape and habitat structural complexity, biomass productivity, connectivity of habitat for fauna, places of refuge in extended dry periods, and a valuable seed source for recovery after periods of environmental stress.

Repeated browsing of foliage and bark, breaking of limbs and eventually the central crown, can ultimately kill individual trees.

Figure 3: An example of floristic diversity within a tree-based clump

Effects of tree grove and tree-based clump breakdown

Heavy browsing of tree groves and tree-based clumps by large herbivores can also eliminate a browse source from an area for smaller herbivores through the development of high browse lines. The physical breakdown of a tree leading to its eventual death through loss of vigour has much greater implications to the local ecosystem than just the death of the tree. The loss of shrub nuclei from around tree-based clumps and within groves results in reduced carrying capacity, species composition and diversity of habitat (Figure 4). The loss of shade also affects animal condition in an open plain environment.

Figure 4: An example of vegetation loss under a tree-based clump

Effect of surface water flow disruption

Disruption of natural surface water flow has disastrous effects on fertile patches with either accelerated flows causing erosion, which strips away precious resources, or restricted flows resulting in water starvation, which causes plants to perish through dehydration (Waddell et al. 2012).

This guide focuses on helping users to identify changes in pasture condition, primarily through presenting the key indicators of pasture condition, such as indicator plant species and categories of soil surface condition.

Fertile patches indicate landscape health

It is important to recognise that fertile patches, and particularly tree-based clumps, can also be used as valuable indicators of landscape health. Monitoring sites in these preferentially grazed habitats provide an effective way to monitor pasture condition. Fenced exclosures would preserve these important habitats and maintain their ecological role, while also serving as benchmarks for monitoring grazing pressure to assess utilisation levels of key indicator species.

Projected foliar cover

The PFC is the vertical projection of perennial shrub and hummock grass (spinifex) foliage, expressed as a percentage of ground surface. The PFC ranges used in these guides are shown in Table 3.

Table 3: Projected foliar cover ranges

Term	Projected foliar cover range (%)
Isolated	0–2.5
Very scattered	2.5–10
Scattered	10–20
Moderately close	20–30
Close	30–50
Closed	>50

Source: Adapted from Curry et al. (1983).

States and transitions

Change from one state to another is referred to as a 'transition'. These new states can be relatively resistant to change, creating essentially permanently altered pastures that may have a lower (or higher) grazing value than the original pasture. Changing management can influence the pasture species and sometimes the change in state. When desirable perennial species are lost through adverse conditions or heavy grazing, they are commonly replaced by less palatable perennial or annual species and form a new stable state.

State and transition models for vegetation communities relevant to the southern rangelands have built on Westoby et al. (1989) and include Hunt (1992), Jones and Burrows (1994), Milton et al. (1994), Heshmatti (1997), Heshmatti et al. (2002) and CSIRO (2018).

Reversing changes in pasture condition and composition

Experience in the southern rangelands and elsewhere shows that improving pasture condition to an original condition with original species is not always possible. Changes in the composition of the rangeland as a consequence of various pressures (grazing, fire and extended dry times) may not be reversible.

Changes in floristic composition may result in improved grazing value of pastures, but this is rare. An example is where degraded pasture is colonised by buffel grass in association with desirable native grasses. This change is likely to be more productive than the original pasture, and will require a change of management.

Speargrass/wallaby grass pastures of the Nullarbor provide another example. Before European settlement, the vegetation existed as a mosaic pattern in a state of cyclic equilibrium alternating between chenopod shrublands and grass-dominated patches. This cyclic state became disrupted with increased fire frequency and the introduction of rabbits and livestock.

Many of the Nullarbor vegetation communities containing chenopods have undergone irreversible transition into grassland or annual herbland (Figures 5, 6). The vegetation has become irreversibly altered because of increased fire frequency and grazing by rabbits in plague proportions. The limited floristic diversity of the Nullarbor region makes it extremely seasonally dependent from a pastoral perspective. Some of these transitional landscapes are extremely productive during favourable seasons, but their long-term carrying capacity is significantly reduced by the loss of the perennial vegetation communities. While good seasons provide abundant feed, there is nothing in reserve for a poor season.

An example from the southern Goldfields demonstrates the more typical shift to a permanent lower grazing value. Some eucalypt woodland pastures that once supported chenopod understoreys have transitioned into a eucalypt woodland with no chenopods because overgrazing caused the proliferation of unpalatable broom bush (*Eremophila scoparia*). It is probable that disturbance events, such as historic grazing, woodcutting, hailstorms and fires, are responsible for the disappearance of the saltbush seed source. Whatever the cause, the new vegetation state is likely permanent.

Figure 5: Mixed chenopod pasture: pearl bluebush (*Maireana sedifolia*) dominates the stony plain while bladder saltbush (*Atriplex vesicaria*) dominates the low-lying corridors between the stony rises

Figure 6: The same land unit patterns as Figure 5 where the chenopod cover has been replaced by speargrass (*Austrostipa scabra*)

When palatable perennial species are lost through overgrazing, they are commonly replaced by less desirable perennial or annual species and begin a transition into an alternative vegetation community. The new states may change conditions which reinforce the change (i.e. grasses increasing the fire susceptibility of shrublands, which favours further grass colonisation and elimination of the shrubs). This can create permanently altered pastures that may have a lower grazing value than the original pasture. Changing management can reverse some transitions but many become irreversible once established.

Cost of pasture condition decline and land degradation

Degradation in the rangelands has a real and significant annual cost to pastoral businesses. DPIRD estimated that the carrying capacity in 2018 in the southern rangelands was about 70% of potential due to land degradation, including pasture condition decline. Loss of carrying capacity equates to a loss in business profit. A recent breeder management case study concluded that applying stocking rates lower than DPIRD's current carrying capacity evened out cash flow and maintained herd productivity in the variable climate of the southern rangelands and was the most profitable strategy over the long term (Clinch n.d.).

This approach recognises that the stocking rate needs to account for restrictions caused by limited access to water and physically inaccessible country.

Rangeland degradation in the southern rangelands, comprising the Gascoyne, Murchison, Goldfields and Nullarbor, had an estimated annual opportunity cost (forgone income) to pastoral production averaging $30 million for the 5 years to 2018. Forgone income in the southern rangelands is estimated between 2008 and 2018 (Table 4). Income increases are driven by higher livestock prices, so the value of forgone income due to degradation increases when livestock prices increase.

Table 4: Estimated forgone income due to degradation for the southern rangelands for the 11 years to 2018

Year	Estimated opportunity cost of degradation in southern rangelands ($)	Estimated opportunity cost per business area operated ($)	Estimated annual receipts per business for sheep and cattle ($)	Estimated annual business profit at full equity ($)
2008	13,446,000	76,000	233,000	19,404
2009	19,916,000	114,000	368,000	−30,654
2010	15,640,000	111,000	274,000	−53,431
2011	21,438,000	149,000	247,000	−243,639
2012	22,918,000	176,000	313,000	46,809
2013	15,571,000	115,000	241,000	139,622
2014	22,947,000	177,000	460,000	−8,359
2015	20,933,000	169,000	614,000	322,861
2016	27,161,000	231,000	971,000	802,639
2017	34,163,000	303,000	982,000	307,872
2018	46,889,000	415,000	1,024,000	310,460

Note: Assumptions and notes about this analysis are in Appendix D.

Data sources: ABARES Agsurf and DPIRD rangelands survey data.

Current carrying capacity is reduced when land is degraded. Stocking beyond the current carrying capacity can contribute to further degradation of the rangelands, particularly if happening over an extended period or increased pressure is extremely high. Degradation leads to ongoing and persistent loss of income from pastoral businesses. Stocking to rangeland condition is the best way to preserve the resource base and potential future income.

This analysis has not considered the possibilities and costs of returning the resource to its potential carrying capacity. The costs could exceed the benefits.

Assessing pasture condition

Timing of assessments

Pasture condition can be assessed at any time of the year because it depends on the perennial species present and their density rather than bulk of the perennials and annuals (biomass). It is easier to identify some plant species when they are flowering; identification can be difficult in dry seasons, and after heavy grazing.

Frequency of assessments

The frequency of assessments depends on how quickly the pasture condition is changing. Yearly assessments allow early changes to be detected; on the other hand, since change is sometimes gradual, it may be easier to detect over intervals of several years. Climatic conditions are extremely variable in the southern rangelands, so reliable trends in some pastures may not become evident until after a series of assessments over many years.

When changing management to improve pasture condition, frequent assessment is recommended.

Choosing sites for assessing pasture condition

Consider your reasons for doing an assessment. Are you concerned about a 'hot' spot where problems are evident and want to judge change over time? If so, select a single site to monitor over a number of years. Alternatively, if you want to assess the 'average' condition of a paddock or management unit, select a number of sites that represent the range of pasture types and conditions in that paddock.

Variability is normal in the rangelands. No matter how hard you try to select uniform sites to assess, you will find variation in the species present compared with nearby areas, and other differences such as grazing pressure. Don't worry about this. It is more important that your assessment sites represent the pasture type and condition of that area.

If 2 or more distinct pasture types occur in the area you are interested in, consider selecting a site within each type. Avoid sampling across the boundary between different pasture types (e.g. where saltbush pasture grades into samphire).

Keeping track of changes

Recording the pasture condition at the same site over a number of years will show whether condition is improving, declining or staying the same. In conjunction with stock management and climate records, monitoring pasture condition enables the impact of management practices and seasonal conditions to be examined. One of the simplest ways to track changes is to photograph the site each time you assess its condition and note the date, pasture type, condition and reasons for your conclusion.

Pasture condition and indicator species

Each pasture type has characteristic plants – known as 'indicator species' – that indicate the condition of the vegetation for pastoral use. Plants in the species list for each pasture type have been assigned a category of indicator value, where known (Table 5).

Some species are more sensitive to grazing than others in the same category. For example, ruby saltbush is much more easily removed from the bluebush/saltbush pasture types than tall saltbush, but both are palatable.

Land managers can determine the impact of their management practices when they are able to distinguish plant species; and can then set goals in terms of the numbers and species of plants that are required to maintain the basic resource in a stable and productive condition on the property (Mitchell and Wilcox 1994).

Desirable (palatable/decreaser) species are usually perennials – they live for more than one season, and they last through the dry times, providing feed and protection from erosion.

Intermediate and undesirable (unpalatable/increaser) species may be annual or perennial. Annual plants generally live for one season only. They can provide short-term feed following a good growing season but have little bulk. Annuals tend not to last through the dry season and so provide little feed and protection from erosion.

Table 5: General characteristics of palatables, intermediates, unpalatables and species with no indicator value

Category	Characteristics
Desirables (D)	Species which decrease in number as grazing pressure increases (e.g. golden bluebush, silver saltbush). These are preferred and are also known as 'palatables' or 'decreasers'.
Intermediates (I)	Species which may initially increase under grazing, but being moderately or slightly palatable, decrease under continued increasing grazing pressure (e.g. three-winged bluebush).
Undesirables (U)	Species that increase in number with grazing pressure (e.g. crinkled cassia, needlebush). These are also known as 'woody weeds' (in the case of shrubs), 'unpalatables' or 'increasers'. They may include palatable species that are poisonous to livestock (e.g. kite leaf poison).
No indicator value (N)	Species which are largely unaffected by grazing and which usually only decrease in number after natural disturbance such as hail damage or fire (e.g. mulga, hard spinifex, eucalypts). These species are not palatable or only slightly palatable (or out of reach of browsing animals) and are sometimes known as 'stability desirables'. They may confer stability on the landscape and contribute to important processes such as water retention and nutrient cycling.

Good condition pasture: what to look for

The density and diversity of desirable species are optimal or close to optimal for the pasture you are observing (Figures 7, 8, 9). In pasture types that support tree-based clumps, the clumps are present and vigorous palatable species are present in the spaces between the clumps. Browse lines are obscure. Some less palatable or unpalatable species may be present, but total perennial cover is close to optimal.

Other features to look for:

- palatable species are present, vigorous and evenly spaced
- some intermediate and unpalatable perennial and annual plants may be present
- palatable species are reproducing; seedlings or young plants may be present
- groundcover is optimal for the site; sites with good soils and higher rainfall can generally support a higher density of plants than sites with shallow stony soils or lower rainfall
- where plants have been grazed down or burned, palatable species are present and evenly spaced.

Figure 7: An example of close to optimal cover (high productivity)

Figure 8: An example of close to optimal cover (low productivity)

Figure 9: An example of close to optimal cover of buffel grass

Fair condition pasture: what to look for

The density and diversity of desirable species are reduced for the pasture you are observing (Figure 10). Most of the palatable species are still present. Unpalatable species may have increased (Figure 11). Foliar cover is reduced compared with pastures in good condition unless an increase in unpalatable plants has occurred. Tree-based clumps are present but desirable species may be reduced or absent in the spaces between the clumps. Browse lines may be evident (Figure 12).

Other features to look for:

- palatable species may show signs of reduced vigour, for example, smaller plants
- seedlings or young plants of desirable species may be hard to find
- groundcover is less than optimal for the site; patches of annual plants may germinate following rain but dry up, or are trampled and blow away, leaving areas of bare ground.

Figure 10: An example of decreased density

Figure 11: An example of increased woody weeds

Figure 12: The obvious browse line is an indicator of heavy grazing

Poor condition pasture: what to look for

Intermediate and/or undesirable species dominate as dense stands or with variable amounts of bare ground (Figure 13). Palatable species may be absent. Foliar cover either decreases with a general loss of perennial plants (Figure 14) or increases due to invasion by unpalatable plants. Tree-based clumps may break down and desirable species are absent in the spaces between the clumps. Browse lines are high and obvious (Figure 15), or bare ground dominates, with occasional perennial plants spaced far apart.

Other features to look for:

- palatable species are rare or absent
- any palatable species remaining are usually stunted and unproductive
- intermediate species may be present but are less frequent compared to fair condition
- groundcover may be sparse or patchy
- large bare areas may be evident, particularly when the annual plants have dried up or been trampled and blown away.

Figure 13: An example of a weed dominated pasture

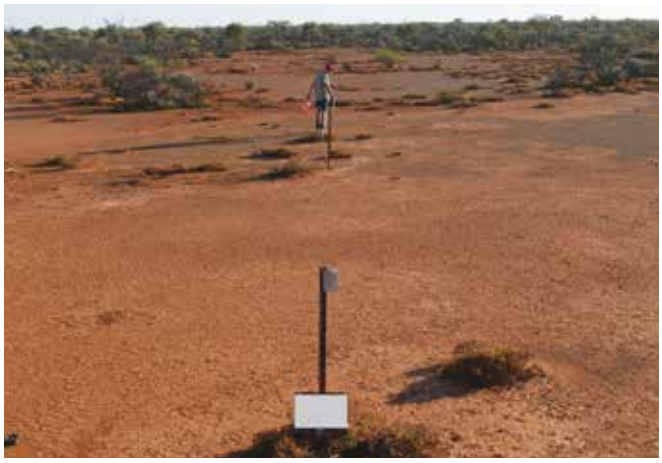


Figure 14: An example of a large bare area

Figure 15: An example of a strong browse line

Pearl bluebush pasture in the Gundockerta land system

Chenopods

Bluebush pastures

Occurrence estimate: 1.74 Mha, 2.1% of the southern rangelands (Appendix B, Figure B1)

Bluebush pastures occur on saline soils on level plains, river and lake frontages and on the Nullarbor Plain. Crystals of salt may be visible on the soil surface or on some plant stems. The soil surface may be puffy under a thin crust.

Vegetation structure and composition

These pastures have isolated to scattered mostly low (<1 m) shrubs (PFC ranges from less than 2% to 20%). Composition is very variable and a function of position in the landscape, geography, soil salinity and past use. Some bluebush pastures have a prominent overstorey of tall shrubs, and occasionally appear as scattered woodlands and, in severely degraded areas, as herbfields.

No single species of bluebush is distributed over the entire southern rangelands. Pearl bluebush is common throughout the Goldfields and Nullarbor (see Nullarbor pastures), while Gascoyne bluebush is restricted to the Gascoyne. Flat leaf bluebush and three-winged bluebush are widely distributed north of Norseman. Some bluebush pastures in the Murchison are now dominated by sago bush. Table 6 has a list of the common and important species for this pasture group.

Pastoral value: high

Bluebush pastures in good condition are a durable, reliable, high quality, year-round food source for stock (15–23% protein), especially when annual feed is scarce or absent. Good quality water supplies must be provided to maximise pasture use and animal productivity. Perennial bluebushes are extremely long-lived and durable shrubs; however, when they have been grazed out, they can take many years or even decades to return to the landscape. Combinations of strategic fencing, adequate distribution of good quality water, conservative stocking rates and spelling can maintain or improve the condition of bluebush pastures. Complete spelling can improve pasture condition after a major recruitment event. Occasional spelling to take advantage of summer rainfall for germination and recruitment of young plants is necessary to maintain a viable age structure. Regular winter spelling is recommended for maintenance of vigour. Opportunistic grazing of annual growth can be employed in fair condition pastures in a good season. Cultivation and reseeding followed by complete spelling and control of all herbivores may be required where few perennials remain.

Most bluebush pastures are degraded due to overgrazing. These pastures may never be restored if the soil surface has eroded. Pastoral value in severely degraded bluebush pastures is far below the potential. Degraded areas may produce prolific annual herbage in good seasons but have no dry season durability.

Condition statement for bluebush pastures

Good: Palatable bluebushes dominate with an even cover of vigorous and robust mature and young plants (Figures 16, 19, 22). PFC is generally 5–20% or better in good seasons. Desirable saltbushes are other important indicators of good condition.

Disappearance of the preferentially grazed bluebush and saltbush species is an early-warning of pasture condition decline. Change in bluebush pastures can be subtle; for instance, shy bluebush is very palatable when present and will be preferentially grazed, leaving no sign of degradation in other plant species. Moderately palatable species such as cotton bush sometimes make a significant contribution to pasture productivity. Undesirable species such as cassias and needlebush may be present at low densities.

In good condition, the soil surface is stable, with an abundance of cryptogamic crusts assisting vegetation protection from wind and water erosion. No erosion is present.

Fair: Reduced density of the dominant palatable bluebush and other low shrubs indicates a decline in pasture condition from good to fair, shown as reduced shrub cover (Figures 17, 20, 23). PFC is generally 5–10% but may be as low as 2.5%. The most palatable perennial shrubs will become rare or absent. Decline in bluebush density usually generates an increase in seasonal growth of annuals and ephemerals in the increased space between the palatable shrubs. The density of moderately palatable and unpalatable plants will tend to remain the same as in good condition pastures, but the increased prominence of the unpalatable species is symptomatic. Minor erosion may be evident.

The slow recovery of fair and poor condition bluebush pastures serves as incentive to manage fair condition pastures conservatively and reduce the risk of further decline.

Poor: Deterioration of bluebush pastures to poor condition is characterised by a marked decline in perennial shrub cover, development of bare areas and often increased density of unpalatable species (Figures 18, 21, 24). The density of the dominant palatable bluebush is reduced considerably. Established bluebush plants may show very poor vigour, often being grazed back to unpalatable woody material. Perennial species may be completely absent in very poor condition. Scalding and hummocking caused by wind is common in poor condition bluebush pastures but water erosion and perennial plant extinguishment are the primary causes that lead to serious cases of soil degradation.

Other notes

Bluebush pastures, regardless of condition, may support fuel loads from annuals and ephemerals sufficient to carry fires following above-average growing seasons. Increased susceptibility to wildfire is a significant threat to these pastures, with burning likely to have detrimental consequences for future pasture productivity.

Some extensive areas formerly supporting bluebush pasture are now so degraded the likelihood of any recovery of palatable bluebushes is limited. The recommended stocking rate for annual-only pastures to have a chance of recovery is very low (>30 ha/DSE). There is no grazing value in very poor condition bluebush pastures without perennial plants to support stock during dry seasons. Annual-only pastures are not viable for commercial pastoralism.

Figure 16: A pearl bluebush pasture in good condition. There is a good mix of other palatable shrubs among the pearl bluebush clumps. The site is a gently undulating, calcareous loamy plain in the Gundockerta land system.

Figure 17: A pearl bluebush pasture in fair condition. Pearl bluebush is abundant to the exclusion of most other species in the understorey, indicating previous overgrazing. Bladder saltbush is lacking in the spaces between the bluebush mounds and palatable feather speargrass is restricted to within bluebush clumps. The site is on a very gently undulating, calcareous loamy plain in the Gundockerta land system.

Figure 18: A pearl bluebush pasture in poor condition. Unpalatable species such as broom bush are relatively abundant and palatable species such as bladder saltbush are much reduced. Large bare areas and erosion are evident. The site is on a level calcareous loamy plain in the Gundockerta land system.

Figure 19: A sago bush pasture in good condition. An abundance of sago bushes exists in dense clusters with individuals of mixed age. The soil surface is intact with cryptogamic crusts and gilgai crabholes are in good condition, with no sign of compaction. The site is on a gilgai plain with cracking clay soils in the Bunyip land system.

Figure 20: A sago bush pasture in fair condition. Sago bush numbers are reduced with bare spaces developing between bush mounds. Loss of shrub connectivity is resulting in some redistribution of the soil surface through sheet and wind erosion. Due to favourable seasonal conditions, some cotton bush is present. The site is on the lower slope of a low rise on a shallow loamy duplex soil in the Gundockerta land system.

Figure 21: A sago bush pasture in poor condition. Sago bush density is greatly reduced with plants existing as individuals, not clusters. Plants are small and stunted from grazing pressure. Erosion is evident with much soil redistribution between the bush mounds, while soil accumulation mounds under shrubs are diminishing. The site is on a level calcareous loamy plain in the Gundockerta land system.

Figure 22: A Gascoyne bluebush pasture in good condition. A diverse species mix includes bladder saltbush and Gascoyne bluebush and a range of ages of the desirable plants. No undesirable bardie bush or needlebush is present and no soil redistribution evident. The site is on an alluvial plain in the Sandal land system.

Figure 23: A Gascoyne bluebush pasture in fair condition. Species diversity is reduced compared with good condition. Only a few silver saltbushes remain. There is slight soil surface erosion. The site is on a lower plain in the Donovan land system.

Figure 24: A Gascoyne bluebush pasture in poor condition. There are fewer than 400 plants per hectare (4/100 m^2) of remnant Gascoyne bluebush. Needlebush and bardie bush are present. Some soil accumulation around plant bases, indicates that soil is being redistributed. The site is on an alluvial plain in the Sandal land system.

Table 6: Common and important species in bluebush pastures

Common name	Scientific name	Desirability
Ball leaf bluebush	*Maireana glomerifolia*	D
Bladder saltbush	*Atriplex vesicaria*	D
Cotton bush	*Ptilotus obovatus*	D
Feather speargrass	*Austrostipa elegantissima*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Flat leaf bluebush	*Maireana planifolia*	D
Gascoyne bluebush	*Maireana polypterygia*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Green cassia	*Senna glutinosa* subsp. *chatelainiana*	D
Sage	*Cratystylis subspinescens*	D
Shy bluebush	*Maireana platycarpa*	D
Silky bluebush	*Maireana villosa*	D
Silver saltbush	*Atriplex bunburyana*	D
Spiny bluebush	*Maireana aphylla*	D
Tall saltbush	*Rhagodia eremaea*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Broom bush	*Eremophila scoparia*	U
Cassias	*Senna* spp.	U
Flannel bush	*Solanum lasiophyllum*	U
Needlebush	*Hakea preissii*	U
Silver poverty bush	*Eremophila pterocarpa*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Tomato bush	*Solanum orbiculatum*	U
Wait-a-while	*Acacia cuspidifolia*	U
Curara	*Acacia tetragonophylla*	I
False bluebush	*Cratystylis conocephala*	I
Gascoyne mulla mulla	*Ptilotus polakii*	I
Granite poverty bush	*Eremophila platycalyx*	I
Lovegrasses	*Eragrostis* spp.	I
Mulga	*Acacia aneura*[1]	I
Pearl bluebush	*Maireana sedifolia*	I
Sago bush	*Maireana pyramidata*	I
Three-winged bluebush	*Maireana triptera*	I
Western myall	*Acacia papyrocarpa*	I
Wilcox bush	*Eremophila forrestii*	I
Woolly poverty bush	*Eremophila lachnocalyx*	I

D = desirable; U = undesirable; I = intermediate

1. Mulga as *Acacia aneura* has been split into multiple species, including *A. aneura, A. aptaneura, A. caesaneura, A. fuscaneura, A. incurvaneura, A. macraneura, A. mulganeura, A. pteraneura*.

Eucalypt chenopod pastures

Occurrence estimate: 2.96 Mha, 3.6% of the southern rangelands (Appendix B, Figure B2)

Eucalypt chenopod pastures predominantly occur in the southern Goldfields and Nullarbor survey areas. In the Goldfields, these pastures are often located on calcareous shallow loams on footslopes and low rises over greenstone or granitic bedrock, and grade down valley floors to alluvial plains on calcareous loamy earths, red loamy earths, clay loams or clays. On slopes and rises a variable mantle typically consisting of the rocks related to the underlying geology may be present. In the Nullarbor, these pastures occur on calcareous loamy earths of generally shallow depth over calcrete plains. Fine to coarse limestone rocks and calcrete nodules are common and cover up to 50% of the surface. Goldfields-Nullarbor eucalypt chenopod pastures occur frequently across the area from south of Menzies to north of Lake Moore, and east of the agricultural vermin barrier fence to Kitchener railway siding on the western edge of the Nullarbor Plain. Similar pastures also occur in the Sandstone, Yalgoo and Paynes Find and the lower Murchison River survey areas on alluvial plains. Soils range from red shallow loams, deep red loamy earths or loamy duplexes to clay soils on clay plains in the eucalypt chenopod pastures of the lower Murchison River.

Vegetation structure and composition

Eucalypt chenopod pastures occur as scattered to moderately close woodlands (PFC 10–30%). The tree stratum comprises tree or mallee form eucalypts which vary across the regions (see Other notes below), although shrubs such as broom bush, curara, jam, tan wattle, quandong and sandalwood (*Santalum* spp.) occur frequently.

The most important forage shrubs are bladder saltbush and/or silver saltbush. Long-lived bluebushes such as pearl bluebush and sago bush have important roles as stabilising shrubs. The salt content in saltbush leaves is generally high, but other plants such as cotton bush, tall sida and tar bush provide some nonsaline, perennial forage for herbivores. Several shorter-lived bluebushes such as felty leaf bluebush, golden bluebush and pink-seeded bluebush and perennial tussock grasses, such as palatable speargrasses, are reliable indicators of good condition.

Tan wattle, three-winged bluebush, grey cassia, bead hopbush and broom bush are unpalatable. In some degraded areas, kidney saltbush may replace more palatable saltbushes; however, this species doesn't necessarily indicate a grazing-induced decline because it is the naturally dominant saltbush in some pastures. Table 7 has a list of the common and important species for this pasture group.

Pastoral value: moderate

The pastoral value of eucalypt chenopod pastures is moderate. The composition of the understorey is the most reliable indicator of grazing effects. Bladder saltbush and silver saltbush are the most important indicators of pasture condition; they respond to both seasonal conditions and grazing pressure. One or both species may be present. Pearl bluebush is a valuable stability desirable plant as it assists in preventing soil erosion and is rarely eaten except where there is heavy grazing pressure. A dramatic loss of pearl bluebush should be regarded as a catastrophe.

Condition statement for eucalypt chenopod pastures

Good: A diverse mix of palatable low shrub species would be expected in the open and under trees and tall shrub canopies (Figures 25, 28, 31). Pearl bluebush, bladder saltbush and/or silver saltbush may be co-dominant and plentiful between trees. Young saltbush and pearl bluebush plants are common and other bluebushes will also be present including felty leaf bluebush, golden bluebush, pink-seeded bluebush and sago bush. The most reliable indication of grazing impact is the diversity and density of palatable low and subshrubs (e.g. ruby saltbush, tall saltbush, tall sida and tar bush), particularly among the tree-based clumps. Perennial grass species, such as palatable speargrasses, may be present and indicate good resource condition when plentiful. There is extensive cryptogamic crusting.

Fair: Species diversity overall is reduced, first in the open areas and then among tree-based clumps (Figure 29, 32), although the density of unpalatable species may have increased (Figure 26). As there are fewer palatable saltbushes present pearl bluebush may dominate, and the density of cotton bush and/or old man saltbush may also have increased. There is some breakdown of the soil surface crust.

Poor: Unpalatable species belonging to the *Eremophila*, *Senna* and *Acacia* genera become abundant (Figures 27, 30, 33). Continued heavy grazing will result in decreasing species diversity. There will be few or no pearl bluebush plants present. Grazing will be evident on old man saltbush plants. Tan wattle, broom bush, grey cassia, silver cassia and bead hopbush may be present and increasing. The soil surface may be sealed and rilled in places. There will be evidence of water erosion in valley floors.

Survey data show that eucalypt chenopod pastures in the southern rangelands are predominantly in fair condition.

Other notes

In the Goldfields, prominent eucalypts include salmon gum, gimlet, redwood, Griffith's grey gum, several varieties of blackbutt and many others – reputedly up to a quarter of all Australian eucalypts. In the Nullarbor region, giant mallee, yorrell and Yalata mallee commonly dominate the tree stratum of equivalent pastures. In the Sandstone, Yalgoo and Paynes Find and the lower Murchison River survey areas, the prominent eucalypt is York gum.

These pastures do not normally burn readily due to high canopies and lack of flammable biomass between tree-based clumps. However, after favourable seasons they may become susceptible to fire due to increased biomass and structural connectivity, as may occur with an abundance of perennial grasses between shrubs. Pearl bluebush can survive low to moderate intensity fires, while saltbushes rarely survive any type of fire. As saltbush regeneration is from seed, if grazing pressure restricts post-fire saltbush re-establishment, then the seed bank may become exhausted. The consequences of poor grazing management after a fire and/or excessive grazing result in similar outcomes with saltbushes being eliminated while simultaneously these pastures are invaded by unpalatable plants such as curara, broom bush, grey cassia and tan wattle. Eucalypt chenopod pastures are usually stable in good and fair condition. Soil erosion is common where the vegetation is degraded.

Figure 25: A eucalypt woodland over saltbush shrubland in good condition. There is good density and diversity of palatable shrubs, with an abundance of saltbush. There is no erosion and cryptogamic crusts are common and intact. The site is on a level plain on a calcareous shallow loam in the Woolibar land system.

Figure 26: A eucalypt woodland over saltbush shrubland in fair condition. Bladder saltbush is present but unpalatable broom bush is increasing in abundance. Cryptogamic crust is still common though there are some patches of soil disturbance and crust loss. The site is on a calcareous loamy plain in the Gumland land system.

Figure 27: A eucalypt woodland over saltbush shrubland in poor condition. The saltbush understorey has been drastically reduced and unpalatable shrubs such as broom bush are common. Widespread soil loss through sheetwash erosion is resulting in stony lag strewn across the soil surface. The site is on a level calcareous loamy plain in the Gumland land system.

Figure 28: A eucalypt woodland over a mixed bluebush-saltbush shrubland in good condition. There is an abundance of saltbush among patches of bluebush between stands of eucalypts. The soil surface is intact and erosion restricted due to the protection and convoluted flow paths created by so many shrubs. Cryptogamic crusts are abundant and intact. The site is on a level calcareous loamy plain in the Woolibar land system.

Figure 29: A eucalypt woodland over a mixed bluebush-saltbush shrubland in fair condition. The density of saltbush and bluebush is reduced between eucalypt stands. The decline in abundance of palatable shrubs exposes areas between eucalypts, leading to unobstructed through-flow, development of erosion cells and loss of resources. The site is on a level calcareous loamy plain in the Woolibar land system.

Figure 30: A eucalypt woodland over a mixed bluebush-saltbush shrubland in poor condition. Palatable saltbush is eliminated; the forage is reduced to seasonally dependent bindiis and forbs. Unpalatable shrubs such as broom bush dominate the understorey. Extensive sheetwash erosion is causing soil loss. Soil redistribution deposits fine ironstone lag across the surface. The site is on a level calcareous loamy plain in the Gumland land system.

Figure 31: A York gum woodland in good condition. Saltbush is abundant between stands of eucalypts. Palatable species such as tall saltbush, ruby saltbush and bluebushes are present under the trees. Unpalatable species such as cassias and broom bush may be present at low density.

Figure 32: A York gum woodland in fair condition. Sparse shrubs are present between stands of eucalypts. Palatable species such as saltbushes and bluebushes are absent. Short-lived cotton bush is present under trees and between stands of eucalypts. Unpalatable Goldfields daisy, cassias and broom bush are present under the trees.

Figure 33: A York gum woodland in poor condition. Palatable species are lacking under the trees and between stands of eucalypts. Unpalatable species such as cassias and Goldfields daisy may be present at very low density. There is very little groundcover between stands of eucalypts.

Table 7: Common and important species in eucalypt chenopod pastures

Common name	Scientific name	Desirability
Bladder saltbush	*Atriplex vesicaria*	D
Cane speargrass	*Austrostipa platychaeta*	D
Cotton bush	*Ptilotus obovatus*	D
Feather speargrass	*Austrostipa elegantissima*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Grey copperburr	*Sclerolaena diacantha*	D
Native currant	*Psydrax suaveolens*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Scrambling saltbush	*Chenopodium curvispicatum*	D
Silver saltbush	*Atriplex bunburyana*	D
Small-leaved poverty bush	*Eremophila parvifolia*	D
Tall saltbush	*Rhagodia eremaea*	D
Tall sida	*Sida calyxhymenia*	D
Tar bush, fuchsia bush	*Eremophila glabra*	D
Bead hopbush	*Dodonaea lobulata*	U
Broom bush	*Eremophila scoparia*	U
Curved-leaf senna	*Senna cardiosperma*	U
Goldfields daisy	*Olearia muelleri*	U
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Kidney saltbush	*Atriplex stipitata*	U/I
Needlebush	*Hakea preissii*	U
Silver cassia, banana-leaf cassia	*Senna artemisioides* subsp. x *artemisioides*	U
Spear-fruit copperburr	*Sclerolaena patenticuspis*	U
Tan wattle	*Acacia hemiteles*	U
Three-winged bluebush	*Maireana triptera*	U
Curara	*Acacia tetragonophylla*	I
Pink-seeded bluebush, downy bluebush	*Maireana trichoptera*	I
False bluebush	*Cratystylis conocephala*	I
Jam	*Acacia acuminata*	I
Limestone wattle	*Acacia sclerosperma*	I
Miljee	*Acacia oswaldii*	I
Mulga	*Acacia aneura*	I
Old man saltbush	*Atriplex nummularia*	I
Pearl bluebush	*Maireana sedifolia*	I
Sago bush	*Maireana pyramidata*	I
Speargrass	*Austrostipa scabra*	I
Spine bush	*Acacia nyssophylla*	I
Sugarwood	*Myoporum platycarpum*	I
Western myall	*Acacia papyrocarpa*	I
Gums and mallees	*Eucalyptus* spp. (see Other notes)	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

Greenstone stony plain pastures

Occurrence estimate: 0.61 Mha, 0.8% of the southern rangelands (Appendix B, Figure B3)

Extensive areas of upland country are based upon metamorphosed volcanic rock. These landforms occur throughout the Murchison and Goldfields. These areas are commonly referred to as the greenstones or greenstone belts and contain major gold and nickel deposits plus a varied assortment of other minerals. Greenstone stony plain pastures are similar to stony mixed chenopod pastures, but as the country can be considerably more fertile than granite or stony bluebush country, possibly due to deeper soils containing extra minerals, it is recognised as supporting distinct pastures. Land systems which typify this country include Coolgardie, Gundockerta, Nubev, Violet and Woolibar in the Goldfields.

Some of the most typical and distinctive examples of greenstone country are found in the Goldfields around Coolgardie, Kalgoorlie, Laverton, Leonora and Menzies. The land has been used extensively for both mining and pastoralism, which historically focused on wool production. Greenstone belts are less frequent west of a line from Meekatharra, Cue to Yalgoo.

Vegetation structure and composition

Greenstone stony plains support a varied population of tall and low shrubs. Variations result from different environmental impacts, primarily caused by grazing and/or mining. These shrubland pastures have a PFC of 10–20% and occasionally up to 30%. They have a pearl bluebush-dominated low shrub stratum, a well-developed mid-shrub stratum and very scattered tall shrubs and trees. In good condition, bladder saltbush is co-dominant with pearl bluebush. Broom bush appears on the less alkaline sites, usually on rising ground. A wide range of other eremophilas may also be present including pixie bush, poverty bush and weeooka. The most sensitive palatables are golden bluebush and the saltbushes. Annuals in season may include everlastings and tall mulla mulla. Table 8 has a list of the common and important species for this pasture group.

Pastoral value: moderately high

The pastoral value of the greenstone stony plain pastures is moderately high, grading upslope into greenstone hills (crests and upper hillslopes) with low pastoral value acacia shrubland. These pastures are suitable for year-round use by all classes of livestock under conservative stocking rates. Moderate grazing can stimulate some low shrub growth. Excessive grazing kills the desirable perennial shrubs. Fencing off large areas of bluebush/saltbush pasture from other pasture types is recommended to manage preferential grazing pressure. Good quality water supplies must be provided to maximise pasture utilisation and animal productivity. Pastures in fair or poor condition will require periodic spelling if condition is to be improved. Spelling is recommended during and immediately after the growing season until seedlings are well established and mature plants have set seed.

Condition statement for greenstone stony plain pastures

Good: Saltbushes are co-dominant with the long-lived bluebushes (Figure 34). There is a diversity of low and medium shrubs present such as golden bluebush, sago bush, sage, bladder and silver saltbush. A range of mixed age plants is present on non-stony surfaces. Very few to no young unpalatable plants are present. Well-developed soil surface crusting will be evident on non-stony areas. Feather speargrass is a common perennial and neverfail often grows in drainage foci. Juvenile saltbushes, golden bluebushes and sago bushes will be present. Low and medium shrubs are well-branched (not hedged) and bush mounds will be healthy and joined together.

Fair: Moderate grazing can result in some loss of bladder and silver saltbush and small bluebushes, but very little change in the number of pearl bluebush and perhaps some increase in sago bush and cotton bush (Figure 35). In this condition, the vegetation retains its resilience and protects the soil surface from erosion. Vegetation is dominated by long-lived shrubs such as pearl bluebush, sago bush and sage. Few young palatable species are present. Three-winged bluebush may increase. Soil surface crusting will be evident on non-stony areas, but may be less well-developed than good condition. Bush mounds may be reduced in size and signs of water flow evident between mounds. Change from fair condition varies and will depend on management and climate. The country can be comparatively fragile where the stony mantle is not heavy. Conservative use and favourable seasons may lead to the recruitment of palatable shrubs although this requires a seed source. When shrubs are lost the annual speargrass and bindii numbers increase.

Poor: Excessive grazing pressure results in further reductions in the number of low shrubs, and depending on climatic events and the presence of seed sources, may encourage a dramatic increase in woody weeds such as needlebush and cassias (Figure 36). Saltbushes are conspicuous by their absence. Three-winged bluebush may increase and can come to dominate the pasture. There is an increase in species such as desert cassia, tan wattle (south of Menzies), needlebush, three-winged bluebush and bead hopbush, while other low shrubs decline. Sago bush can dominate sites that previously supported more palatable species such as bladder saltbush. If pearl bluebush or sago bush is the only shrub in the understorey it usually reflects previous overgrazing. The moderately palatable pearl bluebush and sago bush may be the only palatable plants remaining; the loss of all shrubs with only bindiis and other short-lived species remaining is possible. Needlebush, grey cassia and bead hopbush are likely to be present. Soil surface crusting will be reduced and minor sand piling against fallen trees may be evident. Bush mounds may be lost through trampling, wind erosion and water erosion.

Other notes

Survey data show that greenstone stony plain pastures in the southern rangelands are predominantly in fair condition, due to bladder saltbush being absent or much reduced, but the long-lived species such as pearl bluebush are still present and dominating the pasture. Greenstone stony plain pastures are usually stable in good condition, but fragile and susceptible to rapid decline with overuse.

Figure 34: A greenstone stony plain pasture in good condition. There is a diverse range of chenopod shrubs with the structurally important sago bushes exhibiting a range of different-aged individuals. The site is on a saline stony plain on a duplex soil in the Gundockerta land system.

Figure 35: A greenstone stony plain pasture in fair condition. There is a reduction in species diversity with the more resilient sago bush dominating. A number of juvenile sago bushes are present. Bare areas have increased. The site is on a saline stony plain on a duplex soil in the Gundockerta land system.

Figure 36: A greenstone stony plain pasture in poor condition. Shrub density and diversity are reduced with few desirables. Bush mounds are deteriorating, sheet erosion is stripping away topsoil and the site is shedding water. The site is on a saline stony plain in the Gundockerta land system.

Table 8: Common and important species in greenstone stony plain pastures

Common name	Scientific name	Desirability
Bladder saltbush	*Atriplex vesicaria*	D
Cotton bush	*Ptilotus obovatus*	D
Curly windmill grass	*Enteropogon ramosus*	D
Currant bush	*Scaevola spinescens*	D
Feather speargrass	*Austrostipa elegantissima*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Grey copperburr	*Sclerolaena diacantha*	D
Lake-fringe rhagodia	*Rhagodia drummondii*	D
Limestone grass	*Enneapogon caerulescens*	D
Mingah bush, bullock bush	*Alectryon oleifolius*	D
Neverfail	*Eragrostis setifolia*	D
Pixie bush	*Eremophila oldfieldii*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Sage	*Cratystylis subspinescens*	D
Silver saltbush	*Atriplex bunburyana*	D
Tall sida	*Sida calyxhymenia*	D
Tar bush, fuchsia bush	*Eremophila glabra*	D
Bead hopbush	*Dodonaea lobulata*	U
Broom bush	*Eremophila scoparia*	U
Desert cassia	*Senna artemisioides* subsp. *filifolia*	U
Needlebush	*Hakea preissii*	U
Tan wattle	*Acacia hemiteles*	U
Three-winged bluebush	*Maireana triptera*	U
Black oak	*Casuarina pauper*	I
Curara	*Acacia tetragonophylla*	I
Fine leaf jam	*Acacia burkittii*	I
Mulga	*Acacia aneura*	I
Naked lady	*Exocarpos aphyllus*	I
Old man saltbush	*Atriplex nummularia*	I
Pearl bluebush	*Maireana sedifolia*	I
Poverty bush	*Eremophila alternifolia*	I
Sago bush	*Maireana pyramidata*	I
Sandalwood	*Santalum spicatum*	I
Speargrass	*Austrostipa scabra*	I
Waterbush	*Lycium australe*	I
Weeping pittosporum	*Pittosporum angustifolium*	I
Goldfields daisy	*Olearia muelleri*	N
Slender fuchsia bush	*Eremophila decipiens*	N
Wallaby grass	*Rytidosperma caespitosum*	N
Weeooka	*Eremophila oppositifolia*	N
Tall mulla mulla	*Ptilotus exaltatus*	ann.
Bindiis	*Sclerolaena* spp.	ann.
Annual speargrasses	*Austrostipa* spp.	ann.

D = desirable; U = undesirable; I = intermediate; N = no indicator value; ann. = annual

Mixed chenopod shrub plain pastures

Occurrence estimate: 3.93 Mha, 4.8% of the southern rangelands (Appendix B, Figure B4)

Mixed chenopod shrub plain pastures occur mostly on alluvial plains with saline texture-contrast soil, often over hardpan. These pastures are found on broad alluvial plains associated with lake country as well as the margins of salt lakes and drainage lines carrying flow through alluvial and saline plains. These pastures also occur on the alluvial fans and footslopes below breakaways, in both granite- and greenstone-based landscapes. Mixed chenopod shrub plain pastures are regularly associated with drainage systems that are slow-flowing and sluggish, where local base-levels restrict flow resulting in the deposition of fine sediments and clay formation, with salts accumulating in the soil profile.

The footslopes and the lower plains of the Pillawarra land system (with unique fertile soils of brown loamy earths) also support these pastures.

Frankenia-dominated pastures on saline duplex and clay soils are included.

Vegetation structure and composition

All mixed chenopod shrub plain pastures have a low shrub stratum of halophytic (salt-tolerant) species (with or without a tree or tall shrub stratum) when in good condition. The mixed chenopod group of pastures comprises 2 distinct communities: well-mixed halophytic associations and frankenia-dominated communities associated with samphire and saltbush. Mixed halophytic pastures may occur nearby and grade into saltbush and bluebush communities. Perennial grasses are generally sparse to absent. These pastures have a PFC of 5–50%. Composition is variable and a function of degree of degradation, soil type, degree of soil salinity, level of development in the overstorey and species biology. Low shrubs may form clumps under larger plants in some pastures. Table 9 has a list of the common and important species for this pasture group.

Pastoral value: high

Pastoral value of mixed chenopod shrub plain pastures is high. Conservative pastoral management, regular winter spelling and retention of critical levels of cover are essential to preserving productivity, dry season reserves, seasonal responsiveness, resistance to soil erosion and unpalatable-shrub invasion. Spelling after summer rainfall will also improve the chances for recruitment of new plants. Maintenance of shrub cover well above the critical threshold (PFC around 7.5%) in the low shrub stratum is recommended. Monitoring changes in the low shrub stratum is very important.

Condition statement for mixed chenopod shrub plain pastures

Good: Mixed chenopod shrub plain pastures support annual and ephemeral herbage of a high quality for livestock in good seasons, in addition to desirable perennials with 10% cover or better in most pastures (Figure 37). Low shrub groups commonly associated with them include other halophytes, poverty bushes, cassias and shrubby wattles. Desirable perennial shrubs will be dominant. Examples include silver saltbush, currant bush, ruby saltbush and golden bluebush. Frankenia-dominated associations will also include relatively desirable plants such as bladder saltbush, sweet samphire and bronze bluebush. Short-lived chenopods such as bindiis, saltbushes and bluebushes are major components of the annual herbage.

Fair: Cover usually remains above 10% for the low shrub layer. Key decreasers such as saltbushes and bluebushes are reduced and unpalatable species such as needlebush may be present but will not dominate the understorey (Figure 38). Alternatively, key decreasers are present but not dominant, while more resilient plants such as sago bush, tall saltbush and three-winged bluebush dominate. No accelerated erosion is present when mixed chenopod shrub plain pastures are in fair condition.

Poor: When mixed chenopod shrub plain pastures decline, erosion is generally present and may be accelerated. PFC can fall below 5%. Most of the desirable low shrubs have been lost from the understorey (Figure 39). Some understoreys are dominated by invasive unpalatable species such as silver poverty bush, needlebush, bardie bush and wait-a-while; while other pastures lack understorey perennials.

Heavy stocking and continuous grazing of these pastures has contributed to their near-complete degradation to an ephemeral-only state where no original perennial species remain. Ephemeral plants do not hold the soil together. Excessive grazing pressure and trampling are likely to disturb soil crusting and increase soil loss from scalded and bare areas. Wind erosion can be severe during extended dry periods if shrub cover is lost.

Other notes

The enlargement of scalded areas signals the passing of a degradation threshold – scalded patches overlying saline soil are prone to dispersive sealing, inhibiting plant establishment. Regeneration will be a long-term prospect after bare scalds have formed. Poor condition mixed chenopod shrub plain pastures require spelling from grazing for extended periods. Timeframes of typically greater than 5 complete growing seasons are necessary for any rehabilitation process to begin to yield tangible results. Rehabilitation of poor condition chenopod pastures may take more than 20 years if stock are excluded (in the authors' observations); under grazing use it will take longer, if at all. Water ponding strategies and complete spelling can be effective if regeneration is the priority.

Survey data show that mixed chenopod shrub plain pastures in the southern rangelands are generally in fair and poor condition, with some areas in a severely degraded and eroded state.

Soil erosion is usually associated with a decline in condition in these pastures.

Figure 37: A mixed chenopod shrub plain pasture in good condition. There is a good mix of palatable species, including saltbushes, golden bluebush, bronze bluebush and frankenia. Cover is close to optimal, and the soil surface is stable. The site is on hummocky plains with sand deposits in the Carnegie land system.

Figure 38: A mixed chenopod shrub plain pasture in fair condition. Shrub density and diversity is reduced to the hardier species like sage, sago bush and frankenia, and the soil surface is inflated. The site is on an alluvial plain with duplex soils in the Carnegie land system.

Figure 39: A mixed chenopod shrub plain pasture in poor condition. There is isolated cover and palatable plants are reduced to hardy long-lived species, including silver saltbush and sago bush. Active scald and rill erosion is occurring. The site is on an alluvial plain with sandy-surfaced duplex soil in the Carnegie land system.

Table 9: Common and important species in mixed chenopod shrub plain pastures

Common name	Scientific name	Desirability
Ball leaf bluebush	*Maireana glomerifolia*	D
Bladder saltbush	*Atriplex vesicaria*	D
Bronze bluebush	*Maireana atkinsiana*	D
Cane speargrass	*Austrostipa platychaeta*	D
Cotton bush	*Ptilotus obovatus*	D
Currant bush	*Scaevola spinescens*	D
Feather speargrass	*Austrostipa elegantissima*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Lake-fringe rhagodia	*Rhagodia drummondii*	D
Mulga bluebush	*Maireana convexa*	D
Pussy bluebush	*Maireana melanocoma*	D
	Maireana integra	D
Ruby saltbush	*Enchylaena tomentosa*	D
	Eremophila malacoides	D
Sage	*Cratystylis subspinescens*	D
Scrambling saltbush	*Chenopodium curvispicatum*	D
Silver saltbush	*Atriplex bunburyana*	D
Swamp saltbush	*Atriplex amnicola*	D
Sweet samphire	*Gunniopsis quadrifida*	D
Tall saltbush	*Rhagodia eremaea*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Broom bush	*Eremophila scoparia*	U
Flannel bush	*Solanum lasiophyllum*	U
Limestone fuchsia	*Eremophila phyllopoda*	U
Needlebush	*Hakea preissii*	U
Silver poverty bush	*Eremophila pterocarpa*	U
Slender fuchsia bush	*Eremophila decipiens*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Sunglasses bush	*Lawrencia squamata*	U
Three-winged bluebush	*Maireana triptera*	U
Wait-a-while	*Acacia cuspidifolia*	U
Bindiis	*Sclerolaena* spp.	I
Curara	*Acacia tetragonophylla*	I
Emu bush	*Eremophila maculata*	I
False bluebush	*Cratystylis conocephala*	I
Frankenias	*Frankenia* spp.	I
Mulga	*Acacia aneura*	I
Pearl bluebush	*Maireana sedifolia*	I
Sago bush	*Maireana pyramidata*	I
Samphire	*Tecticornia doliiformis*	I
Samphires	*Tecticornia* spp.	I
Small leaf bluebush	*Maireana brevifolia*	I
Woollybutt grass	*Eragrostis eriopoda*	I
Limestone poverty bush	*Eremophila pantonii*	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

Nullarbor pastures

Occurrence estimate: 4.29 Mha, 5.3% of the southern rangelands (Appendix B, Figure B5)

Nullarbor pastures occur in the geographically distinct Nullarbor region. They predominantly occur on the extensive undulating limestone plains associated with the Bunda Plateau, and to a lesser extent the northern portion of the Roe Plains. Soils are shallow calcareous loams, occasionally with limestone outcrop. Cryptogams are common. Rainfall run-off drains into large shallow depressions, before percolating through the limestone. Groundwater is generally deep (75–150 m) and often saline.

In the north of the Nullarbor, shallow, circular, closed depressions, locally referred to as dongas, intersperse the surrounding stony plains. They commonly have flat clay floors and can be up to several hundred metres across with gently sloped margins. They are zones of soil accumulation.

Vegetation structure and composition

Nullarbor pastures are predominantly pearl bluebush and bladder saltbush. Bluebush favours the rises and saltbush the depressions. Grasses such as speargrass are extremely common; neverfail and wallaby grass occur less frequently.

Higher rainfall areas to the south and west support medium and taller shrubs including false bluebush, broom bush, nitre bush and mingah bush. Trees such as the western myall, sugarwood and some eucalypts (often in mallee form) may also be present. Weeds such as Ward's weed and roly poly have become established in some areas. Ward's weed has some feed value when young. Onion weed is invading many pastures and becoming a problem.

The main indicator of condition is the density of the saltbushes and bluebushes. If land has been burned, the perennial shrubs may be replaced by grasses and annuals, and may transition into Speargrass/wallaby grass or bindii herbland pastures. Unpalatable acacias, eremophilas and cassias may invade degraded areas. Soils of healthy Nullarbor pastures have well-developed cryptogamic crusts which improve nutrient cycling, soil moisture retention and provide protection against raindrop impact and wind erosion. The loss of cryptogamic crust is an indicator of deteriorated range condition. Table 10 has a list of the common and important species for this pasture group.

Pastoral value: moderately high

The pastoral value of the Nullarbor pastures is moderately high because they support an abundance of palatable chenopods when in good condition plus palatable grass during favourable winter seasons. The prolific growth of speargrass can obscure the shrubs in some seasons. This has misled some observers about the productivity of the region for grazing. The difficulty in obtaining reliable sources of fresh water continues to influence the development of pastoral operations.

In the north, donga groves provide a more valuable source of forage than the surrounding plains. The improved soil moisture retention provides favourable conditions for a diverse variety of perennial trees, shrubs and annual herbs. The deterioration of donga groves leads to a reduction in the overall carrying capacity of the landscape as it loses ability to support herbivores during dry periods.

Condition statement for Nullarbor pastures

Good: Saltbush and bluebush are present at more than 1,800 pearl bluebush plants and more than 3,000 bladder saltbush plants per hectare (more than 18 and more than 30/100 m^2) and there is a range of shrubs with mixed ages and sizes (Figure 40). Palatable grasses such as wallaby grass and cane speargrass are also common. Diverse herbs are present in season with good groundcover. There is a good variety and abundance of cryptogamic crusts. There is no erosion.

The structure and diversity of donga groves provide an indication of their condition. In good condition dongas support compact groves of tree-based clumps and associated palatable shrubs. They have an abundance of palatable grasses, such as Murchison red grass and neverfail.

Fair: Saltbush and bluebush are present at 1,000 to 1,800 pearl bluebush plants and 500 to 3,000 bladder saltbush plants per hectare (10 to 18 and 5 to 30/100 m^2) (Figure 41). With the reduction in chenopods there may be a slight increase in seasonally dependent semi-perennials including less palatable bindiis and sidas. Groundcover may be reduced. Cryptogamic crusts are present but may not be well-developed. Minor erosion and redistribution of soil by wind may occur.

In fair condition donga groves there is a decline in the density of palatable species, often coinciding with an increase in curara. Prominent browse lines develop as a result of grazing. The replacement of grasses by short-lived herbs makes dongas susceptible to soil loss as they become more open and exposed to wind erosion.

Poor: Saltbush and bluebush shrubs are absent or very sparse, less than 1,000 pearl bluebush and less than 500 bladder saltbush per hectare (less than 10 and less than 5/100 m^2), and juvenile shrubs may be absent (Figure 42). Speargrass may dominate between the bluebush mounds and the area may be transitioning into a Speargrass/ wallaby grass pasture. Unpalatable annuals such as Ward's weed, roly poly and violet twinleaf may be dominant. Annual growth is poor in average to below-average seasons. There is little or no cryptogamic crust. Erosion and redistribution of soil by wind is likely.

Poor condition dongas can be reduced to sparse stands of aged trees surrounded by undesirable annuals such as Ward's weed and roly poly, and declared weeds such as Bathurst burr, doublegee and saffron thistle.

Other notes

Fires pose a major threat to the chenopod pastures of the Nullarbor. Frequent fires, rabbits and stock have altered many pastures that once supported extensive chenopod shrublands, causing them to transition into grasslands or herblands. Valuable bladder saltbush has been eliminated from some areas by fire. The grasslands are increasingly prone to fire, further reducing the chances of shrub re-establishment.

Bladder saltbush regeneration is by seed alone; therefore, grazing pressure must be reduced post-fire to minimise the risk of exhausting the seed bank. Pearl bluebush will tolerate a 'cool' fire, but recovery is slow; it can be killed by a hot fire. Regeneration is difficult and usually requires a number of consecutive favourable seasons. Western myall is also sensitive to fire. Young myalls (less than 20 years old) are vulnerable to grazing. Regeneration of western myall is also restricted if rabbits are present.

Overgrazing exposes the surface to wind erosion. Water erosion is not as much an issue because of the lack of coordinated drainage and karstic nature of the region's geology.

Figure 40: A Nullarbor pasture in good condition. There is a good even mix of desirable species, and no undesirables are present. Cryptogamic crusts are abundant and in excellent condition. The site is on a calcareous shallow loam in the Morris land system on the Bunda Plateau.

Figure 41: A Nullarbor pasture in fair condition. While the area is still dominated by pearl bluebush there has been a decrease in bladder saltbush with speargrass becoming established between the shrub mounds. The site is on a calcareous shallow loam in the Moonera land system on the Bunda Plateau.

Figure 42: A Nullarbor pasture in poor condition. With infrequent pearl bluebush and bladder saltbush essentially eliminated, the site has been reduced to an open grassland dominated by speargrass. In this post-transitional state this pasture could now also be considered a speargrass/wallaby grassland in poor condition. The pasture now relies on favourable seasonal conditions to produce any suitable forage. Stock pad lines are leading to the breakdown of cryptogamic crusts. The site is on a calcareous shallow loam in the Moonera land system on the Bunda Plateau.

Table 10: Common and important species in Nullarbor pastures

Common name	Scientific name	Desirability
Bladder saltbush	*Atriplex vesicaria*	D
Cane speargrass	*Austrostipa platychaeta*	D
Cotton bush	*Ptilotus obovatus*	D
Mingah bush, bullock bush	*Alectryon oleifolius*	D
Neverfail	*Eragrostis setifolia*	D
Scrambling saltbush	*Chenopodium curvispicatum*	D
Wallaby grass	*Rytidosperma caespitosum*	D
Woolly bindii	*Eriochiton sclerolaenoides*	D
Murchison red grass	*Eragrostis dielsii*	ann./D
Broom bush	*Eremophila scoparia*	U
Curara	*Acacia tetragonophylla*	U in dongas
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Limestone bindii	*Sclerolaena obliquicuspis*	U
Onion weed	*Asphodelus fistulosus*	U
Silver cassia, banana-leaf cassia	*Senna artemisioides* subsp. x *artemisioides*	U
Spear-fruit copperburr	*Sclerolaena patenticuspis*	U
Toothed saltbush	*Atriplex acutibractea*	U
Violet twinleaf	*Roepera iodocarpa*	ann./U
Roly poly	*Salsola australis*	ann./U
Ward's weed	*Carrichtera annua*	ann./U
Berrigan	*Eremophila longifolia*	I
False bluebush	*Cratystylis conocephala*	I
Grey fan leaf	*Lawrencia squamata*	I
Limestone bindiis	*Sclerolaena* spp.	I
Native willow	*Pittosporum angustifolium*	I
Nitre bush	*Nitraria billardierei*	I
Old man saltbush	*Atriplex nummularia*	I
Pearl bluebush	*Maireana sedifolia*	I
Sidas	*Sida* spp.	I
Speargrass	*Austrostipa scabra*	I
Sugarwood	*Myoporum platycarpum*	I
Waterbush	*Lycium australe*	I
Western myall	*Acacia papyrocarpa*	I
Miljee	*Acacia oswaldii*	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value; ann. = annual

Riparian association pastures

Occurrence estimate: 1.81 Mha, 2.2% of the southern rangelands (Appendix B, Figure B6)

Riparian association pastures occur on flood plains and river frontages of major river systems of the Gascoyne and Murchison regions and ephemeral creeks of the Goldfields. Soils are relatively fertile and underlain by clay. Sand or loam may be present on the surface. Cryptogamic crusts cover a major proportion of the soil surface. Soil depth varies depending on condition with some soils more than a metre deep, while others are shallow and eroded.

Vegetation structure and composition

Saltbush is prominent when these pastures are in good condition. Other prominent low shrubs vary with geographical location and local factors. Medium shrubs including green cassia and tall saltbush are common. Desirable low shrubs other than saltbushes are diverse and may include sago bush, cotton bush and scrambling saltbush. Trees and tall shrubs are also varied (PFC is 10% to more than 50%). Undesirable shrubs include bardie bush, needlebush and silver poverty bush.

Introduced buffel and Birdwood grasses have colonised many riparian association pastures. When transition to a stable buffel or Birdwood grass pasture has occurred, management advice for buffel grass pastures applies (see Buffel grass pastures). Table 11 has a list of the common and important species for this pasture group.

Pastoral value: high

Riparian association pastures have high pastoral value. They are very valuable for pastoral use and have considerable durability in extended dry times when in good condition. These pastures are suitable for year-round use by all classes of livestock, provided stocking rates are conservative. Good condition pastures are more likely to withstand flooding without significant soil loss.

Maintaining adequate plant cover is essential. Excessive grazing, especially in dry years, kills desirable perennial shrubs and reduces soil cover. Overstocking in dry times causes stock pads to form, which can become erosion gullies following flood events. Erosion in these fragile riparian soils often leads to exposure and desiccation of the subsoil. This transition can occur over just a few years or from one major flood event. The topsoil and its associated plants cannot be replaced. Fencing off riparian association pastures is recommended to allow active management of grazing pressure.

Summer rainfall events may allow buffel and Birdwood grasses to colonise these pastures, particularly in degraded areas. After the initial summer growth flush, protein levels fall and stock will graze remnant shrubs in an effort to maintain protein intake. The removal of shrub competition contributes to the invasive process.

Pastures in fair or poor condition require periodic spelling if condition is to be improved. Spelling during and immediately after the growing season is recommended. Allow the desirable plants to set seed (6 months or more) and let seedlings become well established before restocking.

Condition statement for riparian association pastures

Good: These pastures are dominated by saltbushes in good condition (Figure 43). They may also support a diverse range of palatable plants such as tall sida, tall saltbush and ruby saltbush, with annual herbs and grasses growing between the shrubs in good seasons. Young bluebush and saltbush plants are present. Occasional bardie bush, needlebush and silver poverty bush may be present. Cryptogamic soil crusts are evident and there is little soil erosion.

Fair: This is indicated by a reduced population of desirable shrubs and perennial grasses (Figure 44). Bardie bush may increase as more favoured shrubs disappear. The reduced cover of desirable plants may allow undesirable shrubs to proliferate if conditions for germination are favourable. Cryptogamic soil crusts are present, but some breakdown of crusts may be evident. Occasional minor to moderate wind and water erosion may be present.

Poor: Total vegetation cover is reduced with very few or no desirable shrubs remaining (Figure 45). Overall perennial plant diversity is diminished. In some cases, the only palatable plants remaining will be annuals in good seasons. Degraded pastures may be invaded by unpalatable larger shrubs such as needlebush, bardie bush, wait-a-while, crinkle leaf cassia and silver poverty bush. Cryptogamic crusts are poorly developed, patchy or absent. Active moderate to severe erosion is likely.

Other notes

Buffel grass colonisation increases the risk of fire and may irreversibly change the pasture type. Strong stands of exotic perennial buffel and/or Birdwood grasses (*Cenchrus ciliaris* and *C. setiger*) are established throughout many northern riparian association pastures. The reduced plant diversity associated with Cenchrus colonisation identifies this pattern of pasture change as a decline in condition from an ecological standpoint; however, transitioned pastures have proven to deliver livestock productivity on par with or higher than the native pastures they have replaced when in good condition and in good seasons. Perennial Cenchrus pastures (including transitioned riparian association pastures) are in good condition where the living basal cover exceeds 4%.

Survey data show that riparian association pastures in the southern rangelands are predominantly in poor condition.

Soil erosion is usually associated with a decline in condition.

Figure 43: A riparian association pasture in good condition. Saltbushes and diverse other palatable species are present, with desirable feather speargrass. Bardie bush is present, but not dominant and there is no erosion. The site is on a level plain in the Beringarra land system.

Figure 44: A riparian association pasture in fair condition. Palatable species are present, but less diverse and abundant than in good condition. Highly palatable saltbushes have been eaten out. Unpalatable sandbank poverty bush and grey cassia are present. The site is on a level plain in the Cunyu land system.

Figure 45: A riparian association pasture in poor condition. Needlebush and curara co-dominate, bluebushes and saltbushes have been lost from the pasture. Density has fallen from around 600 to 350 plants per hectare (from 6/100 m^2 down to 3/100 m^2) over a 10-year period. There are no perennial grasses, and erosion is occurring. The site is on a level plain in the Beringarra land system.

Table 11: Common and important species in riparian association pastures

Common name	Scientific name	Desirability
Berrigan	*Eremophila longifolia*	D
Buffel/Birdwood grasses	*Cenchrus* spp. and hybrids	D
Cotton bush	*Ptilotus obovatus*	D
Currant bush	*Scaevola spinescens*	D
Feather speargrass	*Austrostipa elegantissima*	D
Fuchsia bush	*Eremophila laanii*	D
Green cassia	*Senna glutinosa* subsp. *chatelainiana*	D
Green fuchsia bush	*Eremophila serrulata*	D
Neverfail	*Eragrostis setifolia*	D
Ribbon grass	*Chrysopogon fallax*	D
Roebourne plains grass	*Eragrostis xerophila*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Scrambling saltbush	*Chenopodium curvispicatum*	D
Silver saltbush	*Atriplex bunburyana*	D
Swamp saltbush	*Atriplex amnicola*	D
Tall saltbush	*Rhagodia eremaea*	D
Tall sida	*Sida calyxhymenia*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Needlebush	*Hakea preissii*	U
Sandbank poverty bush	*Eremophila margarethae*	U
Silver cassia, banana-leaf cassia	*Senna artemisioides* subsp. x *artemisioides*	U
Silver poverty bush	*Eremophila pterocarpa*	U
Spear-fruit copperburr	*Sclerolaena patenticuspis*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Turpentine bush	*Eremophila fraseri*	U
Wait-a-while	*Acacia cuspidifolia*	U
Beefwood	*Grevillea striata*	I
Bloodbush	*Senna artemisioides* subsp. *oligophylla*	I
Claypan grass	*Eriachne flaccida*	I
Curara	*Acacia tetragonophylla*	I
Fine leaf jam	*Acacia burkittii*	I
Limestone wattle	*Acacia sclerosperma*	I
Mulga	*Acacia aneura*	I
Native willows	*Pittosporum* spp.	I
Sago bush	*Maireana pyramidata*	I
Cottony saltbush	*Chenopodium gaudichaudianum*	I
Waterbush	*Lycium australe*	I
Wilcox bush	*Eremophila forrestii*	I
Coolibah	*Eucalyptus victrix*	N
River red gum	*Eucalyptus camaldulensis*	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

Saltbush pastures

Occurrence estimate: 2.33 Mha, 2.9% of the southern rangelands (Appendix B, Figure B7)

Saltbush pastures occur on flood plains of major river systems, ephemeral creeks and level plains surrounding salt lakes throughout the southern rangelands. Saltbush pastures also occur in depressions on the Nullarbor Plain. These fertile pastures consist of duplex soils with sand or loam surfaces overlying saline clay. Cryptogamic crusts cover a major proportion of the soil surface. Saltbush pastures occur on less saline soils than those supporting samphire pastures, but saltier than those supporting bluebush-dominated pastures. Soil depth varies with some soils more than a metre deep. Soils are generally susceptible to erosion. A distinctive pattern of shrub mounds is a feature of the level plains.

Vegetation structure and composition

Low saltbush shrubs are dominant when in good condition. Prominent low shrubs vary with geographical location and local factors, although silver saltbush and bladder saltbush are most common. Saltbush pastures may grade into nearby mixed halophytic pastures. Palatable medium shrubs including green cassia, mingah bush and tall saltbush are common. Desirable low shrubs other than saltbushes are diverse and may include bluebushes, mulla mullas, cotton bush and sage. Trees and tall shrubs are also varied, generally occurring as scattered individuals. Undesirable shrubs include bardie bush, needlebush, cassias, poverty bushes and wait-a-while. These pastures support high quality annual plants in good seasons. Summer rain causes germination of annual herbs and some short-lived grasses. Introduced buffel and Birdwood grasses have colonised some saltbush pastures; colonisation is usually grazing-induced and related to favourable seasons. Table 12 has a list of the common and important species for this pasture group.

Pastoral value: high

Saltbush pastures have high pastoral value and are very valuable for pastoral use and have considerable durability in extended dry times when in good condition. They are more sensitive to grazing than bluebush pastures. Saltbushes can be grazed out under continuous heavy use, leading to soil erosion. These pastures are suitable for year-round use by all classes of livestock under conservative stocking rates. Excessive grazing kills the desirable perennial shrubs. Good quality water supplies must be provided to maximise pasture utilisation and animal productivity.

Pastures in fair or poor condition will require significant periods free from grazing pressure if condition is to be improved. Spelling during and immediately after the growing season until seedlings are well established and mature plants have set seed is recommended. Nutritious annual species grow prolifically after seasonal rains and stock can thrive even on degraded saltbush pastures for short periods of time.

Sheep on degraded saltbush pastures at high stocking rates had to be hand-fed in 4 of the 10 years of the Boolathana grazing trial to prevent stock losses, while the good condition saltbush pastures supported sheep without extra feeding, even in dry times.

Condition statement for saltbush pastures

Good: These pastures are dominated by saltbush and may also support a diverse range of palatable plants such as sage, green cassia, bluebushes, cotton bush and tall saltbush, with annual herbs and grasses growing between the shrubs in good seasons (Figure 46). Young saltbush plants are present. Occasional bardie bush, needlebush, wait-a-while, tomato bush and silver poverty bush may be present. Most shrubs are growing on a soil mound. Well-developed cryptogamic soil crusts are evident and there is little or no soil erosion. The best indicator of pasture condition is the number of saltbushes and other desirable shrubs present. Mature silver saltbush plants are larger than bladder saltbush, so numbers per unit area will be lower for country in similar condition. Around 3,000 to 5,000 mature silver saltbush plants per hectare (30 to 50/100 m^2) indicates good pasture condition, whereas over 7,000 mature bladder saltbush plants per hectare (more than 70/100 m^2) would indicate good condition.

Fair: This is indicated by a reduced population of saltbushes and desirable shrubs (Figure 47). Cotton bush may increase as more favoured shrubs disappear. Fewer desirable plants may allow undesirable shrubs to proliferate if germination conditions are favourable. Cryptogamic soil crusts are present, but some breakdown of crusts may be evident. Occasional minor to moderate wind and water erosion may occur, with some disintegration of soil mounds under shrubs.

Poor: Saltbush pastures in poor condition have reduced total vegetation cover (Figure 48). There are very few or no desirable shrubs remaining, and the range of perennial plants will be reduced. In some cases, the only palatable plants remaining will be annuals in good seasons. Degraded saltbush pastures may be invaded by unpalatable larger shrubs such as needlebush, bardie bush, wait-a-while, cassias and silver poverty bush. Cryptogamic crusts are poorly developed, patchy or absent. Active moderate to severe erosion is likely. Soil mounds under shrubs are significantly reduced or absent.

Other notes

Summer rainfall events may allow buffel and Birdwood grasses to colonise these pastures. After the initial summer growth flush, protein levels fall, and animals will graze remnant shrubs heavily to maintain protein intake. Established perennial buffel or Birdwood grasses hasten the colonisation process. Buffel grass colonisation increases the risk of fire and may irreversibly change the pasture type, particularly when sandy areas are stabilised by buffel.

Good condition saltbush pastures can tolerate some flooding depending on inundation levels. Submerged saltbush pastures rarely survive and require spelling after flooding to allow recovery. Overstocking in dry times can result in stock pad development which results in topsoil loss, exposing hardpan or saline subsoils. This transition can occur over years or after one major flood event. The topsoil cannot be replaced. The critical PFC appears to be greater than 10%, so maintaining cover well above this threshold is essential.

Survey data show saltbush pastures in the southern rangelands are predominantly in poor condition and some areas are in very poor condition. Soil erosion is usually associated with a decline in pasture condition.

Figure 46: A saltbush pasture in good condition. Bladder saltbush is dominant and there is a lot of golden bluebush. Other key species present include shy bluebush, sago bush and ball leaf bluebush. Combined low shrub density is 12,500 plants per hectare (125/100 m^2) and bladder saltbush density is 4,100 plants per hectare (41/100 m^2). The site is on the mid-slope of a gently undulating plain in the Gransal land system.

Figure 47: A saltbush pasture in fair condition. There is a reduced population of saltbushes: long-lived sage remains, along with key palatable species golden bluebush and sweet samphire. Unpalatable needlebush provides protection for several palatable plants including ruby saltbush and tall saltbush. Cryptogamic soil crusts are present. The site is on an alluvial plain in the Carnegie land system.

Figure 48: A saltbush pasture in poor condition. Saltbush is significantly reduced and woody weeds (i.e. wait-a-while) are increasing. There is much bare ground and shrub mounds associated with saltbush are disintegrating. Silver saltbush density is 1,100 plants per hectare (11/100 m^2). The reduced cover increases water-shedding. The site is on an alluvial plain in the Gearle land system.

Table 12: Common and important species in saltbush pastures

Common name	Scientific name	Desirability
Ball leaf bluebush	*Maireana glomerifolia*	D
Bladder saltbush	*Atriplex vesicaria*	D
Cotton bush	*Ptilotus obovatus*	D
Currant bush	*Scaevola spinescens*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Flat leaf bluebush	*Maireana planifolia*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Green cassia	*Senna glutinosa* subsp. *chatelainiana*	D
Mingah bush, bullock bush	*Alectryon oleifolius*	D
Ragged leaf fanflower	*Scaevola tomentosa*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Sage	*Cratystylis subspinescens*	D
Scrambling saltbush	*Chenopodium curvispicatum*	D
Shy bluebush	*Maireana platycarpa*	D
Silver saltbush	*Atriplex bunburyana*	D
Swamp saltbush	*Atriplex amnicola*	D
Sweet samphire	*Gunniopsis quadrifida*	D
Tall saltbush	*Rhagodia eremaea*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Woolly bindii	*Eriochiton sclerolaenoides*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Desert cassia	*Senna artemisioides* subsp. *filifolia*	U
Kidney saltbush	*Atriplex stipitata*	U
Needlebush	*Hakea preissii*	U
Rough saltbush	*Atriplex cryptocarpa*	U
Silver poverty bush	*Eremophila pterocarpa*	U
Tomato bush	*Solanum orbiculatum*	U
Toothed saltbush	*Atriplex acutibractea*	U
Wait-a-while	*Acacia cuspidifolia*	U
Curara	*Acacia tetragonophylla*	I
Gascoyne mulla mulla	*Ptilotus polakii*	I
Limestone wattle	*Acacia sclerosperma*	I
Mulga	*Acacia aneura*	I
Old man saltbush	*Atriplex nummularia*	I
Sago bush	*Maireana pyramidata*	I
Cottony saltbush	*Chenopodium gaudichaudianum*	I
Waterbush	*Lycium australe*	I
Wilcox bush	*Eremophila forrestii*	I
Woollybutt grass	*Eragrostis eriopoda*	I
Buffel/Birdwood grasses	*Cenchrus* spp. and hybrids	N
Speargrasses	*Austrostipa* spp.	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

Samphire pastures

Occurrence estimate: 0.77 Mha, 0.9% of the southern rangelands (Appendix B, Figure B8)

Samphire pastures occur in areas where drainage is slow and there is periodic waterlogging which results in salts accumulating in the soil profile, making these areas highly saline. These can be found in a variety of positions in the landscape, but most occur on the highly saline soils of lake beds and lake margins, as well as low-lying kopi deposits adjacent to salt lakes. They are also common on low-lying saline alluvial plains along the rivers and major drainage systems, including some isolated claypans in flood plains and on the banks and levees of some major watercourses. Samphire pastures may also occasionally occur in sluggish drainage tracts where salts accumulate in upland environments. Samphire pastures also occur in the south of the Nullarbor Plain in some saline depressions.

Vegetation structure and composition

Samphire pastures are very distinctive, characteristically uniform areas of low or very low chenopod shrubland. These pastures are almost always a scattered low shrubland less than 60 cm high. PFC usually ranges from 2% to10% in the Gascoyne and 7.5% to 20% in the Murchison, though 30% can occur in some cases. A mid-shrub stratum and, less commonly, a perennial grass stratum may be present. The low shrub layer is dominant, and larger shrubs and trees are usually present as gradations into other pasture types. These pastures may grade into saltbush, bluebush or frankenia pastures.

Tecticornia plants (syn. *Halosarcia, Sclerostegia* and *Pachycornia*) invariably dominate samphire pastures. Other low shrubs are bladder saltbush, sage, pigface, frankenias, sweet samphire, needlebush, ball leaf bluebush, sago bush, three-winged bluebush and flannel bush. The seasonal herbage response is limited and consists of mainly annual grasses with sparse herbs (ephemeral chenopods) and daisies.

Samphire pastures appear to be very durable, though fluctuations in population size can occur in response to episodic flooding. The low species diversity highlights the harshness of these habitats and the types of conditions that only a limited number of halophytic species can tolerate, in particular salinity and waterlogging. Table 13 has a list of the common and important species for this pasture group.

Pastoral value: very low to nil

Samphire pastures in the southern rangelands have very low pastoral value. The saline foliage is not readily grazed by stock unless water supplies are fresh and there is not much else to graze. Some of the palatable species that make up a very minor and peripheral part of samphire pastures can be grazed out. Opportunistic use may be possible when seasonal conditions lead to the growth of annual herbage or buffel grass colonises areas between the perennial shrubs.

Condition statement for samphire pastures

Good: Pastures are dominated by samphires, which may or may not include some palatable perennial shrubs, grasses and annual herbage (Figures 49, 50). They are the most saline of the pasture types dominated by perennial chenopod shrubs and are not normally grazed unless very close to a source of fresh water. Stock show a clear preference for less saline pastures where available.

Fair and Poor: The density and diversity of palatable low shrubs such as saltbushes and bluebushes will decline under heavy grazing pressure. However, as samphire pastures can be homogenous and dominated solely by one species, this is not a reliable indicator of condition as palatable species may not be present. A reduction in total plant cover may constitute vegetation degradation, but this is uncertain as other variables such as death caused by inundation may also contribute to changes in cover.

Other notes

The general finding of the combined surveys, derived from traverse observations, is that samphire pastures are mainly in good condition.

Soil erosion is not usually associated with a decline in condition. Soils are generally stable due to their position in the landscape as deposition zones which are periodically inundated.

Figure 49: A samphire pasture in good condition. There is a relatively even coverage of samphires. The site is on a playa lakebed in the Yardina land system.

Figure 50: Another samphire pasture in good condition. There is a relatively even coverage of samphires and other low shrubs, such as frankenia. The site is on a gypsiferous plain in the Damper land system.

Table 13: Common and important species in samphire pastures

Common name	Scientific name	Desirability
Ball leaf bluebush	*Maireana glomerifolia*	D
Bladder saltbush	*Atriplex vesicaria*	D
Brittle bluebush	*Maireana amoena*	D
Bronze bluebush	*Maireana atkinsiana*	D
Buffel grass	*Cenchrus ciliaris*	D
Cotton bush	*Ptilotus obovatus*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Frankenias	*Frankenia* spp.	D
Old man saltbush	*Atriplex nummularia*	D
Sage	*Cratystylis subspinescens*	D
Sweet samphire	*Gunniopsis quadrifida*	D
Needlebush	*Hakea preissii*	U
Sunglasses bush	*Lawrencia squamata*	U
Three-winged bluebush	*Maireana triptera*	U
False bluebush	*Cratystylis conocephala*	I
Flannel bush	*Solanum lasiophyllum*	I
Sago bush	*Maireana pyramidata*	I
Samphire	*Tecticornia disarticulata*	I
Samphire	*Tecticornia doliiformis*	I
Samphire	*Tecticornia halocnemoides*	I
Samphire	*Tecticornia indica*	I
Samphire	*Tecticornia pergranulata*	I
Samphire	*Tecticornia pruinosa*	I
Samphire	*Tecticornia verrucosa*	I
Samphires	*Tecticornia* spp.	I
Pigface	*Disphyma crassifolium*	N
Nullarbor gunniopsis	*Gunniopsis calcarea*	N
Thick leaf fanflower	*Scaevola crassifolia*	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

Snakewood pasture in the Sable land system

Snakewood pastures

Occurrence estimate: 0.22 Mha, 0.3% of the southern rangelands (Appendix B, Figure B9)

Snakewood pastures are widespread and locally dominant in the north of the Murchison River region as stony snakewood shrublands, merging into stony chenopod pastures in the Carnarvon Basin, and snakewood chenopod pastures in the Pilbara. Stony snakewood pastures intergrade with bluebush, mulga chenopod and saltbush shrubland. Snakewood chenopod pastures are described in the Pilbara pasture condition guide.

Snakewood pastures typically occur on interfluvial slopes and plains that receive run-on, usually on slightly saline, alkaline and sometimes calcareous soils. Shallow red duplex soils with pebbly or gravelly mantles are common. These pastures often occur on saline stony rises adjacent to salt lakes or river systems.

Vegetation structure and composition

Snakewood pastures are characteristically tall (>2 m) shrublands dominated by snakewood with a patchy understorey of chenopod shrubs (saltbush and bluebush), other low shrubs and a few perennial grasses. The low shrubs tend to be clumped beneath the protection of the taller snakewood and are sparser in the inter-snakewood spaces. Snakewood pastures also support areas of wait-a-while as a tall shrub that may be dominant. Low shrubs often dominate these pastures, comprising a mix of chenopods; mainly three-winged bluebush, sago bush, golden bluebush, pussy bluebush, ball leaf bluebush, felty leaf bluebush, ruby saltbush, silver saltbush, tall saltbush and bindii.

Unpalatable species such as silver poverty bush, needlebush and bardie bush are often present, but do not dominate.

Overall, shrubs are usually scattered to moderately close (PFC 10–25%). Table 14 has a list of the common and important species for this pasture group.

Pastoral value: moderate

Snakewood pastures are of moderate pastoral value. The low shrubs include desirable palatable species which are preferred by livestock and provide high quality feed in dry seasons. These may be augmented by isolated perennial grasses and a range of forbs and herbs in season. Snakewood is a poor feed and grazed only as a last resort. Snakewood pastures in good condition can support all classes of stock on a year-long basis provided stocking rates are appropriate. These pastures have no durability in dry times when in poor condition, as forage is reduced to annual herbs and grasses in season.

Condition statement for snakewood pastures

Good: A number of palatable low shrubs will be concentrated around the bases of larger shrubs and trees (snakewood and wait-a-while) and persisting in the spaces between (Figure 51). Sparse tussocks of desirable grasses such as curly windmill grass also grow under snakewood. The inter-shrub spaces support very scattered stands of low shrubs, some of which are palatable.

Common desirable indicator species include ruby saltbush, warty-leaf eremophila, bluebushes and tall saltbush.

Fair: There is an obvious loss of palatable species. Snakewood pastures in fair condition still support palatable shrubs under the snakewood and other large shrubs, but populations are reduced to perhaps 2 or 3 individuals under each tree (Figure 52). Sensitive indicators such as ruby saltbush and warty-leaf eremophila occur only as old, heavily used (grazed) individuals. The density of palatables in the inter-shrub spaces is reduced and there may be an increase in unpalatable shrubs such as cassias.

The presence of a stony mantle reduces susceptibility to erosion.

Poor: The trend of declining cover and density of palatable shrubs continues with a change from fair to poor condition. Palatable shrubs and grasses are absent or occur only as occasional heavily grazed remnants under the snakewood or in open spaces (Figure 53). Tall saltbush is among the last of the hardy palatables to disappear under excessive grazing pressure. Undesirable woody shrubs such as bardie bush may replace the snakewoods.

Soil erosion may begin.

Other notes

Surveys and rangeland condition assessment data indicate that snakewood pastures in the southern rangelands are widely degraded and that the pastoral value is well below potential. Where the vegetation is severely degraded, soil erosion is common.

Acacia eremaea and *A. xiphophylla* are both called snakewood. *A. eremaea* is more common in the south, including the western Murchison and Yalgoo areas. *A. xiphophylla* is more common to the Carnarvon, Gascoyne, Pilbara and northern Murchison areas.

These pastures are prone to degradation. Management should aim to maintain the productivity and vigour of the palatable low shrubs. Grazing can be continuous for a number of years but a strategy of occasional spelling for 3 to 6 months after good rains, on a paddock-by-paddock basis, is recommended to maintain these pastures. Pastures in poor condition may require spelling over consecutive growing seasons to allow recovery.

Figure 51: A stony snakewood pasture in good condition. There is a good density of sago bush, golden bluebush and three-winged bluebush among the snakewood and mulga. The site is on a hillslope in the Badgeradda land system.

Figure 52: A plain snakewood pasture in fair condition. Palatable species are surviving beneath the clumps of shrubs with perennial grasses but are not present between clumps. The site is on a level plain in the Marillana land system.

Figure 53: A snakewood pasture in poor condition. The snakewoods have died and an influx of bardie bush is replacing them. Palatable shrubs are absent, and grasses are only present under the standing dead snakewood. The site is on an alluvial plain in the Globe land system.

Table 14: Common and important species in snakewood pastures

Common name	Scientific name	Desirability
Ball leaf bluebush	*Maireana glomerifolia*	D
Buffel grass	*Cenchrus ciliaris*	D
Cotton bush	*Ptilotus obovatus*	D
Creeping cassia	*Senna hamersleyensis*	D
Curly windmill grass	*Enteropogon ramosus*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Gascoyne bluebush	*Maireana polypterygia*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Horse mulla mulla	*Ptilotus schwartzii*	D
Mulga bluebush	*Maireana convexa*	D
Creeping sida	*Sida fibulifera*	D
Pussy bluebush	*Maireana melanocoma*	D
Roebourne plains grass	*Eragrostis xerophila*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Shy bluebush	*Maireana platycarpa*	D
Silver saltbush	*Atriplex bunburyana*	D
Snakewood	*Acacia eremaea/A. xiphophylla*	D
Tall saltbush	*Rhagodia eremaea*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Needlebush	*Hakea preissii*	U
Silver cassia, banana-leaf cassia	*Senna artemisioides* subsp. x *artemisioides*	U
Silver poverty bush	*Eremophila pterocarpa*	U
Straight leaf cassia	*Senna* sp. *Meekatharra*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Wait-a-while	*Acacia cuspidifolia*	U
Bindiis	*Sclerolaena* spp.	I
Bloodbush	*Senna artemisioides* subsp. *oligophylla*	I
Curara	*Acacia tetragonophylla*	I
Currant bush	*Scaevola spinescens*	I
Flannel bush	*Solanum lasiophyllum*	I
Gascoyne mulla mulla	*Ptilotus polakii*	I
Mulga	*Acacia aneura*	I
Sago bush	*Maireana pyramidata*	I
Three-winged bluebush	*Maireana triptera*	I
White cassia	*Senna glutinosa* subsp. x *luerssenii*	I

D = desirable; U = undesirable; I = intermediate

Stony mixed chenopod pastures

Occurrence estimate: 1.74 Mha, 2.1% of the southern rangelands (Appendix B, Figure B10)

Stony mixed chenopod pastures occur on footslopes, stony plains and interfluves with duplex soils of variable depth with moderate to dense mantles. The topsoils are sandy or loamy. These pastures frequently occur in a mosaic with acacia–cassia short grass forb pastures and bluebush or saltbush pastures.

Vegetation structure and composition

Stony mixed chenopod pastures are tall to low shrublands (PFC 5–10%). PFC may reach 20%, subject to annual rainfall, the position within the landscape and soil depth.

The upper stratum is generally sparse and may include wait-a-while, mulga, snakewood and bardie bush.

The ground layer supports a diverse range of perennial shrubs, some of which are halophytic. They may include sago bush, three-winged bluebush, grey cassia, ruby saltbush, royal poverty bush, Gascoyne mulla mulla, tall saltbush and others. Low shrub densities are around 25,000 per hectare (250/100 m^2). Shrubs are often in clumps concentrated beneath occasional trees or large shrubs with relatively sparse stony areas in the interpatches. Curly windmill grass is sometimes present among the shrub patches. Table 15 has a list of the common and important species for this pasture group.

Pastoral value: moderate

Stony mixed chenopod pastures are of moderate pastoral value when in good condition. The amount of available forage is low compared to highly productive pasture types such as saltbush and bluebush. However, these pastures are more productive than acacia–cassia short grass forb pastures and will be preferentially grazed where they occur together. They are generally degraded and pastoral value is often well below potential.

These pastures may support continuous grazing at a conservative level when in good condition. Spelling for 3 to 6 months occasionally after rainfall is recommended to maintain good pasture condition. Spelling over a number of consecutive growing seasons to decades is recommended to allow recovery of pastures in poor condition.

Condition statement for stony mixed chenopod pastures

Good: Indicated by the presence and density of desirable low shrubs concentrated around the bases of larger shrubs and trees, and persisting elsewhere (Figure 54). Ruby saltbush, bluebushes and tall saltbush are common desirable indicator low shrubs and juveniles of these plants should be present. Undesirable shrubs such as bardie bush and wait-a-while are often present at very low densities.

Fair: Indicated by a loss of desirable species from open areas, but these are still reasonably common under larger shrubs (Figure 55). Ruby saltbush and other sensitive desirable plants occur only as old, heavily grazed individuals. Less palatable species, particularly three-winged bluebush and royal poverty bush can be expected to increase. The undesirable species such as bardie bush, wait-a-while and grey cassia may occur more frequently as seedlings and young plants increase.

Poor: Declining cover and density of desirable low shrubs indicate a change from fair to poor condition. Desirable plants are often absent (Figure 56). Intermediate species such as pink-seeded bluebush may be grazed and decline in density. Undesirable species such as grey cassia and bardie bush may increase.

In general, the total PFC remains fairly constant with a decline to poor condition. The removal of desirables may not drastically reduce foliar cover as many grow beneath the canopy of taller shrubs which have remained intact. Increases in the density and size of undesirables will also be compensating for the decline in desirables.

Other notes

Survey data show that the condition of stony mixed chenopod pastures in the southern rangelands is about a third each of good, fair and poor condition.

These pastures are generally not susceptible to erosion because of soil protection afforded by the stony mantle.

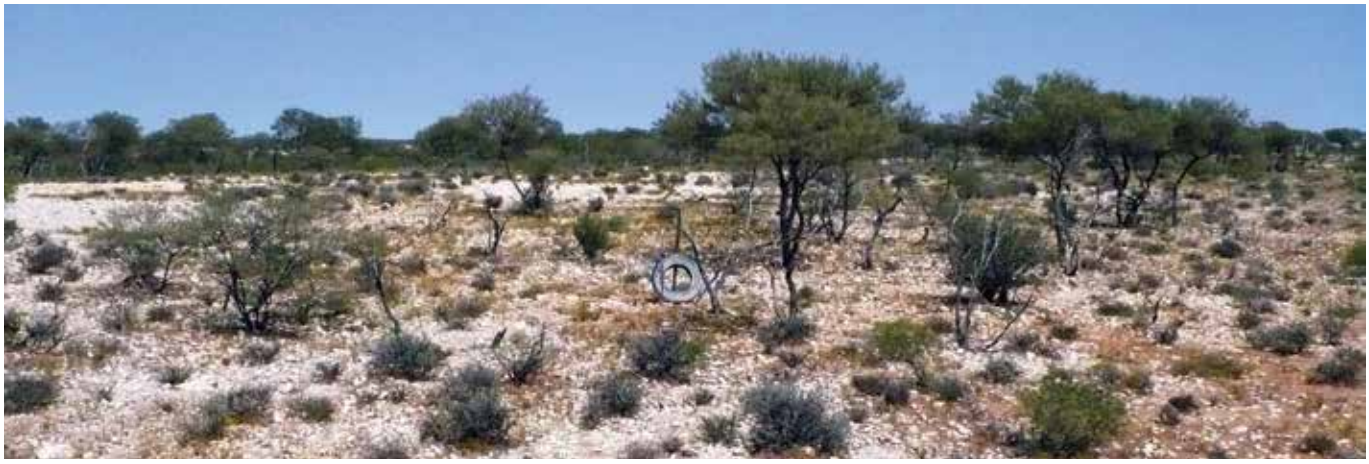


Figure 54: A stony mixed chenopod pasture in good condition. There are a number of desirable low shrubs around the bases of larger shrubs and trees and persisting in the spaces between. Desirable bluebushes, ruby saltbush and tall saltbush are present and there is a mix of age classes in the stand. The site is on a stony plain in the Sherwood land system.

Figure 55: A stony mixed chenopod pasture in fair condition. Palatable sago bush, golden bluebush and frankenias are present but density is reduced compared with good condition. Unpalatable needlebush is increasing. Bare areas have increased. The site is on a stony plain in the Sherwood land system.

Figure 56: A stony mixed chenopod pasture in poor condition. Hardy sago bush is still present with reduced density. Overall shrub density and diversity are reduced, and the more sensitive palatable plants are at very low density. Unpalatable needlebush is present. The site is on a stony plain in the Sherwood land system.

Table 15: Common and important species in stony mixed chenopod pastures

Common name	Scientific name	Desirability
Ball leaf bluebush	*Maireana glomerifolia*	D
Bladder saltbush	*Atriplex vesicaria*	D
Cotton bush	*Ptilotus obovatus*	D
Creeping cassia	*Senna hamersleyensis*	D
Curly windmill grass	*Enteropogon ramosus*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Flat leaf bluebush	*Maireana planifolia*	D
Frankenias	*Frankenia* spp.	D
Gascoyne bluebush	*Maireana polypterygia*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Horse mulla mulla	*Ptilotus schwartzii*	D
Mulga bluebush	*Maireana convexa*	D
Pussy bluebush	*Maireana melanocoma*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Sage	*Cratystylis subspinescens*	D
Scrambling saltbush	*Chenopodium curvispicatum*	D
Shy bluebush	*Maireana platycarpa*	D
Silver saltbush	*Atriplex bunburyana*	D
Tall saltbush	*Rhagodia eremaea*	D
Tall sida	*Sida calyxhymenia*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Wilcox bush	*Eremophila forrestii*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Bloodbush	*Senna artemisioides* subsp. *oligophylla*	U
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Needlebush	*Hakea preissii*	U
Silver poverty bush	*Eremophila pterocarpa*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Three-winged bluebush	*Maireana triptera*	U
Wait-a-while	*Acacia cuspidifolia*	U
Currant bush	*Scaevola spinescens*	I
Pink-seeded bluebush, downy bluebush	*Maireana trichoptera*	I
Gascoyne mulla mulla	*Ptilotus polakii*	I
Mulga	*Acacia aneura*	I
Royal poverty bush	*Eremophila cuneifolia*	I
Sago bush	*Maireana pyramidata*	I
Silver cassia, banana-leaf cassia	*Senna artemisioides* subsp. x *artemisioides*	I
Snakewood	*Acacia eremaea/A. xiphophylla*	I

D = desirable; U = undesirable; I = intermediate

Shrubs

Acacia hardpan pastures

Occurrence estimate: 9.49 Mha, 11.7% of the southern rangelands (Appendix B, Figure B11)

These pastures are on level or very gently sloping plains underlain by red-brown hardpan. The acacia hardpan pastures typically occur as groves or sandy banks with dense vegetation with broad interpatches between the groves or banks. The groves and banks are more or less arranged on the contour of the land. The largest groves and banks have soils which are deep loams or loam over clay. The interpatches with sparse vegetation are shallow, slightly acidic, loam soils over hardpan. Surface mantles vary from very few to abundant pebbles of ironstone or quartz. The plains are subject to sheetwash water flow after rainfall.

Vegetation structure and composition

The interpatches of acacia hardpan pastures are typically low to tall shrublands (PFC ranges from less than 2.5% to 10%). Common variants within this broad group are dominated by mulga, snakewood and gidgee. The most common low shrubs are cotton bush, horse mulla mulla and *Eremophila* species. Tall and mid-height shrubs include mulga, snakewood, gidgee and curara. Annual grasses and herbs occur as a ground layer in favourable seasons.

Acacia hardpan pasture groves consist of tall shrublands or woodlands (PFC >25%). Trees and tall shrubs are mulga and gidgee. Common mid to low shrubs are Wilcox bush, cotton bush, tall sida, tall saltbush, ruby saltbush and cassias. A few perennial grasses may be present.

Acacia-dominated tree groves and bush clumps act as fertile patches. Branches and leaf litter build up within groves, obstructing ground surface winds and water flow. Leaf litter, seeds, animal scats and general debris accumulate within and immediately upslope of the grove or clump. This enriches soil with nutrients, increases microbial activity, contributes to greater soil moisture and creates improved conditions for germination and establishment. Table 16 has a list of the common and important species for this pasture group.

Pastoral value: moderate to low

The patches between groves of acacia hardpan pastures typically only support a very sparse range of desirable shrubs, with some annual grasses and herbs in favourable seasons. The groves are more productive with greater floristic diversity including desirable shrubs that provide high quality feed, but durability is limited in dry times. The soil surface infiltration capacity of the interpatch areas is significantly lower than within the groves.

The groves of acacia hardpan pastures are preferentially grazed. Those in good condition are now typically rare. Short-term opportunistic use of the ephemeral plants in good seasons is possible, provided that the period of grazing is limited so that damage to desirable shrubs is avoided. Periods of complete spelling over 2 or more growing seasons are recommended to improve the abundance and vigour of shrubs.

Condition statement for acacia hardpan pastures

Good: These pastures support isolated to very scattered palatable low shrubs such as horse mulla mulla and cotton bush in the intergroves in good condition (Figure 57). A diverse range of palatable plants occur in the groves under the acacia trees and tall shrubs. Healthy groves have deeper soils, good soil moisture holding and resource retention characteristics, dense vegetation and thick accumulations of organic matter from decomposing leaf litter. Healthy groves typically do not exhibit browse lines. There is no soil erosion; where there is no leaf litter, cryptogamic soil crusts are well-developed and extensive.

Fair: Palatable shrubs in the intergrove areas are reduced but palatable species are still relatively common in the groves (Figure 58). Unpalatable species such as crinkle leaf cassia may increase marginally in the intergroves, and intermediate species such as Wilcox bush are common but do not form dense stands. Browse lines may be evident. Soil erosion (if present) is minor sheet erosion.

Poor: Palatable shrubs are absent where acacia hardpan pastures are in poor condition (Figure 59). Hardpan intergrove plains support only isolated to very scattered intermediate or undesirable species. Unpalatable large shrubs such as turpentine bush and royal poverty bush have increased in these pastures as they are generally not grazed. Groves may still be intact with relatively dense tall shrublands or woodlands of mulga but browse lines are common and palatable low shrubs are sparse to absent. In some instances, the grove structure is breaking down as herbivores push further into groves to search for feed; browsing can eventually lead to tree death. The shrubs beneath the mulgas consist of a few undesirable or intermediate species such as crinkle leaf cassia and Wilcox bush. Changes in hydrological processes, due to erosion or poorly located infrastructure such as tracks, can cause water starvation which may result in the grove community dying from dehydration. As pasture condition deteriorates rates of soil infiltration also decline.

Other notes

Survey data indicate that the condition of acacia hardpan pastures is most commonly fair or poor. Extensive areas are degraded with substantial loss of understorey plants and cryptogams. Soil erosion risk is likely to rise with summer rainfall and high intensity rainfall events. The resulting increased overland water flow further exacerbates soil erosion. Good condition pastures are relatively resistant to erosion due to intact resource capture mechanisms. Sheet erosion occurs on hardpan plains when understorey plants and cryptogams are reduced, and soil crusts are broken by trampling or other disturbances. Concentrated waterflows contribute to an increased rate of soil erosion on pastures degraded by grazing.

Acacia hardpan pastures will not generally carry fire in average seasons but in good seasons, grasses and herbs can supply sufficient fuel. These pastures should be protected from burning as mulga and many associated shrubs are sensitive to fire.

Figure 57: An acacia grove in good condition with mixed-aged shrubs, a dense canopy and abundant mix of perennial and annual grasses. The foreground shows the upslope intergrove. The site is on a level plain in the Frederick land system.

Figure 58: An acacia hardpan pasture in fair condition. Desirable species including green mulla mulla and tall sida remain and occasional bluebush is present under bush clumps. The site is on a level plain in the Tindalarra land system.

Figure 59: An acacia hardpan pasture in poor condition. Weedy juvenile needlebush dominates the low shrub layer. The stumps from dead mulga trees are evident and sheet erosion is occurring. The site is on a level plain in the Belele land system.

Table 16: Common and important species in acacia hardpan pastures

Common name	Scientific name	Desirability
Broad leaf wanderrie grass	*Monachather paradoxus*	D
Compact poverty bush, felty fuchsia bush	*Eremophila compacta*	D
Cotton bush	*Ptilotus obovatus*	D
Currant bush	*Scaevola spinescens*	D
Flat leaf bluebush	*Maireana planifolia*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Green mulla mulla	*Ptilotus xerophilus*	D
Horse mulla mulla	*Ptilotus schwartzii*	D
Lax bluebush	*Maireana thesioides*	D
Mulga bluebush	*Maireana convexa*	D
Native currant	*Psydrax suaveolens*	D
Native plum	*Psydrax latifolia*	D
Ribbon grass	*Chrysopogon fallax*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Silky bluebush	*Maireana villosa*	D
Silver saltbush	*Atriplex bunburyana*	D
Tall saltbush	*Rhagodia eremaea*	D
Tall sida	*Sida calyxhymenia*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Bead hopbush	*Dodonaea lobulata*	U
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Needlebush	*Hakea preissii*	U
Sandbank poverty bush	*Eremophila margarethae*	U
Three-winged bluebush	*Maireana triptera*	U
Bowgada, wanyu, horse mulga	*Acacia ramulosa*[1]	I
Buck wanderrie grass	*Eriachne helmsii*	I
Curara	*Acacia tetragonophylla*	I
Fine leaf jam	*Acacia burkittii*	I
Fine-toothed poverty bush	*Eremophila georgei*	I
Gidgee, yalardy	*Acacia pruinocarpa*	I
Hop mulga	*Acacia craspedocarpa*	I
Miniritchie	*Acacia grasbyi*	I
Mulga	*Acacia aneura*	I
Mulga broombush	*Teucrium teucriiflorum*	I
Poverty bush	*Eremophila alternifolia*	I
Royal poverty bush	*Eremophila cuneifolia*	I
Snakewood	*Acacia eremaea/A. xiphophylla*	I
Turpentine bush	*Eremophila clarkei* or *E. fraseri*	I
Wilcox bush	*Eremophila forrestii*	I

D = desirable; U = undesirable; I = intermediate

1. *Acacia ramulosa* includes 2 subspecies, *A.r.* subsp. *ramulosa* and *A.r.* subsp. *linophylla*. Common names include bowgada, wanyu and horse mulga and are applied to both subspecies. A described species *Acacia wanyu* from the Pilbara and northern Gascoyne is also called wanyu. Bowgada in this publication applies to *A. ramulosa* in the broad sense.

Acacia–cassia short grass forb pastures

Occurrence estimate: 3.30 Mha, 4.1% of the southern rangelands (Appendix B, Figure B12)

Acacia–cassia short grass forb pastures generally occur on sandy or loamy, reddish-brown to dark red, lithosols on stony plains, footslopes, hills and plateaus. Soils are usually shallow (20–50 cm) and contain abundant fragments of the underlying parent material (e.g. sandstone, granite). Moderate to dense mantles are often present. Texture-contrast (duplex), gradationally textured or fine-textured uniform soil profiles may also be present in some areas.

Vegetation structure and composition

Acacia–cassia short grass forb pastures are generally tall (>2 m) shrublands with a prominent low shrub layer mostly of eremophilas and cassias. PFC ranges from 5% to 20%. They also occur as low (<2 m) shrublands and low (<6 m) open woodlands. Dominant trees in woodlands are usually black mulga and mulga or spreading gidgee. Mulga dominance is generally restricted to the hilly areas and spreading gidgee to the lower landscapes. Other trees may include gidgee. The upper stratum can include bowgada, curara, bardie bush and snakewood. Total tall shrub densities are often between 200 and 300 plants per hectare (2–3/100 m^2) but can range from 25 to more than 800 plants per hectare (less than 1 to more than 8/100 m^2).

Most good condition pastures are characterised by a diverse low shrub understorey. Grey cassia, crinkle leaf cassia, Wilcox bush and cotton bush are common. Other widespread low shrubs include royal poverty bush, turpentine bush, warty-leaf eremophila, flat leaf bluebush, horse mulla mulla and flannel bush. Total densities vary with pasture condition and position in the landscape, ranging up to 5,500 plants per hectare (55/100 m^2).

Perennial grasses are frequently absent but of local significance on sandier soils. Buck wanderrie grass and other wanderrie grasses may occur. Annual grasses and forbs may be abundant in good seasons. Table 17 has a list of the common and important species for this pasture group.

Pastoral value: low

The pastoral value of acacia–cassia short grass forb pastures is generally low. The shrub component of these pastures in good condition provides a valuable reserve in dry times. Very hilly pastures have low accessibility for stock and the pastoral value in these areas is very low. Heavy grazing results in the removal of palatable species and a reduction in carrying capacity. Strategic fencing and optimal spacing of water supplies are necessary to achieve full usage of these pastures. Fencing to separate them from more productive pastures will reduce the likelihood of preferential grazing of higher pastoral value pastures. The flush of annual species after good seasonal rains allows managers the opportunity to spell better quality pastures, where fencing is adequate, to promote recruitment of palatable shrubs elsewhere.

Condition statement for acacia–cassia short grass forb pastures

Good: This is indicated by the density and composition of the low shrub layer. A robust and diverse layer with scattered palatable species indicates good condition (Figure 60). Widespread desirable indicator species are warty-leaf eremophila, Wilcox bush, flat leaf bluebush and cotton bush. Other palatable species may include ruby saltbush, felty leaf bluebush and currant bush. Less palatable and unpalatable shrubs are always present. Grey cassia, crinkle leaf cassia and flannel bush are the most widely spread and may be dominant in the low shrub layer. Other unpalatable shrubs expected include poverty bushes at low densities. In good condition total low shrub densities are commonly between 1,500 and 3,000 plants per hectare (15–30/100 m^2). There is no erosion.

Fair: This is reflected by a reduced total shrub cover — a direct result of the loss of the more palatable species. The density of desirable indicator species is reduced. Few young desirable plants are present and some of the more sensitive indicators such as warty-leaf eremophila, ruby saltbush and flat leaf bluebush are grazed out (Figure 61). Undesirable species such as wait-a-while, bardie bush and needlebush may increase marginally. Total low shrub densities are usually about 1,000 plants per hectare (10/100 m^2).

Poor: Few, if any, desirable species are present and the effects of overgrazing are obvious (Figure 62). Grazing pressure is often redirected towards the less palatable shrubs and these may also be heavily grazed and show a decline in density. Understoreys are sparse, sometimes with only undesirable species remaining. Grazing pastures that are in poor condition is not recommended, even in good seasons. Pulse recruitment opportunities are rare in the southern rangelands; grazing the annual growth that occurs with such pulses will limit the recovery. Total low shrub densities may reach 700 plants per hectare (7/100 m^2).

Other notes

Erosion is uncommon where soils are stable and mostly protected by a mantle of stones. Even in very poor condition there is generally no erosion.

Surveyed pasture condition is mostly fair or good but some localised areas show considerable loss of palatable shrubs.

Figure 60: An acacia short grass forb pasture in good condition. Total low shrub density is around 920 plants per hectare (9/100 m^2), dominated by cotton bush and crinkle leaf cassia. Poverty bushes are present at low density (<100 plants/ha or <1/100 m^2). The site is on a lower slope of an undulating plain in the Mulgul land system.

Figure 61: An acacia short grass forb pasture in fair condition. There has been a decline in total cover. The site is on a low hill with an abundant mantle of cobbles, pebbles and gravel in the Phillips land system.

Figure 62: An acacia short grass forb pasture in poor condition. Total low shrub density is about 240 plants per hectare (2/100 m^2), dominated by turpentine bush. Royal mulla mulla is the only palatable species remaining. The site is on the crest of an undulating rise in the Thomas land system.

Table 17: Common and important species in acacia–cassia short grass forb pastures

Common name	Scientific name	Desirability
Bluebushes	*Maireana* spp.	D
Compact poverty bush, felty fuchsia bush	*Eremophila compacta*	D
Cotton bush	*Ptilotus obovatus*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Flat leaf bluebush	*Maireana planifolia*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Horse mulla mulla	*Ptilotus schwartzii*	D
Lax bluebush	*Maireana thesioides*	D
Mulga bluebush	*Maireana convexa*	D
Mulla mullas	*Ptilotus* spp.	D
Rhagodias	*Rhagodia* spp.	D
Round-leaved eremophila	*Eremophila muelleriana*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Tall sida	*Sida calyxhymenia*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Wilcox bush	*Eremophila forrestii*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Grey turpentine bush	*Eremophila macmillaniana*	U
Needlebush	*Hakea preissii*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Wait-a-while	*Acacia cuspidifolia*	U
Black mulga	*Acacia citrinoviridis*	I
Bloodbush	*Senna artemisioides* subsp. *oligophylla*	I
Bowgada, wanyu, horse mulga	*Acacia ramulosa*	I
Buck wanderrie grass	*Eriachne helmsii*	I
Crimson eremophila	*Eremophila punicea*	I
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	I
Curara	*Acacia tetragonophylla*	I
Currant bush	*Scaevola spinescens*	I
Fine-toothed poverty bush	*Eremophila georgei*	I
Flannel bush	*Solanum lasiophyllum*	I
Gidgee, yalardy	*Acacia pruinocarpa*	I
Granite poverty bush	*Eremophila platycalyx*	I
Hop mulga	*Acacia craspedocarpa*	I
Mulga	*Acacia aneura*	I
Royal poverty bush	*Eremophila cuneifolia*	I
Silver cassia, banana-leaf cassia	*Senna artemisioides* subsp. x *artemisioides*	I
Snakewood	*Acacia eremaea/A. xiphophylla*	I
Spreading gidgee	*Acacia subtessarogona*	I
Turpentine bush	*Eremophila fraseri*	I
Woollybutt grass	*Eragrostis eriopoda*	I
Royal mulla mulla	*Ptilotus rotundifolius*	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

Currant bush mixed shrub pastures

Occurrence estimate: 0.41 Mha, 0.5% of the southern rangelands (Appendix B, Figure B13)

Currant bush mixed shrub pastures are found in the Carnarvon Basin and adjacent Gascoyne. These pastures often grow in combination with sandplain acacia pastures. They are common on alluvial soils, including salt lake tributary areas, and less frequently on rocky slopes, hardpan plains, sandbanks and sandplains.

Vegetation structure and composition

Currant bush mixed shrub pastures are predominantly moderately close tall shrublands (PFC 20–30%), dominated by *Acacia*, *Eremophila* and *Senna* species, with a diverse shrub understorey. These pastures are characterised by currant bush, which can occur either as a low or tall shrub. Currant bush is a distinctive plant, named for its small black berries which grow singly on short stems along the branches. Currant bush grows 3 m high in favourable, nonsaline conditions.

There are spiny and less spiny currant bushes. Currant bushes with acute spines are not a useful indicator species for pasture condition. The Gascoyne coast currant bushes on the major river floodplains are either not spined or carry relatively short, mostly single spines. In the stony uplands the spines are commonly acutely developed and much branched. The acutely spined ecotypes may expand to infestation proportions, particularly adjacent to stock water points. These weedier forms appear restricted to stony inland soils that are saline in some degree. ‘Weed proportion’ populations develop under heavy grazing pressure.

Other major tall shrubs include curara, bardie bush, needlebush, mingah bush and pebble bush. Total low shrub densities vary. Common low shrubs include grey cassia, cottony saltbush, ruby saltbush, waxy leaf poverty bush, turpentine bush, flat leaf bluebush, felty leaf bluebush, cotton bush, Gascoyne mulla mulla, tall saltbush and flannel bush. Perennial grasses are often absent, but may include erect kerosene grass, curly windmill grass and buffel grass. Table 18 has a list of the common and important species for this pasture group.

Pastoral value: high

The pastoral value of the currant bush mixed shrub pastures is high. Currant bush leaves contain up to 13% protein and are relished by stock. Pastures in good or fair condition support a broad range of palatable shrub species with excellent durability in dry times and there is an abundance of palatable annual species in season. When in good or fair condition pastoral value is high and the pastures are suitable for grazing on a year-long basis by all classes of stock.

Many currant bush mixed shrub pastures are degraded, with a loss of desirable species. Poor condition pastures will produce bulk annual species in good seasons, but durability is considerably reduced. Dramatic increases in undesirable shrubs such as needlebush, waxy leaf poverty bush, grey cassia and other cassia species have occurred in some parts, greatly reducing pastoral value to well below the potential.

Condition statement for currant bush mixed shrub pastures

Good: An abundance of palatable shrub species is present, and may include green cassia, cottony saltbush, ruby saltbush, warty-leaf eremophila, Wilcox bush, flat leaf bluebush, felty leaf bluebush, currant bush, cotton bush and tall saltbush (Figure 63). The distribution of these species is irregular, and it would be rare for them all to be growing on the one site. The individual densities of such indicators are relatively low, but combined as a stand they provide significant dry season forage. Undesirable species only occur as scattered individuals within communities. No erosion is present.

Total shrub densities vary from 3,000 to 5,000 plants per hectare (30–50/100 m^2). PFC may range from 5% to 50% but is usually between 20% and 25%.

Fair: There is a partial, but obvious loss of the palatable species indicated above. The most palatable, preferentially browsed species such as green cassia, ruby saltbush and warty-leaf eremophila may be present only as large, old individuals (Figure 64). Other palatable species such as currant bush and tall saltbush are usually still present but may show poor vigour and lack young plants. Seedlings and young plants of unpalatables such as needlebush and bardie bush may be prominent, especially in dry conditions when they are most visible. There is generally no erosion.

Total shrub densities are commonly around 3,000 plants per hectare (30/100 m^2). PFC may range from less than 5% to 25% but is commonly 10% to 15%.

Poor: There is low species diversity and pastures are dominated by unpalatable species (Figure 65). Bardie bush, needlebush, waxy leaf poverty bush, grey cassia, silver poverty bush, tomato bush and other unpalatables can dominate. Palatable species are often absent, dead or exist only as occasional heavily browsed relics.

Total shrub densities may be higher or lower than when in good condition, averaging 2,000 plants per hectare (20/100 m^2), depending upon species and individual plant size. PFC ranges from less than 5% to 50% depending on whether an invasion by undesirables has occurred. Groundcover is commonly 20–25% (similar to good condition) but is provided by unpalatable rather than palatable species.

Other notes

Currant bush is capable of recolonising areas dominated by buffel grass, provided grazing pressure is not excessive and the area remains free from fire.

Survey data show that currant bush mixed shrub pastures in the southern rangelands are predominantly in fair to poor condition.

Erosion is uncommon even when the pastures are in poor or very poor condition. Minor to moderate water or wind erosion occurs locally in the form of an accumulation of windblown soil around plant bases (hummocking) or pedestalling with soil loss and scalding between shrubs.

Figure 63: A currant bush mixed shrub pasture in good condition. Total shrub density is 3,800 plants per hectare (38/100 m^2). There is a good mix of palatable species including currant bush, cotton bush, climbing mulla mulla and Gascoyne mulla mulla. The site is on a level plain in the Sandal land system.

Figure 64: A currant bush mixed shrub pasture in fair condition. The site is dominated by horse mulla mulla, but cottony saltbush and ruby saltbush have been grazed out. Total shrub density is around 3,000 plants per hectare (30/100 m^2). The site is on a level plain in the Sandal land system.

Figure 65: A currant bush mixed shrub pasture in poor condition. The dominant shrub is royal poverty bush and there has been a marked decrease in Gascoyne mulla mulla since 1996 (from 400 to 67 plants per hectare (from 4/100 m^2 to <1/100 m^2)). Total shrub density is around 450 plants per hectare (4–5/100 m^2). The site is on a level plain in the Sandal land system.

Table 18: Common and important species in currant bush mixed shrub pastures

Common name	Scientific name	Desirability
Buffel grass	*Cenchrus ciliaris*	D
Climbing mulla mulla	*Ptilotus divaricatus*	D
Cotton bush	*Ptilotus obovatus*	D
Currant bush[1]	*Scaevola spinescens*	D
Curly windmill grass	*Enteropogon ramosus*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Gascoyne bluebush	*Maireana polypterygia*	D
Green cassia	*Senna glutinosa* subsp. *chatelainiana*	D
Horse mulla mulla	*Ptilotus schwartzii*	D
Mingah bush, bullock bush	*Alectryon oleifolius*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Silver saltbush	*Atriplex bunburyana*	D
Split leaf buttercup bush	*Senna charlesiana*	D
Tall saltbush	*Rhagodia eremaea*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Wilcox bush	*Eremophila forrestii*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Bloodbush	*Senna artemisioides* subsp. *oligophylla*	U
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Erect kerosene grass	*Aristida holathera*	U
Needlebush	*Hakea preissii*	U
Royal poverty bush	*Eremophila cuneifolia*	U
Shark Bay poverty bush	*Eremophila maitlandii*	U
Silver poverty bush	*Eremophila pterocarpa*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Tomato bush	*Solanum orbiculatum*	U
Turpentine bush	*Eremophila fraseri*	U
Waxy leaf poverty bush	*Eremophila crenulata*	U
Curara	*Acacia tetragonophylla*	I
Flannel bush	*Solanum lasiophyllum*	I
Gascoyne mulla mulla	*Ptilotus polakii*	I
Limestone wattle	*Acacia sclerosperma*	I
Pebble bush	*Stylobasium spathulatum*	I
Cottony saltbush	*Chenopodium gaudichaudianum*	I
Snakewood	*Acacia xiphophylla*	I
Perennial tar vine	*Commicarpus australis*	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

1 Currant bushes with acute spines are not a useful indicator species for pasture condition. The acutely spined ecotypes appear restricted to stony inland soils.

Eucalypt–acacia–eremophila shrubland plain pastures

Occurrence estimate: 4.53 Mha, 5.6% of the southern rangelands (Appendix B, Figure B14)

These pastures are found on broad, level valley floors forming drainage tracts between extensive sandplains, very gently undulating to level plains draining into adjacent salt lakes and wide drainage tracts connected with large granite outcrops. They commonly lack a mantle, except where they grade into upland landforms. A variable mantle may be present. Soils are calcareous loamy earths, red loamy earths or red sandy earths, sometimes over hardpan or calcrete and generally receiving dispersed run-on.

Vegetation structure and composition

Pastures are low woodland, tall shrubland or eucalypt woodland (PFC 15–30%). Low shrub stratum is also well-developed, with a variably developed mid-shrub stratum.

The variability in eucalypt species is influenced by regional distribution, geology or topographic location. The upper strata are often co-dominated by mallee eucalypts and tall shrubs (e.g. mulga). PFC of the combined tree–shrub layer is typically 20–25%. In the southern Goldfields, tall (>15 m) trees dominate the overstorey, and PFC ranges from 5% to 30%.

The mid and low shrub stratum is commonly dominated by acacias, cassias or eremophilas with few halophytic species (PFC 2.5–15%). Halophytes may be present, but these pastures do not support complex chenopod communities. Tree-based clumps are important microhabitats that indicate condition. These are characterised by suites of palatable low and mid-shrubs different from the acacias and other shrubs that predominate between tree-based clumps. Palatable shrubs may include saltbushes, ruby saltbush, bluebushes, cotton bush, tall saltbush and currant bush.

Perennial grasses are largely absent, but may include broad leaf wanderrie grass, greybeard grass or speargrasses when present. Table 19 has a list of the common and important species for this pasture group.

Pastoral value: low

Eucalypt–acacia–eremophila shrubland plain pastures have low pastoral value. They are generally not impacted by grazing as there are usually few palatable species present. Palatable species associated with tree-based clumps may disappear under heavy grazing. Some similar pastures that once supported chenopod understoreys in the southern Goldfields have transitioned into this form of eucalypt woodland pasture due to overgrazing causing the proliferation of unpalatable broom bush. It is likely that disturbances such as historic grazing, woodcutting, hailstorms and/or frequent fires are responsible for disappearance of the saltbush seed source. This transition is likely to be a permanent state.

Condition statement for eucalypt–acacia–eremophila shrubland plain pastures

Good: The most reliable indication of grazing impact is the diversity and density of palatable low shrubs (e.g. saltbushes, bluebushes, cotton bush). Tree-based clumps are important indicators of condition (Figure 66). There is good mix of shrubs among tree-based clumps, including palatable bird-dispersed berry-bearing plants such as ruby saltbush, tall saltbush, lake-fringe rhagodia and currant bush.

Fair: A reduction in palatable low shrubs may be evident, with or without an increase in unpalatable species such as broom bush or cassias (Figure 67). Tree-based clumps are not well-developed and palatable bird-dispersed berry-bearing plants are sparse or absent.

Poor: Palatable low shrubs are absent. Unpalatable species (e.g. broom bush, grey cassia, tomato bush) may dominate the mid to low shrub strata (Figure 68). Tree-based clumps are absent. Soil erosion is usually associated with a decline in condition.

Other notes

Survey data show that these pastures in the southern rangelands are predominantly in fair condition.

Figure 66: A eucalypt–acacia–eremophila woodland in good condition. There is a good mix of shrubs among tree-based clumps, including palatable bird-dispersed berry-bearing plants. The interpatch understorey is not dominated solely by unpalatable eremophilas. The soil surface is intact with a sand sheet supporting perennial grasses and annual herbs. Erosion is restricted due to the obstructed flow paths created by branches, leaf litter, grasses and cryptogamic crusts, and grasses and herbage in favourable seasons. The site is on a loamy plain in the Johnston land system.

Figure 67: A eucalypt–acacia–eremophila woodland in fair condition. Tree-based clumps are not well-developed and palatable bird-dispersed berry-bearing plants are sparse or absent. The understorey is becoming dominated by unpalatable shrubs such as broom bush and tan wattle. While cryptogamic crust is still present, the decline in obstructions between eucalypts and shrubs is resulting in unobstructed through-flow and sheet erosion is beginning to occur. The site is on a level, loamy plain in the Doney land system.

Figure 68: A eucalypt–acacia–eremophila woodland in poor condition. Unpalatable broom bush dominates the understorey and there are no tree-based clumps. Extensive sheetwash erosion is causing soil loss, and rills are developing as flow paths coalesce. The site is on a loamy plain in the Doney land system.

Table 19: Common and important species in eucalypt–acacia–eremophila shrubland plain pastures

Common name	Scientific name	Desirability
Bladder saltbush	*Atriplex vesicaria*	D
Bluebushes	*Maireana* spp.	D
Broad leaf wanderrie grass	*Monachather paradoxus*	D
Cane speargrass	*Austrostipa platychaeta*	D
Cotton bush	*Ptilotus obovatus*	D
Currant bush	*Scaevola spinescens*	D
Feather speargrass	*Austrostipa elegantissima*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Grey copperburr	*Sclerolaena diacantha*	D
Lake-fringe rhagodia	*Rhagodia drummondii*	D
Lax bluebush	*Maireana thesioides*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Tall saltbush	*Rhagodia eremaea*	D
Tar bush, fuchsia bush	*Eremophila glabra*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Violet-flowered eremophila	*Eremophila ionantha*	U
Broom bush	*Eremophila scoparia*	U
Desert cassia	*Senna artemisioides* subsp. *filifolia*	U
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Kidney saltbush	*Atriplex stipitata*	U
Slender fuchsia bush	*Eremophila decipiens*	U
Tan wattle	*Acacia hemiteles*	U
Tomato bush	*Solanum orbiculatum*	U
Bowgada, wanyu, horse mulga	*Acacia ramulosa*	I
Curara	*Acacia tetragonophylla*	I
False bluebush	*Cratystylis conocephala*	I
Fine leaf jam	*Acacia burkittii*	I
Flannel bush	*Solanum lasiophyllum*	I
Greybeard grass	*Amphipogon caricinus*	I
Mulga	*Acacia aneura*	I
Speargrass	*Austrostipa scabra*	I
Umbrella wattle	*Acacia ligulata*	I
	Acacia colletioides	N
	Eremophila caperata	N
Gums and mallees	*Eucalyptus* spp.[1]	N
Hedgehog acacia	*Acacia erinacea*	N
Weeooka	*Eremophila oppositifolia*	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

1 Prominent eucalypts include the Victoria Desert mallee (*E. concinna*), Goldfields blackbutt (*E. lesouefii*), York gum (*E. loxophleba* subsp. *lissophloia*), giant mallee (*E. oleosa*), salmon gum (*E. salmonophloia*), gimlet (*E. salubris*), redwood (*E. transcontinentalis*) and yorrell (*E. yilgarnensis*). The full species list can be accessed on the DPIRD website.

Sandplain acacia pastures

Occurrence estimate: 9.49 Mha, 11.7% of the southern rangelands (Appendix B, Figure B15)

Sandplain acacia pastures occur throughout the southern rangelands. These pastures typically occur on sandy banks, sand sheets and sandplains in a variety of land systems with sandy soils which typically consist of noncalcareous, deep red or yellow sands, with acid or neutral soil reaction trends through their profiles.

Vegetation structure and composition

Vegetation is dominated by bowgada and sugar brother. Trees are scattered and may include mulga, native pine or several species of eucalypts. Other prominent tall shrubs can include curara, limestone wattle and sandplain wattle. Low shrubs are sparse and struggle to grow beneath the tall shrubs. The shrub layer may include Wilcox bush, turkey bush, turpentine bush, rhagodias, variable cassia, crinkle leaf cassia, green cassia, cotton bush and other species.

Common palatable species include cotton bush, horse mulla mulla, warty-leaf eremophila, green cassia and silky bluebush. Wilcox bush is moderately palatable on soils underlain by granite, it is less palatable in these pastures and should not be relied upon as an indicator of condition. Unpalatable low shrubs include poverty bushes such as sandbank poverty bush and turkey bush.

These pastures support similar perennial grasses to wanderrie grass pastures, normally in much lower numbers, although soft and broad leaf wanderrie grasses may be plentiful following wet years, particularly with summer rains. These include broad leaf wanderrie grass, soft wanderrie grass and buck wanderrie grass. Greybeard grasses and feather speargrass become more common in the south and east of the southern rangelands. Buffel and Birdwood grasses and spinifex are of local importance. If spinifex is abundant and extensive in area, then ‘Hard spinifex pastures’ can be referred to (See Hard spinifex pastures).

Annual grasses such as wind grass, three-awned wanderrie grass and forbs occupy inter-tussock spaces in favourable seasons. These annuals may become dominant under continuous heavy grazing. Table 20 has a list of the common and important species for this pasture group.

Pastoral value: low

The pastoral value of the sandplain acacia pastures is low. However, as ‘Bowgada beans’ are very palatable with crude protein levels more than 20% (Mitchell and Wilcox 1994) there are periods when these pastures can temporarily provide a valuable feed source.

Excessive grazing of sandplain acacia pastures may eliminate the few palatable perennial shrubs that can occur. A mix of burnt and unburnt areas in combination are useful for stock. Unburnt areas provide shelter, palatable bowgada beans and wanderrie grass in favourable seasons. Recently burnt areas can provide a wide range of palatable low shrubs and annuals in season during the re-colonisation period.

Condition statement for sandplain acacia pastures

Good (unburnt): The tall shrub overstorey can be quite dense, limiting the development of the understorey (Figure 69). Palatable low shrubs and the occasional grasses are often quite scattered and sparse. Palatable low shrubs such as warty-leaf eremophila, bluebushes, ruby saltbush, green cassia and tall saltbush occur beneath the taller shrubs. Unpalatable sandbank poverty bush, pebble bush and tomato bush are occasionally present. The soil surface is usually soft and friable. There is no erosion.

In burnt pastures the overstorey is reduced and the range of low shrubs increases. Cotton bush and crinkle leaf cassia are common and co-dominate the low shrub component with flat leaf bluebush, Wilcox bush, tall saltbush and cottony saltbush.

Fair (unburnt): The range of species remains broad but fewer palatables are present (Figure 70). It may be easier to see through the vegetation and browse lines may develop. Density of unpalatables such as sandbank poverty bush, pebble bush and tomato bush may increase marginally. Erosion is rare.

The density and vigour of desirable indicators will decline 10 to 15 years after fire. The low shrubs such as cotton bush and flannel bush tend to increase as more palatable species are grazed out and undesirables may increase.

Poor (unburnt): Species diversity is much reduced and few palatables remain (Figure 71). Browse lines enable visibility through the shrubland. Surviving palatables often show evidence of heavy grazing or are small and hidden among other shrubs. Unpalatables may continue to increase but are not usually weedy. The ground may have a swept appearance due to sheetflow washing leaf litter away. Erosion is rare.

Previously burnt areas support a very reduced range of species. There are few, if any, desirable indicators and those remaining lack vigour. Cotton bush and flannel bush are increasingly grazed as the more palatable species are eaten out. Unpalatable poverty bushes, cassias and tomato bush may dominate the pasture. Wind erosion is more common in recently burnt areas as the soil surface is unprotected.

Other notes

Intense fires have eliminated bowgada from some areas. Hot fires can eliminate the acacia overstorey, allowing recruitment of some understorey species, like cotton bush. The initial post-fire colonisers are replaced, and there is a slow recruitment of longer-lived acacias with the climax acacia-dominated community re-establishing after about 30 years. Grazing should be deferred for at least one growing season immediately following fire to allow low shrubs to establish and herbs to set seed. The tall acacia scrub is normally too dense for sufficient grass growth to carry fire. Extended dry periods can kill and open up the overstorey, or exceptional summer rainfall events producing sufficient grassy understoreys can create a grass fuel load. When fires occur, the thick scrub is conducive to large and extensive fires. Major fires were recorded in 1964 and 2011 in the Carnarvon region. Extended dry times and fire frequency are likely to increase with predicted climate change scenarios.

Survey and rangeland condition assessment data show that sandplain acacia pastures in the southern rangelands are predominantly in fair condition.

These pastures are usually very stable and erosion is rare.

Figure 69: A sandplain acacia pasture in good condition. The dominant shrub is sugar brother with a mulga overstorey. Silky bluebush has been grazed out, but other desirable low shrubs are green cassia and tall saltbush. The site is on the mid-slope of a gently undulating plain in the Yowie land system.

Figure 70: A sandplain acacia pasture in fair condition. The site is on an undulating plain in the Yaringa land system.

Figure 71: A sandplain acacia pasture in poor condition. Desirable low shrubs have been grazed out, and the bush clumps are breaking down. There are serious hydrological problems. The site is on an undulating plain in the Yaringa land system.

Table 20: Common and important species in sandplain acacia pastures

Common name	Scientific name	Desirability
Birdwood grass	*Cenchrus setiger*	D
Broad leaf wanderrie grass	*Monachather paradoxus*	D
Buffel grass	*Cenchrus ciliaris*	D
Cotton bush	*Ptilotus obovatus*	D
Feather speargrass	*Austrostipa elegantissima*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Green cassia	*Senna glutinosa* subsp. *chatelainiana*	D
Horse mulla mulla	*Ptilotus schwartzii*	D
Rhagodias	*Rhagodia* spp.	D
Roebourne plains grass	*Eragrostis xerophila*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Silky bluebush	*Maireana villosa*	D
Soft wanderrie grass	*Thyridolepis mitchelliana*	D
Split leaf buttercup bush	*Senna charlesiana*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Pebble bush	*Stylobasium spathulatum*	U
Sandbank poverty bush	*Eremophila margarethae*	U
Shark Bay poverty bush	*Eremophila maitlandii*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Tomato bush	*Solanum orbiculatum*	U
Turkey bush	*Eremophila gilesii*	U
Turpentine bush	*Eremophila fraseri*	U
Bowgada, wanyu, horse mulga	*Acacia ramulosa*	I
Buck wanderrie grass	*Eriachne helmsii*	I
Cottony saltbush	*Chenopodium gaudichaudianum*	I
Curara	*Acacia tetragonophylla*	I
Flannel bush	*Solanum lasiophyllum*	I
Greybeard grasses	*Amphipogon* spp.	I
Limestone wattle	*Acacia sclerosperma*	I
Mulga	*Acacia aneura*	I
Sandplain wattle	*Acacia murrayana*	I
Sugar brother	*Acacia coolgardiensis*	I
Thin-leaved poverty bush	*Eremophila granitica*	I
Witchetty bush, granite wattle	*Acacia kempeana*	I
Woollybutt grass	*Eragrostis eriopoda*	I
Creeping wanderrie grass	*Eragrostis lanipes*	N
Native poplar	*Codonocarpus cotinifolius*	N
Fire bush	*Gyrostemon ramulosus*	N
Gums, eucalypts	*Eucalyptus* spp.	N
Native pine	*Callitris* spp.	N
Spinifex	*Triodia* spp.	N
Wilcox bush	*Eremophila forrestii*	N
Three-awned wanderrie grass	*Eriachne aristidea*	ann.
Wind grass	*Aristida contorta*	ann.

D = desirable; U = undesirable; I = intermediate; N = no indicator value; ann. = annual

Sandy granitic acacia pastures

Occurrence estimate: 1.85 Mha, 2.3% of the southern rangelands (Appendix B, Figure B16)

Sandy granitic acacia pastures occur on low granite pavements and are often adjacent to hardpan plains. The soils are generally shallow sandy loams. Granite outcrop is common. Soil surfaces are covered with coarse sandy grit plus some larger stones and pebbles of quartz and granite. The soils tend to be a paler red than the hardpan plains below. These pastures grade into stony hardpan in some northern areas. Both landscapes are similar, but the soil surfaces are sandier in the granitic shrubland. The soils of sandy granitic acacia shrub pastures are typically nutrient poor and their shallowness reduces their capacity to hold water. The gritty-surfaced plains supporting these pastures occur on most granite-based land systems, and the largest areas are on the Challenge, Sherwood, Norie, Bandy, Charlina and Wyarri land systems.

Vegetation structure and composition

Sandy granitic acacia pastures vary with location: the dominant plants are generally acacias, eremophilas, cassias or *Ptilotus* species (cotton bush and mulla mullas).

Trees and tall shrubs are mostly sparse – usually only 100 to 200 per hectare (1–2/100 m^2) – but include granite wattle, mulga, curara and minniritchie. Tall saltbush can also be a feature. Palatables include compact poverty bush, flat leaf bluebush, horse mulla mulla, lax bluebush, warty-leaf eremophila, silky bluebush, cotton bush and Wilcox bush.

The characteristic grasses are short annuals such as wind grass and Murchison red grass. Lemon-scented grass is widely distributed through the Murchison, Gascoyne and northern Goldfields; other perennial grasses such as broad leaf wanderrie grass and creeping wanderrie are uncommon. Table 22 has a list of the common and important species for this pasture group.

Pastoral value: low to very low

The pastoral value of the sandy granitic acacia pastures is low to very low. Even in good condition, vegetation will not support high stocking rates.

The abundance of outcrop, shallow soils and low water-holding capacity makes the vegetation of these granitic pastures more vulnerable to water stress than surrounding pasture types during dry periods. The gently inclined gradients also allow run-off after even the lightest of rain which can stimulate the rapid growth of annual species, though how long they persist depends on seasonal conditions. Fresh water run-off can also be captured and pooled in gnamma holes in the granite, which can temporarily attract animals to these pastures while the water persists and may result in overgrazing of palatable plants.

Kite leaf poison occurs around the granite domes in some areas and has resulted in poisoning of sheep, cattle, goats and horses. The leaves are usually eaten when fresh green shoots are present but no other attractive forage is available.

Condition statement for sandy granitic acacia pastures

Good: Dominant plants are acacias, poverty bushes, cotton bush and cassias (Figure 72). A good indicator of pasture condition is species diversity and the density of palatable plants. Concentrating on one species only (e.g. cotton bush) can be misleading. Some areas within these pastures may be unusually productive for cotton bush, and soil fertility can vary over short distances irrespective of range condition. Not all palatable species grow in the same area, but 4 to 9 palatable species are expected (Table 21), and there is a range of different-aged plants. These include cotton bush, Wilcox bush, felty fuchsia bush, tall saltbush, horse mulla mulla, warty-leaf eremophila, sidas and small bluebushes. The density of palatables is at least 1,000 plants per hectare (≥10/100 m^2). A few unpalatable species such as cassias may be present but are not dominant in any of the vegetation layers. There is no soil erosion. Soil surface crusts are well-developed and common.

Table 21: Indicators of pasture condition in sandy granitic acacia pastures

Indicator	Good condition	Fair condition	Poor condition
Number of different palatable species	4–9	4–6	<4
Average number of palatable species per hectare	>1,000	500–1,000	<300

Fair: The number of palatable low shrubs falls to between 500 and 1,000 plants per hectare (5–10/100 m^2) and the number of species is about 4 to 6 (Figure 73). Key decreaser species may become confined to protected areas under taller shrubs where grazing is restricted. Some unpalatable species are present but not usually dominant. There is no soil erosion and soil surface crusts are still obvious and largely intact.

Poor: Few palatable species are present and areas of bare ground are evident (Figure 74). The number of different palatables will fall to below 4 species and the total number of palatable plants to less than 300 per hectare (3/100 m^2). Cotton bush, Wilcox bush, curara and mulga are likely to be absent. Tall sida and tall saltbush are very resilient to overgrazing and may be the last remaining palatables. Unpalatable species such as turpentine bush, grey turpentine bush, spoon-leaf eremophila, straight leaf cassia, banana-leaf cassia and crinkle leaf cassia are more frequent and dominate the low and/or medium shrub layers. There may be slight or minor soil erosion in the form of small scalds up to 5 metres in diameter with redistribution of soil surface material and litter. Soil surface crusts are still present but patchy.

Other notes

Sandy granitic acacia pastures are usually stable, but erosion may be evident in degraded areas.

Figure 72: A sandy granitic acacia pasture in good condition. Cotton bush is dominant and abundant; other desirable plants include Wilcox bush, tall sida and tall saltbush. Desirable palatable shrub density is around 2,750 plants per hectare (28/100 m^2). The site is on the mid-slope of an undulating rise in the Challenge land system.

Figure 73: A sandy granitic acacia pasture in fair condition. Flat leaf bluebush and silky bluebush are absent, but mulga bluebush remains. Cotton bush and horse mulla mulla are present but not abundant and palatable shrub density is about 620 plants per hectare (6/100 m^2). Wilcox bush is desirable in these pastures. Unpalatable fine-toothed poverty bush and annual grasses are present. The site is on the mid-slope of an undulating rise in the Challenge land system.

Figure 74: A sandy granitic acacia pasture in poor condition. Unpalatable pink poverty bush dominates. Low shrub diversity and density are reduced, though cotton bush and horse mulla mulla are present. Bare ground is evident and erosion is occurring. The site is on the upper slope of a gently undulating plain in the Challenge land system.

Table 22: Common and important species in sandy granitic acacia pastures

Common name	Scientific name	Desirability
Broad leaf wanderrie grass	*Monachather paradoxus*	D
Compact poverty bush, felty fuchsia bush	*Eremophila compacta*	D
Cotton bush	*Ptilotus obovatus*	D
Currant bush	*Scaevola spinescens*	D
Flat leaf bluebush	*Maireana planifolia*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Green cassia	*Senna glutinosa* subsp. *chatelainiana*	D
Horse mulla mulla	*Ptilotus schwartzii*	D
Lax bluebush	*Maireana thesioides*	D
Lemon-scented grass	*Cymbopogon ambiguus*	D
Mulga bluebush	*Maireana convexa*	D
Silky bluebush	*Maireana villosa*	D
Small bluebushes	*Maireana* spp.	D
Tall saltbush	*Rhagodia eremaea*	D
Tall sida	*Sida calyxhymenia*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Wilcox bush	*Eremophila forrestii*	D
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Grey turpentine bush	*Eremophila macmillaniana*	U
Needlebush	*Hakea preissii*	U
Kite leaf poison	*Gastrolobium laytonii*	U
Pink poverty bush	*Eremophila glandulifera*	U
Silver cassia, banana-leaf cassia	*Senna artemisioides* subsp. x *artemisioides*	U
Spoon-leaf eremophila	*Eremophila spathulata*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Turpentine bush	*Eremophila fraseri*	U
Granite wattle	*Acacia quadrimarginea*	I
Bowgada, wanyu, horse mulga	*Acacia ramulosa*	I
Curara	*Acacia tetragonophylla*	I
Fine-toothed poverty bush	*Eremophila georgei*	I
Granite poverty bush	*Eremophila platycalyx*	I
Minniritchie	*Acacia grasbyi*	I
Mulga	*Acacia aneura*	I
Mulla mullas	*Ptilotus* spp.	I
Poverty bushes	*Eremophila* spp.	I
Cassias	*Senna* spp.	variable
Wattles	*Acacia* spp.	N
Wind grass	*Aristida contorta*	ann.
Murchison red grass	*Eragrostis dielsii*	ann.

D = desirable; U = undesirable; I = intermediate; N = no indicator value; ann. = annual

Stony acacia–cassia–eremophila pastures

Occurrence estimate: 3.51 Mha, 4.3% of the southern rangelands (Appendix B, Figure B17)

Stony acacia–cassia–eremophila pastures occur on broad convex rises among undulating upland stony plains and near level interfluvial plains. Some small remnant plateaus also support these pastures. The soils are usually shallow (<60 cm) red lithosols with sandy or loamy textures throughout the profile, though uniformly fine-textured and texture-contrast soils occasionally occur. Mantles are a common feature and fragments of quartz, mixed or gneissic material often provide a dense groundcover (>50%). These pastures are often associated with hardpan mulga shrubland pastures, occurring in the landscape below, as the interfluvial plains grade into adjacent sheetwash plains.

Vegetation structure and composition

Stony acacia–cassia–eremophila pastures typically occur as low (<2 m) shrublands (PFC 2–15%). Upper strata are very sparse or absent. Trees occur rarely and sparse tall shrubs may include mulga, curara or other acacias. Low shrubs form the dominant layer, although they are relatively sparse and contain fewer desirable species when compared with the similar, and often adjacent, acacia–cassia short grass forb pastures. Common low shrubs include Murchison willow, grey cassia, crinkle leaf cassia, grey turpentine bush, limestone fuchsia, royal poverty bush, cotton bush and flannel bush.

These pastures can also occur as tall (>2 m) scattered shrublands in restricted areas where mulga and curara are the dominant tall shrubs (PFC 10–20%). Perennial grasses are generally absent and do not form an important component, though some may be present in creeklines and on open plains. Annual grasses and herbs provide considerable cover for a limited time in good seasons. Table 23 has a list of the common and important species for this pasture group.

Pastoral value: very low

Pastoral value is very low due to rugged terrain and lack of water, resulting in some parts of these pastures being inaccessible to stock. Shallow soils and poor infiltration limit the establishment of perennial vegetation. Palatable perennials are scarce and durability in dry times is poor. These pastures are rarely suitable for carrying stock on a year-long basis. At best, they allow sparse grazing at very low stocking rates. Sufficient water must be available to ensure even grazing pressure. Fencing these pastures off from more attractive pastures will reduce the potential for preferential grazing of higher pastoral value pastures. The flush of annual species after good seasonal rains may be grazed in these areas for the short period that green feed is abundant, allowing managers the opportunity to spell better quality pastures and promote recruitment of palatable shrubs where fencing is adequate.

Condition statement for stony acacia–cassia–eremophila pastures

Good: The density and vigour of palatable perennial shrubs indicates the condition of stony acacia–cassia–eremophila pastures (Figure 75). Palatable perennials are generally sparsely distributed, and cotton bush is the dominant species; however, warty-leaf eremophila, ruby saltbush, golden bluebush, tall saltbush and currant bush are all important locally. The presence of any of these species as healthy robust individual plants indicates good condition. Total low shrub densities are commonly around 1,500 per hectare (15/100 m^2) but may vary between 600 and 4,000 plants per hectare (6–40/100 m^2) according to soil type and depth. Species of marginal palatability usually dominate the stand with grey cassia, crinkle leaf cassia and royal poverty bush occurring widely. Bardie bush, wait-a-while and needlebush may occur at densities below 50 plants per hectare (<1/100 m^2).

Dense stony mantles usually provide some degree of protection to the shallow soil.

Fair: Cassias and poverty bushes are dominant, similar to good condition pastures. The major distinction is a reduction in density or absence of living palatable perennial plants (Figure 76). Gully erosion is absent, but sheet erosion may occur after heavy rainfall.

Poor: Desirable species are absent and even the marginally palatable species remaining are grazed; there is an overall decline in density and diversity (Figure 77). Pastures are characterised by bare stony ground with only a few individual shrubs remaining. Rilling or gully erosion may be present, particularly in areas where stock pad lines have disturbed the mantle.

Other notes

Surveys revealed significant patterns of reduced populations of total perennials, with much reduced populations and species counts of palatable perennials in areas close to waters (within 1–3 km). Areas showing a reduction in palatable perennial plant coverage and a general loss of acacias from mid and upper strata may exhibit compensatory increases in cover from unpalatable eremophilas.

Survey data generally indicate stony acacia–cassia–eremophila pastures often remain in relatively good condition, with deterioration occurring slowly only after intense grazing pressure. Water availability for herbivores, in particular sheep, is an important factor influencing degradation. The Murchison River catchment survey found that nearly half of the surveyed points for these pastures were in poor condition and that palatable perennials averaged significantly less in the north-east quadrant of paddocks than elsewhere.

Figure 75: A stony mulga short grass forb pasture in good condition. The combined desirable low shrub (golden bluebush and cotton bush) density is 1,200 plants per hectare (12/100 m^2). The site is on the crest of a gently undulating plain in the Thomas land system.

Figure 76: A stony short grass forb pasture in fair condition. The only desirable low shrub is cotton bush at 1,000 plants per hectare (10/100 m^2). The site is on the upper slope of an undulating rise in the Fossil land system.

Figure 77: A stony short grass forb pasture in poor condition. The combined desirable low shrub density (bluebushes, tall saltbush and cotton bush) is 232 plants per hectare (2/100 m^2). The site is on a level plain in the Three Rivers land system.

Table 23: Common and important species in stony acacia–cassia–eremophila pastures

Common name	Scientific name	Desirability
Berrigan	*Eremophila longifolia*	D
Bluebushes	*Maireana* spp.	D
Cotton bush	*Ptilotus obovatus*	D
Curly windmill grass	*Enteropogon ramosus*	D
Currant bush	*Scaevola spinescens*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Horse mulla mulla	*Ptilotus schwartzii*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Scrambling saltbush	*Chenopodium curvispicatum*	D
Tall saltbush	*Rhagodia eremaea*	D
Tall sida	*Sida calyxhymenia*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Wilcox bush	*Eremophila forrestii*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Bloodbush	*Senna artemisioides* subsp. *oligophylla*	U
Broom bush	*Eremophila scoparia*	U
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Desert cassia	*Senna artemisioides* subsp. *filifolia*	U
Grey cassia, desert cassia	*Senna artemisioides* subsp. x *coriacea*	U
Grey turpentine bush	*Eremophila macmillaniana*	U
Limestone fuchsia	*Eremophila freelingii*	U
Needlebush	*Hakea preissii*	U
Royal poverty bush	*Eremophila cuneifolia*	U
Sandbank poverty bush	*Eremophila margarethae*	U
Spoon-leaf eremophila	*Eremophila spathulata*	U
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. x *sturtii*	U
Turpentine bush	*Eremophila fraseri*	U
Wait-a-while	*Acacia cuspidifolia*	U
Bowgada, wanyu, horse mulga	*Acacia ramulosa*	I
Curara	*Acacia tetragonophylla*	I
Fine leaf jam	*Acacia burkittii*	I
Flannel bush	*Solanum lasiophyllum*	I
Gidgee, yalardy	*Acacia pruinocarpa*	I
Granite poverty bush	*Eremophila platycalyx*	I
Jam	*Acacia acuminata*	I
Minniritchie	*Acacia grasbyi*	I
Mulga	*Acacia aneura*	I
Murchison willow	*Acacia demissa*	I
Poverty bush	*Eremophila alternifolia*	I
Western myall	*Acacia papyrocarpa*	I
White cassia	*Senna glutinosa* subsp. *pruinosa*	I
Royal mulla mulla	*Ptilotus rotundifolius*	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

Grasses

Buffel grass pastures

Occurrence estimate: 0.34 Mha, 0.4% of the southern rangelands (Appendix B, Page 143)

Buffel grass pastures (including Birdwood grass) cover extensive areas in the semi-arid and arid environments of Western Australia. These introduced grasses have spread significantly in recent decades to become naturalised in many areas. Suitable areas have annual rainfall within the 300–750 mm range or may occur in areas with a lower rainfall but in locations receiving water run-on. These pastures occur on a range of soils but prefer alkaline or neutral soils with relatively high nutrient levels; they do not tolerate flooding or waterlogging. Buffel and Birdwood grasses have the capacity to adapt to hostile growing conditions over time and may hybridise, potentially increasing the expected range.

Vegetation structure and composition

Buffel grass pastures have varying structure and composition. They occur as open tussock grassland or as tall shrublands/low woodlands with grassy understories. PFC of the shrubs is correspondingly variable (0% to more than 30%). Widespread tall shrubs include limestone wattle, wanyu and curara, while on stabilised alluvial areas, wait-a-while, bardie bush and needlebush may be dominant. A sparse overstorey of coolibah may be present on floodplains. Low shrubs include silver saltbush, grey cassia, crinkle leaf cassia, ruby saltbush, Wilcox bush, cotton bush, Gascoyne bluebush and currant bush. Buffel grass is the dominant understorey and occurs with basal cover of 1% to more than 8%. Other perennial grasses include Birdwood grass, curly windmill grass and silky browntop, all of which normally occur with basal cover less than 1%, although Birdwood grass may co-dominate with a basal cover up to 2%. Table 24 has a list of the common and important species for this pasture group.

Pastoral value: high to very high

The pastoral value of buffel grass pastures is high to very high and varies according to the season. Buffel and Birdwood grasses can tolerate heavy grazing after good rains, but feed value declines as the grass hays off. Livestock then seek supplementary forage on adjacent native pastures, such as bluebush or acacia–cassia short grass forb pastures. Stock numbers supported by buffel grass pastures in favourable seasons are higher than the surrounding native vegetation can support, this leads to areas of overgrazing in adjacent pastures. Grazing pressure requires monitoring and stock should be removed before the shrubs are overgrazed. Buffel grass pastures in hard and soft spinifex pastures is easier to manage, as both pastures are resilient under grazing and the rapid growth of buffel after rain and the value of spinifex in dry times complement each other.

Condition statement for buffel grass pastures

Good: There is an even coverage of buffel and/or Birdwood grass with a basal cover of more than 4% (Figure 79). Other desirable perennial plants are present and vigorous.

Fair: Buffel grass basal cover is between 1% and 3% with patchy tussock distribution and possibly some small bare scalded areas (Figure 80). Some woody weeds (e.g. bardie bush, wait-a-while) may be present.

Poor: Buffel grass frequency declines. Tussocks will lack vigour and may be stunted (Figure 81). Buffel plants may behave as

annuals lacking tussock development and seeding as small prostrate plants with little root development. Other desirable perennial plants may be hard to find and bare ground will be evident.

Other notes

Many riparian habitats were degraded prior to buffel grass establishment. Buffel and Birdwood grasses have had a significant role in stabilising surfaces and preventing further erosion (Figure 78). Grazing aids establishment through soil disturbance and reducing competition from other plants. Ecosystem processes may be altered as buffel or Birdwood grasses become established and out-compete native species in a variety of habitats.

Riparian and adjacent buffel grass-dominated plant communities in the southern rangelands are increasingly susceptible to fire. A feedback loop is promoted in the fire cycle, as there is more biomass (and therefore, higher fuel load) than in native pastures and increased connectivity to carry fire into pastures where fire is less common. Fire-sensitive species such as chenopods may disappear. Affected landscapes become inherently fire-prone and are left with exposed surfaces after fire. The risk of erosion to exposed soil surfaces is increased after fire. Weed invasion risk increases after fire.

Survey data show that buffel grass pastures in the southern rangelands are predominantly in fair condition.

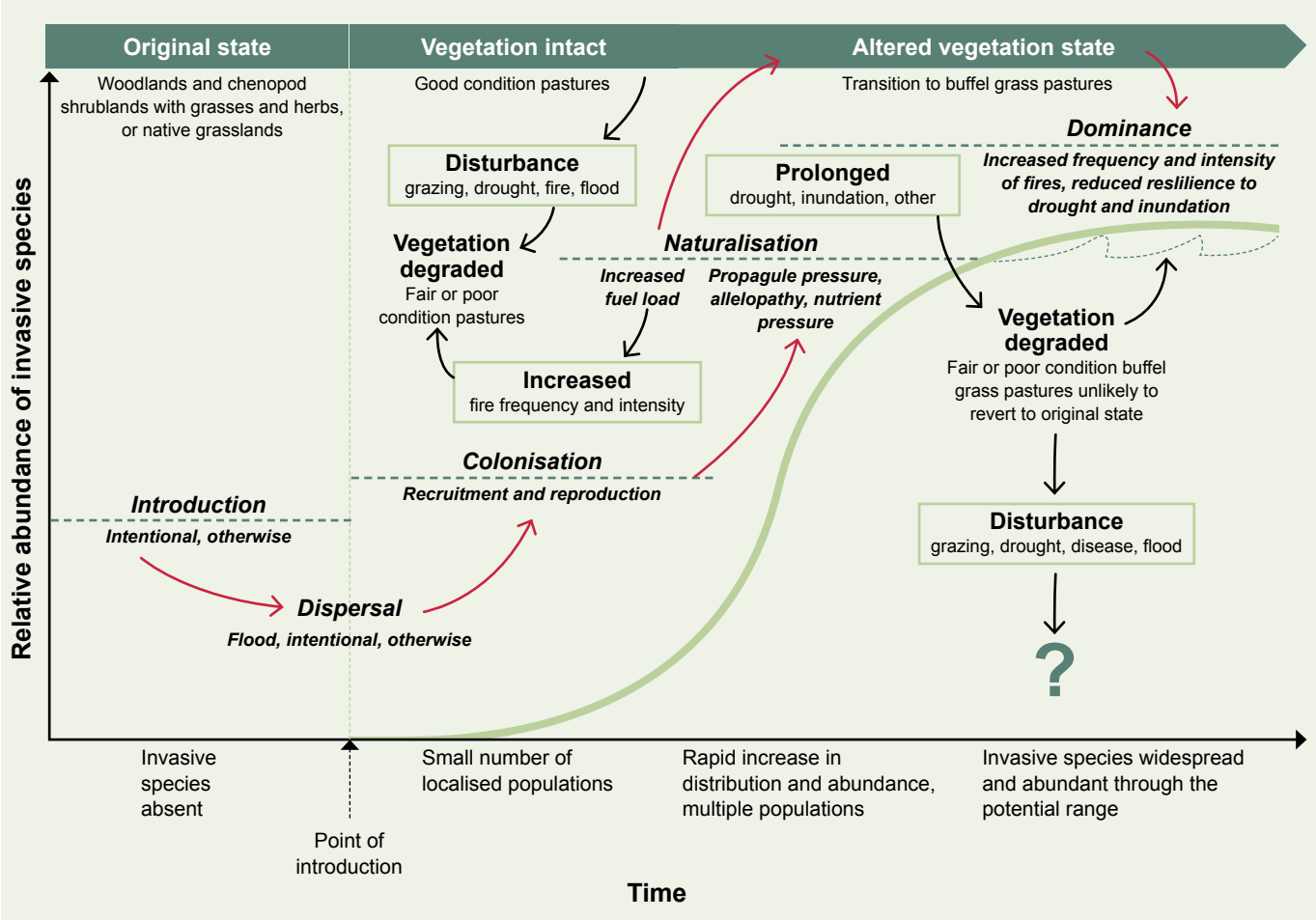


Figure 78: Buffel grass invasion diagram. The dominant process is the invasion, indicated by red arrows. Undisturbed (intact) good condition pastures within the potential range can be colonised and may become buffel grass pastures.

Figure 79: A buffel grass pasture in good condition. There is a strong, even coverage of buffel grass and the tussocks are vigorous and healthy. Other perennials include limestone wattle. The site is on a floodplain in the Gascoyne land system.

Figure 80: A Birdwood grass pasture in fair condition. Tussock density is reduced with frequent small bare areas. Unpalatable crinkle leaf cassia has increased. The soil surface is stable. The site is on a sandy-surfaced plain in the Mary land system.

Figure 81: A buffel grass pasture in poor condition. Buffel grass cover has decreased and the small tussocks lack vigour. There are very few other surviving perennial plants and even the bardie bush is showing signs of stress. The site is on a level plain in the Wandagee land system.

Table 24: Common and important species in buffel grass pastures

Common name	Scientific name	Desirability
Birdwood grass	*Cenchrus setiger*	D
Bluebushes	*Maireana* spp.	D
Broad leaf wanderrie grass	*Monachather paradoxus*	D
Buffel grass	*Cenchrus ciliaris*	D
Cotton bush	*Ptilotus obovatus*	D
Curly windmill grass	*Enteropogon ramosus*	D
Currant bush	*Scaevola spinescens*	D
Gascoyne bluebush	*Maireana polypterygia*	D
Hopalong grass	*Paraneurachne muelleri*	D
Oat-eared spinifex	*Triodia schinzii*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Silky browntop	*Eulalia aurea*	D
Silver saltbush	*Atriplex bunburyana*	D
Soft spinifex	*Triodia pungens*	D
Tall saltbush	*Rhagodia eremaea*	D
Woollybutt grass	*Eragrostis eriopoda*	D
Bardie bush	*Acacia synchronicia/A. victoriae*	U
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Grey cassia, desert cassia	*Senna artemisioides* subsp. *x coriacea*	U
Erect kerosene grass	*Aristida holathera*	U
Needlebush	*Hakea preissii*	U
Threeawns	*Aristida* spp.	U
Tomato bush	*Solanum orbiculatum*	U
Wait-a-while	*Acacia cuspidifolia*	U
Bloodbush	*Senna artemisioides* subsp. *oligophylla*	I
Bowgada, wanyu, horse mulga	*Acacia ramulosa*	I
Curara	*Acacia tetragonophylla*	I
Fitzroy wattle	*Acacia ancistrocarpa*	I
Flannel bush	*Solanum lasiophyllum*	I
Limestone wattle	*Acacia sclerosperma*	I
Pebble bush	*Stylobasium spathulatum*	I
Wilcox bush	*Eremophila forrestii*	I
Woolly corchorus	*Corchorus walcottii*	I
Coolibah	*Eucalyptus victrix*	N
Three-awned wanderrie grass	*Eriachne aristidea*	ann.

D = desirable; U = undesirable; I = intermediate; N = no indicator value; ann. = annual

Hard spinifex pastures

Occurrence estimate: 7.76 Mha, 9.6% of the southern rangelands (Appendix B, Figure B18)

Hard spinifex pastures dominate large areas of infertile red sandy soils. They occur in arid areas of the eastern Goldfields, parts of the Gascoyne and Ashburton, and Sandstone, Yalgoo and Paynes Find areas, and minor parts of the Murchison River catchment, southern Goldfields, Nullarbor and unmapped Wiluna areas. Very extensive areas also occur in the Pilbara and Kimberley. Hard spinifex pastures can occur on hills and stony plains but in the southern rangelands they mostly occur on sandplains.

Vegetation structure and composition

Hard spinifex pastures are predominantly hummock grasslands, with spinifex dominating the vegetation to the near exclusion of other ground layer species. The dominant type of spinifex (*Triodia* species) varies according to regional distribution. A variable overstorey of trees and tall shrubs including mallee eucalypts, marble gum, gidgee or spreading gidgee may be present. These pastures are sometimes tall (>2 m) or low (<2 m) shrublands over hummock grasses, with some such as those in the Murchison River catchment having only a sparse cover of spinifex between tall shrub or mallee clumps.

PFC varies between 0% and more than 50%, depending on the fire history. Typically, old hard spinifex stands have a high PFC and low moisture content within the foliage. Fire often kills senescent stands and may totally remove all groundcover.

The composition of the upper stratum within hard spinifex pastures is variable and generally very scattered. A wide range of low shrubs occurs, and the most diverse stands are associated with early post-fire successional stages. The densities of individual upper-canopy species rarely exceed 1,500 plants per hectare (15/100 m^2). Locally important desirable perennial grasses also occur. Broad leaf wanderrie grass, feather speargrass and buffel grass are occasionally present. Annual grasses and forbs may be present in good seasons for a few years after fire. Table 25 has a list of the common and important species for this pasture group.

Pastoral value: very low to nil

The pastoral value of the hard spinifex pastures is very low to nil – unless recently burned, when germination of some palatable grasses and herbs is stimulated. Post-fire grazing should be deferred for at least 8 weeks after significant rainfall. Spinifex country's greatest value for herbivores is about a year after fire and subsequent rain, when diverse short-lived grasses and woody herbs become established. The short-lived plants gradually decline in abundance and diversity as spinifex regains dominance after about 5 to 7 years. Spinifex can continue to increase in size and density, which can inhibit other plants from establishing from about 5 years after a fire event; gradually increasing the fuel load until the next fire event.

Condition statement for hard spinifex pastures

Good: There is an even coverage of hard spinifex plants (Figures 82, 83). A few palatable perennial grasses (e.g. broad leaf wanderrie, soft spinifex, feather speargrass) may occur in low numbers between spinifex hummocks but will tend to be concentrated on drainage lines and under trees. Variable cover of relatively palatable intermediate value annuals such as wind grass may be found for a short time following a good growing season.

Fair: Hard spinifex is generally ignored by stock, so it is mainly the in-between species that cattle will graze when on these pastures. For this reason, a decline from good towards fair condition is usually accompanied by a reduction in numbers and vigour of palatable grasses (Figure 84). The coverage of spinifex plants may appear patchier or uneven and areas supporting only a sparse cover of annuals and undesirable perennial plants (e.g. cassias) may be present. Poor post-fire grazing management can increase the uneven appearance of these pastures.

Poor: Larger bare patches may be present where perennial plant re-establishment no longer occurs. Palatable companion grasses lack vigour or are absent. Those non-spinifex species that are present tend to be undesirable cassias and annuals with low fodder value. The abundance of annual grasses depends on the season. **Recently burnt spinifex should not be assessed as being in poor condition.**

Other notes

Spinifex seedlings in good condition pastures establish readily after one post-fire growing season, but cover remains low for 1 or 2 seasons. Perennial shrubs emerge as pioneers with spinifex, forming a much larger suite of species than in the climax community. As such a stand matures, it is often classified as a shrubland, and PFC of the shrub component may reach 25% or more. As the climax state approaches (10 to 15 years after fire), the hummock grassland form will be resumed as the shrub component diminishes through senescence or competition and crowding by spinifex (Suijdendorp 1967).

Survey data show that hard spinifex pastures in the southern rangelands are predominantly in good condition.

Hard spinifex pastures are usually very stable, but wind erosion can occur on recently burnt areas which have yet to stabilise with seasonal growth.

Figure 82: A hard spinifex pasture in good condition in 2014. There is a relatively even coverage of spinifex plants, and new recruits are present between older hummocks. The site is on a sandy level plain in the Uaroo land system.

Figure 83: The same hard spinifex pasture as in Figure 82, in 2011. The pasture is in good condition after a recent patchy burn. The site is on a sandy level plain in the Uaroo land system.

Figure 84: A hard spinifex pasture in fair condition. Palatable species including woollybutt grass, cotton bush and fanflowers (*Scaevola* spp.) have been grazed out. The site is dominated by buck spinifex and has low tree cover. There is no soil erosion. The site is on a sandy level plain in the Giralia land system.

Table 25: Common and important species in hard spinifex pastures

Common name	Scientific name	Desirability
Bluebushes	*Maireana* spp.	D
Broad leaf wanderrie grass	*Monachather paradoxus*	D
Buffel grass	*Cenchrus ciliaris*	D
Camel weed	*Scaevola parvifolia*	D
Cotton bush	*Ptilotus obovatus*	D
Currant bush	*Scaevola spinescens*	D
Feather speargrass	*Austrostipa elegantissima*	D
Hopalong grass	*Paraneurachne muelleri*	D
Oat-eared spinifex	*Triodia schinzii*	D
Soft spinifex	*Triodia pungens*	D
Tall saltbush	*Rhagodia eremaea*	D
Tar bush, fuchsia bush	*Eremophila glabra*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Woollybutt grass	*Eragrostis eriopoda*	D
Bloodbush	*Senna artemisioides* subsp. *oligophylla*	U
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Bowgada, wanyu, horse mulga	*Acacia ramulosa*	I
Buck wanderrie grass	*Eriachne helmsii*	I
Flannel bush	*Solanum lasiophyllum*	I
Giant grey spinifex	*Triodia longiceps*	I
Gidgee, yalardy	*Acacia pruinocarpa*	I
Greybeard grass	*Amphipogon caricinus*	I
Poverty wattle	*Acacia stellaticeps*	I
Spreading gidgee	*Acacia subtessarogona*	I
Sugar brother	*Acacia coolgardiensis*	I
Wilcox bush	*Eremophila forrestii*	I
Wind grass	*Aristida contorta*	I
Buck spinifex	*Triodia scariosa*	N
Grevillea	*Grevillea* sp.	N
Heath-myrtle	*Micromyrtus flaviflora*	N
Kingsmill's mallee	*Eucalyptus kingsmillii*	N
Limestone spinifex	*Triodia wiseana*	N
Low paperbark	*Melaleuca cardiophylla*	N
Marble gum	*Eucalyptus gongylocarpa*	N
Native mints	*Prostanthera* spp.	N
Porcupine spinifex	*Triodia irritans*	N
Hard spinifex	*Triodia basedowii*	N
Hard spinifex	*Triodia lanigera*	N
Spinifex	*Triodia concinna*	N
Spinifex	*Triodia desertorum*	N
Spinifex	*Triodia melvillei*	N
Spinifex	*Triodia plurinervata*	N
Spinifex	*Triodia rigidissima*	N
Spinifex	*Triodia tomentosa*	N
Victoria Desert mallee	*Eucalyptus concinna*	N

D = desirable; U = undesirable; I = intermediate; N = no indicator value

Soft spinifex pastures

Occurrence estimate: 0.50 Mha, 0.6% of the southern rangelands (Appendix B, Figure B19)

Soft spinifex pastures mostly occur in the Pilbara and Kimberley, with some also in the western Gascoyne and Ashburton. They are associated with landforms developed on marine deposits and often covered with a veneer of eolian sand in the Carnarvon Basin. They occur on longitudinal dunes and swales, undulating sandy plains, limestone rises, platforms and low hills, loamy plains and interfluves and some flow zones.

Vegetation structure and composition

Vegetation structure and composition are variable in soft spinifex pastures and are influenced by time elapsed since fire and prevailing climatic conditions. Pastures may take the form of hummock grasslands, tall or low shrublands or, very occasionally, low woodlands. These pastures are prone to fire. Early successional stages often take the form of low shrubland, as colonising perennial shrubs become dominant, together with spinifex seedlings. About 5 years after burning, soft spinifex may regain dominance as the shrubs die or are outcompeted by the expanding spinifex hummocks. Pastures that are managed conservatively will eventually resume their form as hummock grasslands with little or no shrub cover, whereas overutilised pastures will become dominated by shrubs.

Soft spinifex pastures occur most commonly as hummock grasslands. The ground layer is dominated by soft spinifex and sometimes oat-eared spinifex. These species may account for nearly all of the total PFC which may be up to 50%. Hard spinifex is occasionally co-dominant with soft spinifex. Soft wanderries and neverfail may form useful stands in these pastures. Buffel grass may be present. Spinifex cover rarely exceeds 10% in shrub-dominated pastures. PFC of the shrubs may reach 30%. The more widespread low shrubs include bloodbush, ruby saltbush, cotton bush and flannel bush. Mid-shrubs may include hopbush, *Rhagodia preissii* and others. Tall shrubs that may be dominant include curara and pebble bush. Table 26 has a list of the common and important species for this pasture group.

Pastoral value: moderate to high

Pastoral value is high when soft spinifex plants are young and a range of other grasses, herbs and forbs are present. Grazing value is reduced to moderate in older stands and may be low in very old stands. Soft spinifex pastures are suitable for carrying stock when maintained in a productive state (see Appendix E for grass growth diagrams). Crude protein levels as high as 9% have been reported in soft spinifex (*Triodia pungens*) seedlings. Older spinifex plants are less palatable. These pastures can be maintained by a system involving periodic burning and rotational grazing. Soft spinifex pastures should be fenced separately from useful shrub pastures such as bluebush. Buffel grass pastures associated with soft spinifex pastures can be paddocked together. A buffel grass–soft spinifex mixture is desirable for rapid rain-response, nutrition and resilience in dry times. Resilience is compromised when buffel grass becomes dominant.

Condition statement for soft spinifex pastures

Good: The dominant grass is soft spinifex (Figure 85). Other perennial grasses may include oat-eared spinifex, ribbon grass, hopalong grass and buffel grass. Palatable low shrubs, such as silver saltbush, green cassia, ruby saltbush and tall saltbush may be present. Annual herbs and grasses such as wind grass may also be present. Plants are vigorous, productive and evenly spaced. The size and density of plants in the stand depends on time elapsed since fire, seasonal conditions and grazing pressure.

Fair: As pasture condition declines from good to fair, less desirable and unpalatable species such as Flinders River poison become more prominent, though soft spinifex is still dominant (Figure 86). Soft spinifex plants may be less vigorous and other desirable species are hard to find. A decline to fair condition is usually accompanied by reduced frequency and vigour of the palatable species such as saltbushes and split leaf buttercup bush. The coverage of spinifex plants may appear patchy or uneven, with the areas between supporting a sparse cover of annuals and undesirable perennial plants (e.g. wind grass and undesirable cassias). Poor grazing management after fire can cause an uneven distribution of perennial species in these pastures.

Poor: Soft spinifex pasture that has declined to poor condition will most likely be dominated by unpalatable cassias, herbs or annuals with low fodder value. There may be dense shrub thickets making it difficult for stock to access the grass or there may be large bare areas. Where soft spinifex pasture in poor condition is adjacent to hard spinifex pasture, bare areas may be colonised by hard spinifex. Palatable grasses lack vigour or are absent. The abundance of annual grasses depends on the season. Dense thickets of cockroach bush after fire indicate poor condition in these pastures. **Recently burnt spinifex should not be assessed as being in poor condition.**

Other notes

Grazing after fire should be deferred for at least 8 weeks after effective rain. Spinifex country's greatest value for stock or other animals is about a year after fire and subsequent rain, when diverse short-lived grasses and woody herbs germinate. The short-lived plants gradually decline in diversity as spinifex regains dominance after about 5 years. Rotational burning of these pastures helps to ensure that, at any given time, some areas are in the more palatable stages of growth with a wide range of plant species available for grazing.

Survey and rangeland condition assessment data show that soft spinifex pastures in the southern rangelands are predominantly in fair condition.

Soft spinifex pastures are usually very stable, but wind erosion may occur on recently burnt areas which have yet to stabilise with seasonal growth.

Figure 85: A soft spinifex pasture in good condition. There is a high frequency of desirable soft spinifex, and plants appear healthy. Young soft spinifex plants are present. The site is on the upper slope of a gently undulating plain in the Uaroo land system.

Figure 86: A soft spinifex pasture in fair condition. Desirable soft spinifex plants are still present, but the frequency is reduced with substantial bare areas between. The site is on a gently undulating plain in the Paradise land system.

Table 26: Common and important species in soft spinifex pastures

Common name	Scientific name	Desirability
	Cullen martinii	D
	Dipteracanthus australasicus	D
Buffel grass	*Cenchrus ciliaris*	D
Cotton bush	*Ptilotus obovatus*	D
Flat leaf bluebush	*Maireana planifolia*	D
Green cassia	*Senna glutinosa subsp. chatelainiana*	D
Neverfail	*Eragrostis setifolia*	D
Mingah bush, bullock bush	*Alectryon oleifolius*	D
Oat-eared spinifex	*Triodia schinzii*	D
Ragged leaf fanflower	*Scaevola tomentosa*	D
Ribbon grass	*Chrysopogon fallax*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Silver saltbush	*Atriplex bunburyana*	D
Soft spinifex	*Triodia epactia*	D
Soft spinifex	*Triodia pungens*	D
Split leaf buttercup bush	*Senna charlesiana*	D
Tall saltbush	*Rhagodia eremaea*	D
Cockroach bush	*Senna notabilis*	U
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Erect kerosene grass	*Aristida holathera*	U
Fitzroy wattle	*Acacia ancistrocarpa*	U
Flinders River poison	*Tephrosia rosea*	U
Hard spinifex	*Triodia lanigera*	U
Poverty wattle	*Acacia stellaticeps*	U
Shark Bay poverty bush	*Eremophila maitlandii*	U
	Rhagodia preissii	I
Bloodbush	*Senna artemisioides* subsp. *oligophylla*	I
Buck wanderrie grass	*Eriachne helmsii*	I
Curara	*Acacia tetragonophylla*	I
Flannel bush	*Solanum lasiophyllum*	I
Grey fanflower	*Scaevola canescens*	I
Hard spinifex	*Triodia basedowii*	I
Hopalong grass	*Paraneurachne muelleri*	I
Hopbushes	*Dodonaea* spp.	I
Ranji bush	*Acacia pyrifolia*	I
Limestone spinifex	*Triodia wiseana*	I
Limestone wattle	*Acacia sclerosperma*	I
Myrtles	*Thryptomene* spp.	I
Naked lady	*Exocarpos aphyllus*	I
Pebble bush	*Stylobasium spathulatum*	I
Two-veined wattle	*Acacia bivenosa*	I
Woollybutt grass	*Eragrostis eriopoda*	I
Butterfly bush	*Petalostylis labicheoides*	N
Fire bush	*Gyrostemon ramulosus*	N
Wind grass	*Aristida contorta*	ann.

D = desirable; U = undesirable; I = intermediate; N = no indicator value; ann. = annual

Speargrass/wallaby grass pastures

Occurrence estimate: 3.26 Mha, 4% of the southern rangelands (Appendix B, Figure B20)

Speargrass/wallaby grass pastures dominate large areas of the Nullarbor region on both the extensive limestone plains and in the depressions within the plains on clay plains and claypans. Soils range from calcareous shallow loams and loamy earths to red/brown non-cracking clays in claypans. Patches of these grassland pastures are likely to have always existed in a mosaic state and transition pattern with Nullarbor chenopod pastures. However, many chenopod-dominated pastures have become irreversibly altered as a result of increased fire frequency and through grazing by rabbits in plague proportions. These grasslands now dominate extensive areas, having replaced other habitats by increasing the fire susceptibility of much of the Nullarbor region. Speargrass/wallaby grass pastures are considered a fire induced vegetation association. Speargrass/wallaby grass pastures are the major habitat type on Bullseye, Carlisle, Chowilla, Gafa, Kybo, Oasis, Nightshade, Nurina, Shakehole and Skink land systems, and are common to many others.

Vegetation structure and composition

Speargrass/wallaby grass pastures are dominated by speargrass and wallaby grass. Where speargrass and wallaby grass have been completely eliminated, these grasslands may transition into seasonally dependent bindii or annual herbfields. Table 27 has a list of the common and important species for this pasture group.

Pastoral value: moderately high

The pastoral value of speargrass/wallaby grass pastures is moderately high. In good seasons these pastures are highly productive and during the active growth phase are readily grazed. Speargrass has maximum nutritional value when it has new green shoots, becoming less appealing as it becomes dry and harsh. Wallaby grass is highly palatable and is preferentially sought by herbivores. Total grazing pressure must be managed to prevent wallaby grass being grazed out and the pasture becoming dominated by only speargrass and unpalatable species such as toothed saltbush, Ward's weed, balsam and roly poly, reducing the long-term carrying capacity of the grassland. Once degraded, these pastures rarely grow grass in poor seasons and are therefore unreliable as a source of feed during extended dry periods.

Condition statement for speargrass/ wallaby grass pastures

Good: There is an even coverage of grasses and the stand will include wallaby grass. Cryptogamic crusts are present (Figure 87).

Fair: The coverage of grasses may appear patchy or uneven, with the areas in between being either bare or supporting occasional annuals and/or unpalatable perennial plants (e.g. toothed saltbush) (Figure 88). Speargrass may come to dominate the stand as palatable wallaby grass is grazed out. Cryptogamic crusts may be breaking up.

Poor: Larger bare patches occur among the grass plants. Palatable grasses lack vigour or are absent and speargrass dominates the sward if grasses are present (Figure 89). Unpalatable and annual shrubs such as toothed saltbush, Ward's weed, balsam, roly poly, hairy bindii, limestone bindii, spear-fruit copperburr and twinleafs may dominate the area. Cryptogamic crusts may be absent.

Other notes

Patches of speargrass/wallaby grass pastures are likely to have always existed in a mosaic state and transition pattern between saltbush and bluebush low shrubland.

These pastures are usually stable in good seasons, but wind erosion is common in dry conditions or on recently burnt areas which have yet to re-establish vegetation cover.

Figure 87: A speargrass/wallaby grass pasture in good condition. Abundant mixed perennial grasses protect the soil from wind erosion. Cryptogamic crusts are intact but hard to see. (Note that with subsequent dry conditions after the good seasonal conditions that have stimulated such growth, this grassland is now highly susceptible to fire.) The site is an open depression drainage floor with calcareous shallow loam in the Nightshade land system.

Figure 88: A speargrass/wallaby grass pasture in fair condition. The density of grasses has been reduced. Much of the desirable wallaby grass has been heavily grazed, resulting in its replacement by annuals and semi-perennials. The site is a clay plain with non-cracking clay in the Kybo land system.

Figure 89: A speargrass/wallaby grass pasture in poor condition. Perennial grasses are sparse and have been replaced by seasonally dependent annuals and semi-perennials. In dry seasons such areas have limited carrying capacity. Stock pad lines are common, and scalds are developing leading to breaking down of cryptogamic crusts and exposure of soil surfaces to wind erosion. The site is an open depression, clay plain with non-cracking clay in the Shakehole land system.

Table 27: Common and important species in speargrass/wallaby grass pastures

Common name	Scientific name	Desirability
Bladder saltbush	*Atriplex vesicaria*	D
Cotton bush	*Ptilotus obovatus*	D
Felty leaf bluebush	*Maireana tomentosa*	D
Grey copperburr	*Sclerolaena diacantha*	D
Jointed nineawn	*Enneapogon cylindricus*	D
Limestone grass	*Enneapogon caerulescens*	D
Neverfail	*Eragrostis setifolia*	D
Pearl bluebush	*Maireana sedifolia*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Scrambling saltbush	*Chenopodium curvispicatum*	D
Wallaby grass	*Rytidosperma caespitosum*	D
Woolly bindii	*Eriochiton sclerolaenoides*	D
Hairy bindii	*Sclerolaena densiflora*	U
Limestone bindii	*Sclerolaena obliquicuspis*	U
Spear-fruit copperburr	*Sclerolaena patenticuspis*	U
Toothed saltbush	*Atriplex acutibractea*	U
Pink-seeded bluebush, downy bluebush	*Maireana trichoptera*	I
Speargrass	*Austrostipa scabra*	I
Erect bluebush	*Maireana pentatropis*	N
Fleshy saltbush	*Rhagodia crassifolia*	N
Grey bluebush	*Maireana radiata*	N
Murchison red grass	*Eragrostis dielsii*	N
Rosy bluebush	*Maireana erioclada*	N
Shrubby twinleaf	*Roepera aurantiaca*	N
Waterbush	*Lycium australe*	N
Balsam	*Euphorbia drummondii*	ann.
Everlasting	*Rhodanthe floribunda*	ann.
Roly poly	*Salsola australis*	ann.
Violet twinleaf	*Roepera iodocarpa*	ann.
Ward's weed	*Carrichtera annua*	ann.

D = desirable; U = undesirable; I = intermediate; N = no indicator value; ann. = annual

Wanderrie grass pastures

Occurrence estimate: 4.92 Mha, 6.1% of the southern rangelands (Appendix B, Figure B21)

Wanderrie grass pastures occur in the Gascoyne, Murchison and Goldfields. These pastures occur on sandy banks and sand sheets, generally overlying hardpan. They occur on ironstone gravel plains and on deep red earths less frequently. Wanderrie banks can be in organised patterns (linear and parallel), or less organised and irregularly shaped as on the gravel plains. The largest areas are in Bullimore, Monk, Yowie, Kalli, Yanganoo, Desdemona and Belele land systems. A schematic diagram of wanderrie grass pastures is shown in Appendix F.

Vegetation structure and composition

Wanderrie grass pastures are generally shrubs and grasses (PFC 10–25%). PFC of the grass component is 5–10%. Important perennial grasses include palatable broad leaf wanderrie, soft wanderrie and woollybutt grass and the less palatable buck wanderrie grass. Grass density is variable depending on landform, season and grazing pressure.

Wanderrie grass pastures are similar to sandplain acacia pastures and share many equivalent species. Sandplain acacia pastures occur on deep sands, whereas wanderrie grass pastures are generally on sand sheets over hardpan. There is a sparse to dense cover of mulga, witchetty bush and bowgada on the banks and interbanks. Dense stands of low shrubs may be present post-fire or after the acacias senesce.

Annual grasses, such as wind grass and three-awn wanderrie grass, and forbs occupy inter-tussock spaces in season. Table 28 has a list of the common and important species for this pasture group.

Pastoral value: moderate

Wanderrie grass pastures typically have moderate pastoral value. The density of palatable species varies depending upon season, fire and grazing history. They are capable of carrying stock on a year-long basis with adequate waters and conservative stocking rates.

These pastures generally have low to moderate value as a reserve in poor seasons, due to the low density of palatable low shrubs and the relatively short-lived nature of the wanderrie grasses. With the onset of dry seasonal conditions stocking rates should be adjusted as annual feed decreases so that perennial plants are not overgrazed. Recovery of wanderrie grasses is much slower than buffel and Birdwood grasses following grazing.

Condition statement for wanderrie grass pastures

Good: Palatable low shrubs such as warty-leaf eremophila, Wilcox bush and tall saltbush are scattered throughout the pasture (Figure 90). Cotton bush and flannel bush are occasionally present at low densities and wanderrie grasses form a sparse to dense ground layer. There is no erosion.

Fair: A small proportion of palatable low shrubs remains and favoured plants may show poor vigour (Figure 91). Undesirable species are uncommon and generally do not increase, however, the less palatable buck wanderrie grass may increase. Erosion is uncommon.

Poor: There are no palatable low shrubs. Annual grasses such as wind grass and three-awn wanderrie and forbs become dominant in poor condition (Figure 92). Erosion is limited to rilling and gullying on the more concentrated flow lines, with sheeting occurring along the edges of the sandbanks near lines of concentrated flow.

Other notes

Fires in wanderrie grass pastures are patchier than in sandplain pastures. On burnt areas, common low shrubs include cotton bush, flannel bush, tall saltbush, Wilcox bush, cottony saltbush, flat leaf bluebush, ruby saltbush, warty-leaf eremophila, horse mulla mulla, crinkle leaf cassia, fire bush and native poplar. Taller shrubs may include limestone wattle in later stages.

Where perennial grasses are depleted, but palatable shrubs remain, rehabilitation of the pasture can be achieved by resting pastures for 6 to 12 months after effective summer rains repeatedly until grasses are re-established and recruiting (Wilcox 1960). Longer periods of rest (dependent on seasonal conditions: drier=longer) will be required where desirable shrubs are depleted until they are re-established and recruiting. Providing rest for these pastures is recommended following prolonged dry periods.

Survey data show that wanderrie grass pastures in the southern rangelands are predominantly in poor condition, except where a lack of stock water has prevented grazing. Most wanderrie grass pastures have deteriorated to the extent that the perennial grasses have disappeared and have been replaced by wind grass, three-awn wanderrie and annual forbs. Valuable shrub species such as Wilcox bush and tall saltbush have also disappeared with overuse. Cattle appear to affect the shrub component less than sheep; overgrazing by sheep causes the loss of both the palatable perennial grasses and the desirable shrubs.

Figure 90: A wanderrie grass pasture in good condition. It has a mixed age population of grasses with good, even cover. There is a sparse mulga overstorey and few undesirable species. The site is a deep sand on a level plain in the Yowie land system.

Figure 91: A wanderrie grass pasture in fair condition. Poverty bushes dominate and woody plants in general are increasing. Silky bluebush has been grazed out and buck wanderrie grass is present. The site is on the mid-slope of a level plain in the Desdemona land system.

Figure 92: A wanderrie grass pasture in poor condition. The understorey is much reduced and mulga is the dominant plant. Bluebushes are absent. Woollybutt grass is present with a few scattered desirable plants, indicating that this pasture is recovering from fire. The site is on a level plain in the Monk land system.

Table 28: Common and important species in wanderrie grass pastures

Common name	Scientific name	Desirability
Broad leaf wanderrie grass	*Monachather paradoxus*	D
Cotton bush	*Ptilotus obovatus*	D
Currant bush	*Scaevola spinescens*	D
Flat leaf bluebush	*Maireana planifolia*	D
Golden bluebush, George's bluebush	*Maireana georgei*	D
Green cassia	*Senna glutinosa* subsp. *chatelainiana*	D
Horse mulla mulla	*Ptilotus schwartzii*	D
Mulga bluebush	*Maireana convexa*	D
Native currant	*Psydrax suaveolens*	D
Ruby saltbush	*Enchylaena tomentosa*	D
Silky bluebush	*Maireana villosa*	D
Soft wanderrie grass	*Thyridolepis multiculmis*	D
Tall saltbush	*Rhagodia eremaea*	D
Tall sida	*Sida calyxhymenia*	D
Warty-leaf eremophila	*Eremophila latrobei*	D
Wilcox bush	*Eremophila forrestii*	D
Woollybutt grass	*Eragrostis eriopoda*	D
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*	U
Needlebush	*Hakea preissii*	U
Sandbank poverty bush	*Eremophila margarethae*	U
Tomato bush	*Solanum orbiculatum*	U
Bowgada, wanyu, horse mulga	*Acacia ramulosa*	I
Buck wanderrie grass	*Eriachne helmsii*	I
Curara	*Acacia tetragonophylla*	I
Gidgee, yalardy	*Acacia pruinocarpa*[1]	I
Flannel bush	*Solanum lasiophyllum*	I
Limestone wattle	*Acacia sclerosprema*	I
Mulga	*Acacia aneura*	I
Mulga broombush	*Teucrium teucriiflorum*	I
Cottony saltbush	*Chenopodium gaudichaudianum*	I
Showy poverty bush	*Eremophila spectabilis*	I
Spreading gidgee	*Acacia subtessarogona*[2]	I
Thin-leaved poverty bush	*Eremophila granitica*	I
Turpentine bush	*Eremophila clarkei*	I
Witchetty bush, granite wattle	*Acacia kempeana*	I
Creeping wanderrie grass	*Eragrostis lanipes*	N
Shark Bay poverty bush	*Eremophila maitlandii*	N
Native poplar	*Codonocarpus cotinifolius*	N
Fire bush	*Gyrostemon ramulosus*	N
Three-awned wanderrie grass	*Eriachne aristidea*	ann.
Wind grass	*Aristida contorta*	ann.

D = desirable; U = undesirable; I = intermediate; N = no indicator value; ann. = annual

1. North-east only
2. West only

A sandy bank with wanderrie grass pasture in the Three Rivers land system

Appendixes

Appendix A

Described habitat/vegetation types and codes

Table A1: Habitat/vegetation types for each pasture group in this guide (see Table A2 for full names of each vegetation code)

Pasture group	Habitat/vegetation code (survey)
Bluebush	BLUE (CBS Carnarvon Basin*, GAS Gascoyne Catchment, LMU Lower Murchison River, WMA Wiluna–Meekatharra)
	CPBS, PSAS (NEG North-eastern Goldfields, SGF Southern Goldfields)
	PSAS (SYP Sandstone, Yalgoo and Paynes Find*)
	BLUS (MUR Murchison River Catchment)
Eucalypt chenopod	ESOW (LMU)
	CEAS, PECW, PESW, PEBW (NEG)
	GEBW, GESW, ERHW, EOSW, PEBW, PESW, PEHW (SGF)
	PECW, PESW, PYCW (SYP)
	EMCW, ESAW, ESCW, EXCW, EXHS, EXSW, PESW (WNB Western Australian part of the Nullarbor region)
Greenstone stony plain†	SMMS in Violet land system (MUR)
	CPBS, PEBW, SBMS, USBS – range of proportions in 11 land systems (largest to smallest): Bevon, Nubev, Moriarty, Violet, Gundockerta, Leonora, Yilgangi, Laverton, Hootanui, Teutonic, Steer (NEG)
	SCBS, SBMS (SGF)
	SBMS, USBS – range of proportions in 8 land systems (largest to smallest): Austin, Nubev, Bevon, Yilgangi, Violet, Hootanui, Teutonic, Steer (SYP)
Mixed chenopod shrub plain	DMCS, MHHS (GAS)
	MXCS, MXHS, FRAN (LMU)
	MCHS, MXHS (MUR)
	PXHS, DMCS, FRAN, MHHS (NEG)
	DACS, FRAN, PXHS (SGF)
	DACS, DMCS, FRAN, MHHS, PXHS (SYP)
	FRAN, MHHS, MXHS (WMA)
	CXCS, DDXS, NXCS, PXCS, PXHS (WNB)
Nullarbor	DOGR, DDSS, MHXS, MPBS, MSAS, MSCW, MXCS, MXSS, PBAC, PBLS, PXLS, SWCS (WNB)

* Some habitat codes described in particular published survey reports (SYP, CBS) have been used in adjacent areas (CBS, MUR, NEG, LMU) due to edge matching.

† The greenstone group is slightly different because of the underlying rock. These habitat types can exist in the stony mixed chenopod pastures which do not have underlying greenstone.

Pasture group	Habitat/vegetation code (survey)
Riparian association	ACCR (CBS) DRAS, DRMS, RIMS (GAS) RIMS, RIVS, DRMS, DRCW (LMU) CRGS, CRLS, RIMS (MUR) DRMS (NEG) DRAS, DREW (SGF) DRAS (SYP, WNB) ACCR, DRAS, DRMS, RIMS (WMA)
Saltbush	SALT (CBS) SALS (MUR) SSAS, SBLS, BLSS (NEG, SYP) SBLS, BLSS (SGF) SBLS (WMA) BSSL (WNB)
Samphire	SAMP (CBS, NEG, SGF, SYP, WMA, WNB) SAMS (MUR)
Snakewood	ASWS (SYP) SSWS (LMU, MUR)
Stony mixed chenopod	STCH (CBS, GAS) USBS, SBMS (NEG) BECW, SBMS, SCBS (SGF) USBS, BCLS, BECW, SBMS, SSMS (SYP)
Acacia hardpan	GRMU, HPMS (GAS, WMA) HPAS (LMU) HPMS, MGRW (MUR) HPMS, LHMS, HMCS, GRMU, DRMS, CPMG (NEG) HPMS, HMCS (SGF) HPMS, HCAS, HMCS, GRMU, LHMS, MUBW (SYP)
Acacia–cassia short grass forb	ASGF, SSGF (CBS) MSGF, SSGF (GAS, WMA)
Currant bush mixed shrub	CBMS (CBS)

Pasture group	Habitat/vegetation code (survey)
Eucalypt–acacia–eremophila shrubland plain	ACMS (CBS) ACMS, EUAW (LMU) CEAS (NEG) CEWS, EFBW, PEAW, PEEW, PYAW (SGF) PYAW (SYP)
Heath	HEAT (CBS) HEAT, SCHE, TRHE, COHE (LMU) SAHE, SAMH, PINH (SGF) LSHE (SYP) EHEW, ECHW, BCHS (WNB)
Sandplain acacia	ACSA, AEGF (CBS) ACSA (GAS) ASSW, CYSS, MASA, SDUS (LMU) LACS, SAAS, SDUS (MUR) SACS (NEG) PINW, SACS, SCMS (SGF) PINW, LACS, SACS, SCMS, MAAS (SYP) LACS (WMA)
Sandy granitic acacia	GMUS (LMU, MUR) GRHS, SGRS (NEG) GABS, GRHW, SCJS, SGRS (SGF) GABS, GRHS, SGRS (SYP) GRHS (WMA) GROS (WNB)
Stony acacia–cassia–eremophila	SMMS (GAS, MUR, WMA) ISAS, STAS, SMMS (LMU) SAES, SIMS (NEG) SAES, SIMS, SIAS (SYP) DEXS, XAOS (WNB)
Buffel grass	TUGR (CBS)

Pasture group	Habitat/vegetation code (survey)
Hard spinifex	HASP (CBS)
	HASP, SASP (GAS)
	SAHS, SAMU, SASP, SDSH (NEG)
	MHGW, SAMA, SAMU, SASP, SAGS (SGF)
	SASP, SAMU, SDSH (SYP)
	HSPG, SAMU, SASP (WMA)
	MHGW (WNB)
Soft spinifex	SOSP (CBS)
Speargrass/wallaby grass	ANNH, SWOG (SGF)
	ANNH, ESOG, MSOG, SWOG, OBIG (WNB)
Wanderrie grass	WABS (GAS)
	SWGS (LMU)
	SWGS, WBGS (MUR)
	MUWA, LMWS, WABS (NEG)
	MUWA, PLMS, SWGS, WABS (SYP)

Table A2: List of survey codes mentioned in Table A1 and their meaning

Survey code	Habitat/vegetation type name
ACCR	Acacia creekline
ACMS	Acacia mixed shrubland
ACSA	Acacia sandplain
AEGF	Acacia, eucalypt grass forb
ANNH	Annual herbland
ASGF	Acacia, short grass forb
ASSW	Acacia sandplain woodland
ASWS	Alluvial plain snakewood, chenopod low shrub
BCHS	Banksia coastal heath scrubland
BCLS	Breakaway footslope chenopod low shrub
BECW	Breakaway footslope eucalypt woodland with chenopod understorey
BLSS	Bladder saltbush low shrubland
BLUE	Bluebush
BLUS	Bluebush shrubland
BSSL	Bladder saltbush shrubland
CBMS	Currant bush mixed shrubland
CEAS	Calcareous eucalypt, acacia shrubland
CEWS	Colluvial slope eucalypt woodland over nonhalophytic shrubland
COHE	Coastal heath
CPBS	Calcareous pearl bluebush shrubland
CPMG	Claypan mulga grassland
CRGS	Creekline grassy shrubland
CRLS	Creekline shrubland
CXCS	Casuarina mixed chenopod shrubland
CYSS	Cypress sandplain shrubland
DACS	Drainage tract acacia shrubland or woodland with chenopod understorey
DDSS	Drainage depression saltbush shrubland
DDXS	Drainage depression mixed shrub shrubland
DEXS	Dodonaea, eremophila mixed shrubland
DMCS	Drainage line mulga, chenopod shrubland
DOGR	Donga grove
DRAS	Drainage tract acacia shrubland

Survey code	Habitat/vegetation type name
DRCW	Drainage channel woodland
DREW	Drainage tract eucalypt woodland
DRMS	Drainage mulga shrubland
ECHW	Eucalypt coastal heath woodland
EFBW	Eucalypt, false bluebush woodland
EHEW	Eucalypt heath woodland
EMCW	Eucalypt, melaleuca mixed chenopod woodland
EOSW	*Eucalyptus oleosa*, saltbush woodland
ERHW	*Eucalyptus ravida*, halophytic woodland
ESAW	Eucalypt, saltbush woodland
ESCW	Eucalypt, sugarwood mixed chenopod woodland
ESOG	Eucalypt, speargrass open grassland
ESOW	Eucalypt, saltbush open woodland
EUAW	Eucalypt, acacia woodland
EXCW	Eucalypt, mixed chenopod woodland
EXHS	Eucalypt, mixed halophyte shrubland
EXSW	Eucalypt, mixed scrub woodland
FRAN	Frankenia low shrubland
GABS	Granitic acacia, Borya shrubland
GEBW	Greenstone eucalypt, bluebush woodland
GESW	Greenstone eucalypt, saltbush woodland
GMUS	Granitic mulga shrubland
GRHS	Granite hill mixed shrubland
GRHW	Granite hill mixed woodland
GRMU	Hardpan plain mulga grove
GROS	Granite outcrop shrubland
HASP	Hard spinifex
HCAS	Hardpan acacia shrubland
HEAT	Heath
HMCS	Hardpan mulga, chenopod shrubland
HPAS	Hardpan acacia shrubland
HPMS	Hardpan mulga shrubland
HSPG	Hill spinifex grassland

Survey code	Habitat/vegetation type name
ISAS	Ironstone acacia shrubland
LACS	Lateritic sandplain acacia shrubland
LHMS	Lateritic hardpan mulga shrubland
LMWS	Lateritic mulga, wanderrie grassy shrubland
LSHE	Lateritic sandplain heath
MAAS	Sandplain mallees acacias
MASA	Mallee, acacia sandplain
MCHS	Mulga, chenopod shrubland
MGRW	Mulga grove woodland
MHGW	Mallee, hummock grass (spinifex) woodland
MHHS	Mixed chenopod shrublands with mulga overstorey
MHXS	Myall, mixed halophyte shrubland
MPBS	Myall, pearl bluebush shrubland
MSAS	Myall, saltbush shrubland
MSCW	Myall, sugarwood mixed chenopod woodland
MSGF	Mulga, short grass forb
MSOG	Myall, speargrass open grassland
MUBW	Hardpan plain mulga, bowgada woodland
MUWA	Mulga, wanderrie grassy shrubland
MXCS	Mixed chenopod shrubland
MXHS	Mixed halophytic shrubland
MXSS	Myall mixed shrub shrubland
NXCS	Nitraria mixed chenopod shrubland
OBIG	Open bindii grassland
PBAC	Pearl bluebush, acacia shrubland
PBLS	Pearl bluebush low shrubland
PEAW	Plain eucalypt, acacia woodland
PEBW	Plain eucalypt, bluebush woodland
PECW	Plain eucalypt, chenopod woodland
PEEW	Plain eucalypt, eremophila woodland
PEHW	Plain eucalypt, halophytic woodland
PESW	Plain eucalypt, saltbush woodland
PINH	Plain native pine heathland

Survey code	Habitat/vegetation type name
PINW	Plain native pine, acacia woodland
PLMS	Plain sandy loam mulga shrubland
PSAS	Plain sago bush shrubland
PXCS	Plain mixed chenopod shrubland
PXHS	Plain mixed halophyte shrubland
PXLS	Plain mixed low shrubland
PYAW	Plain York gum, acacia woodland
PYCW	Plain York gum, chenopod woodland
RIMS	Riverine mixed shrubland
RIVS	Riverine shrubland
SAAS	Sandplain acacia shrubland
SACS	Sandplain acacia shrubland
SAES	Stony acacia, eremophila shrubland
SAGS	Sandplain spinifex grassland with marble gum
SAHE	Sandplain heathland
SAHS	Sandplain spinifex hummock grassland with low heath stratum
SALS	Saltbush shrubland
SALT	Saltbush
SAMA	Sandplain mallee, spinifex woodland
SAMH	Sand sheet mallee heath
SAMP	Samphire shrubland
SAMS	Samphire shrubland
SAMU	Sandplain mulga, spinifex hummock grassland
SASP	Sandplain spinifex hummock grassland
SBLS	Sandy bank lake shrubland
SBMS	Stony plain bluebush mixed shrubland
SCBS	Stony casuarina, bluebush shrubland
SCHE	Scrub heath
SCJS	Stony close jam shrubland
SCMS	Sandplain close mixed shrubland
SDSH	Sand dune shrubland
SDUS	Sand dune shrubland
SGRS	Sandy granitic acacia shrubland

Survey code	Habitat/vegetation type name
SIAS	Stony ironstone acacia shrubland
SIMS	Stony ironstone mulga shrubland
SMMS	Stony mulga mixed shrubland
SOSP	Soft spinifex
SSAS	Silver saltbush shrubland
SSGF	Stony short grass forb
SSMS	Stony saltbush mixed shrubland
SSWS	Stony snakewood shrubland
STAS	Stony acacia shrubland
STCH	Stony chenopod
SWCS	Sugarwood mixed chenopod shrubland
SWGS	Sandplain wanderrie grassy shrubland
SWOG	Speargrass and wallaby grass open grassland
TRHE	Tree heath
TUGR	Tussock grass
USBS	Upland small bluebush species shrubland
WABS	Wanderrie bank grassy mulga shrubland
WBGS	Wanderrie bank grassy shrubland
XAOS	Mixed acacia open shrubland

Appendix B

Estimated occurrence maps

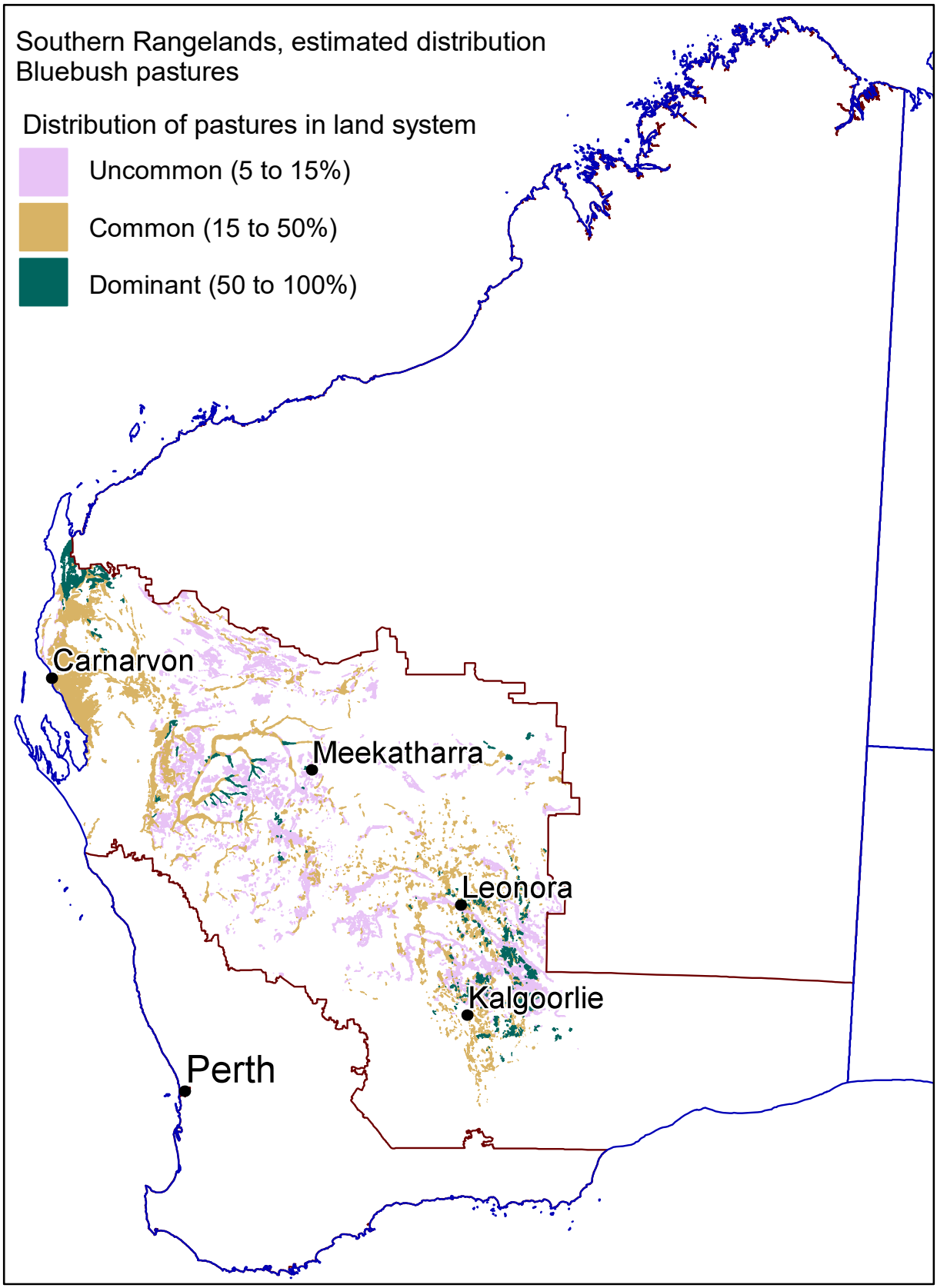


Figure B1: Estimated distribution of bluebush pastures in the southern rangelands. Bluebush pastures are described in 88 land systems: the largest areas are in the Gundockerta, Carnegie, Sandal, Gransal, Ero and Beringarra land systems.

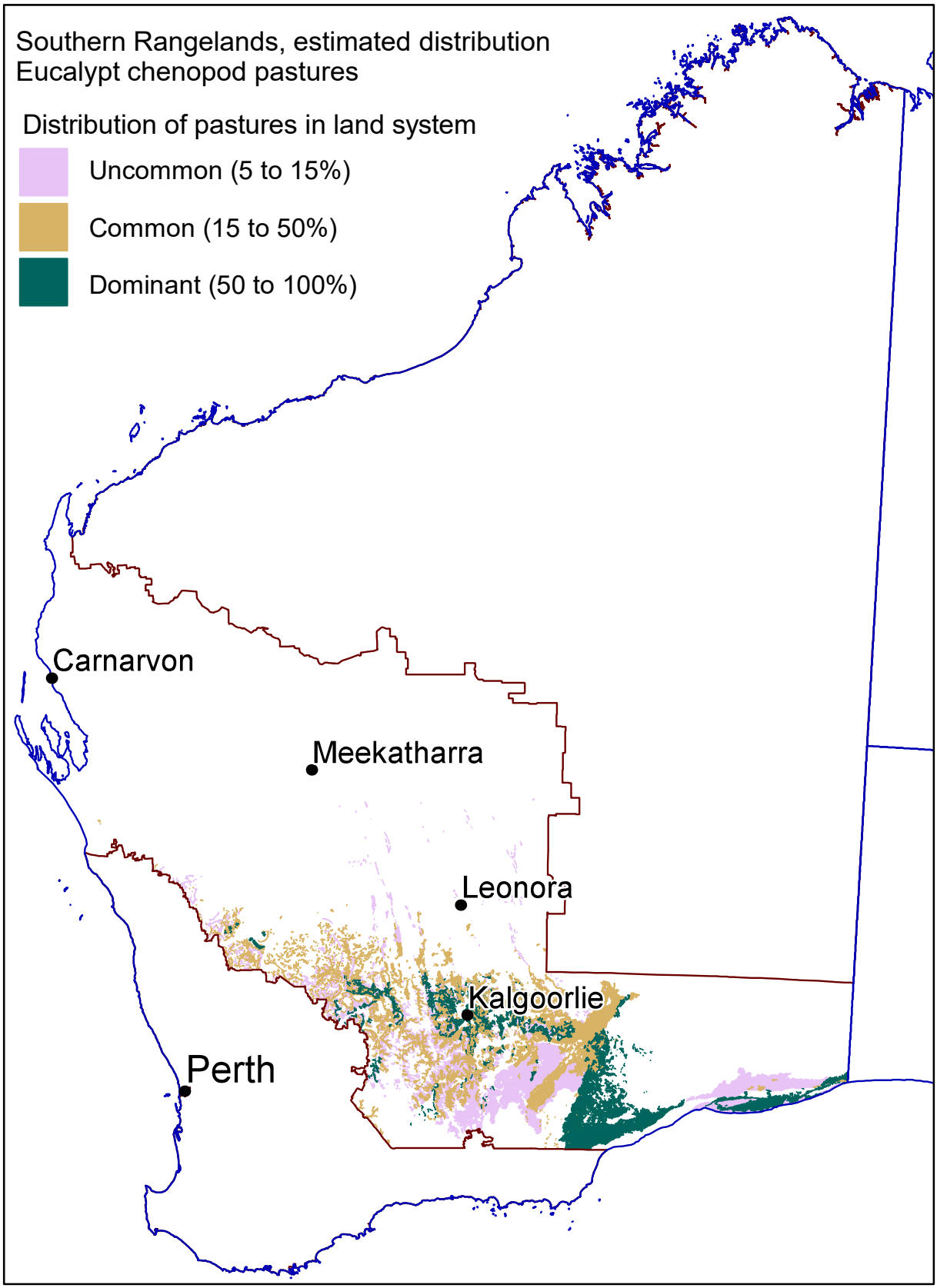


Figure B2: Estimated distribution of eucalypt chenopod pastures in the southern rangelands. Eucalypt chenopod pastures are described in 61 land systems: the largest areas are in the Caiguna, Gumbelt, Gumland, Doney and Roe land systems.

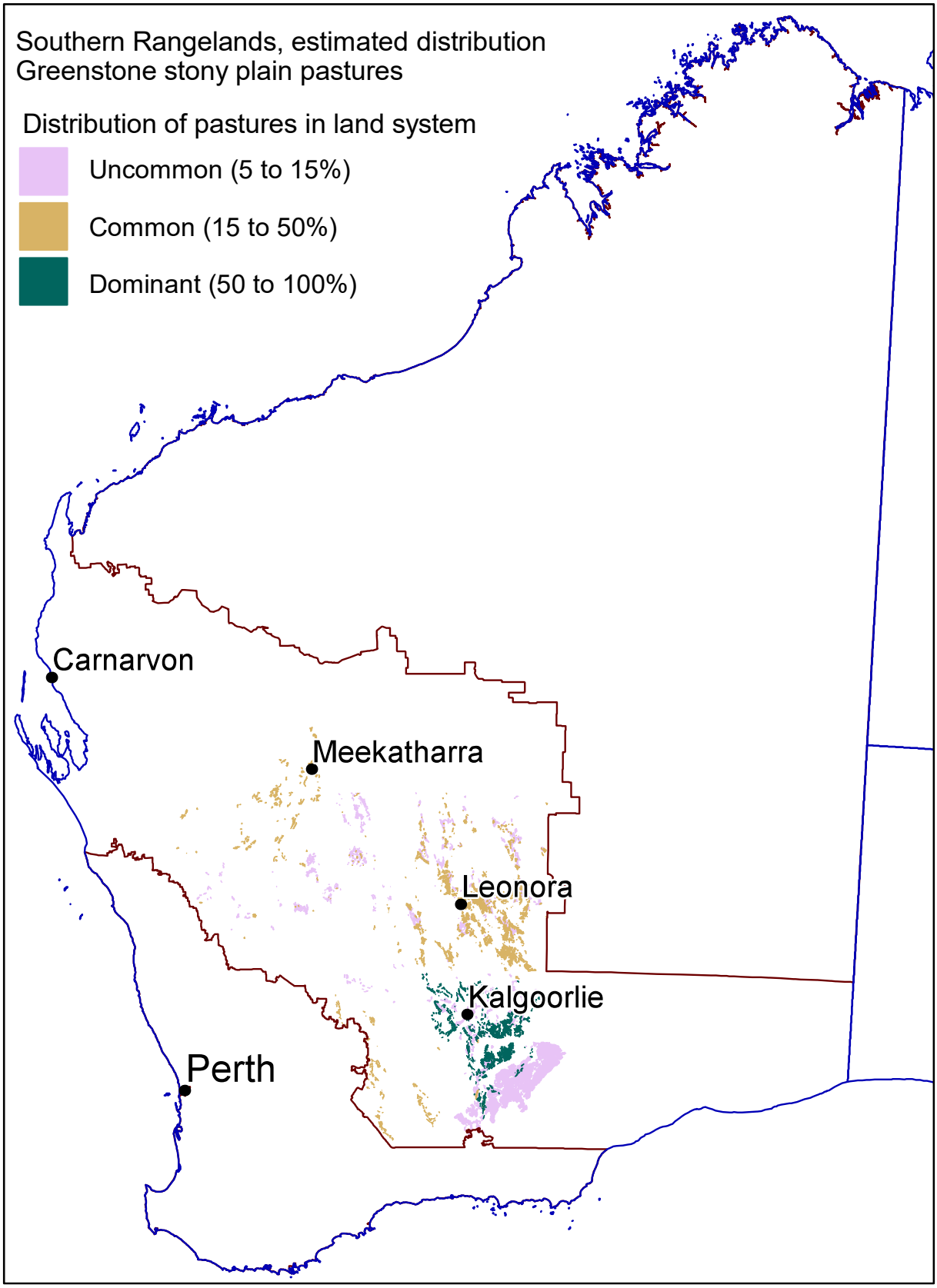


Figure B3: Estimated distribution of greenstone stony plain pastures in the southern rangelands. Greenstone stony plain pastures are described in 22 land systems: the largest areas are in the Woolibar, Coolgardie, Gundockerta, Nubev, Dundas and Violet land systems.

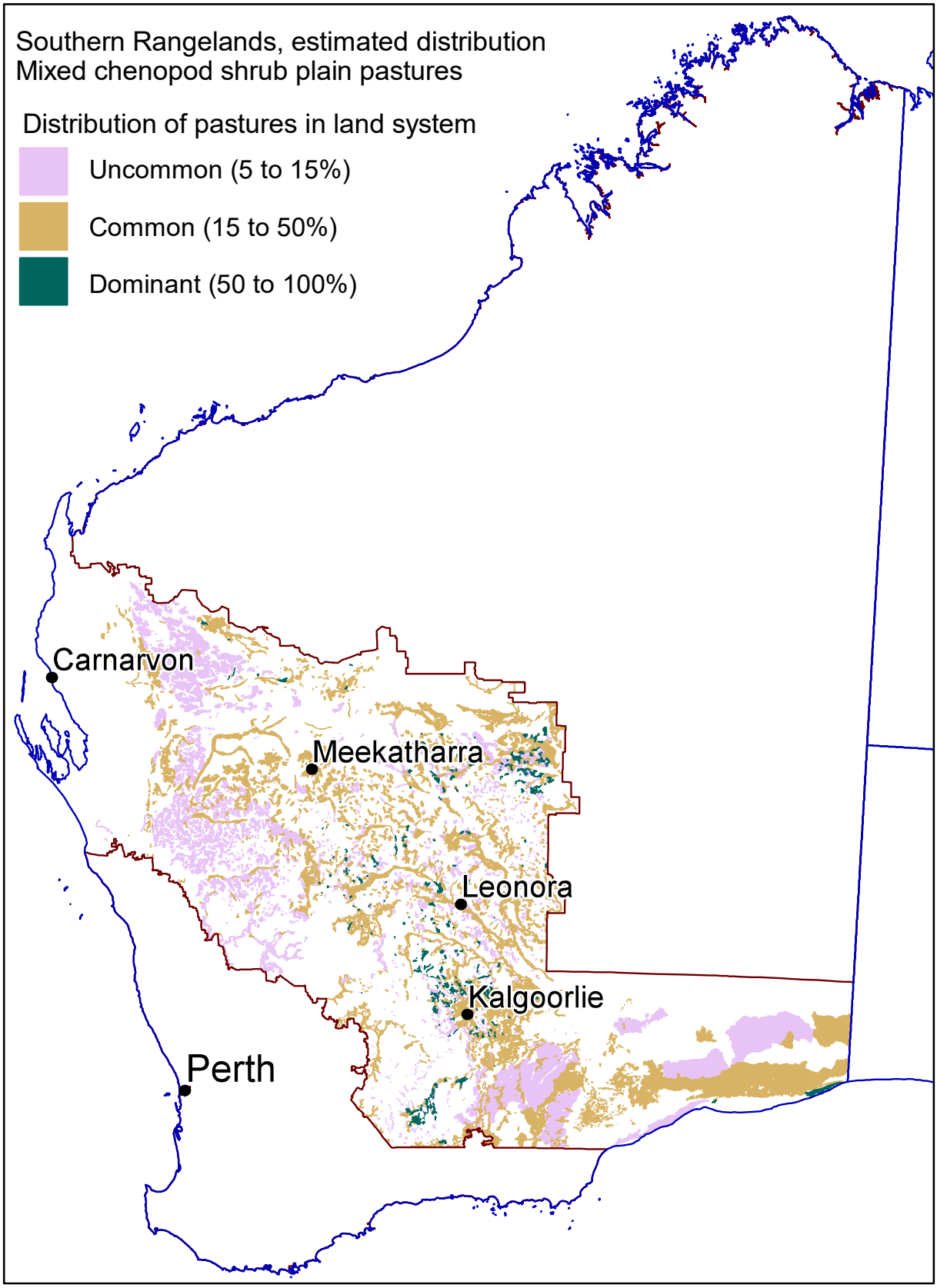


Figure B4: Estimated distribution of mixed chenopod shrub plain pastures in the southern rangelands. Mixed chenopod shrub plain pastures are described in 116 land systems: the largest areas are in the Carnegie, Sherwood, Challenge, Reid, Thampanna and Gafa land systems.

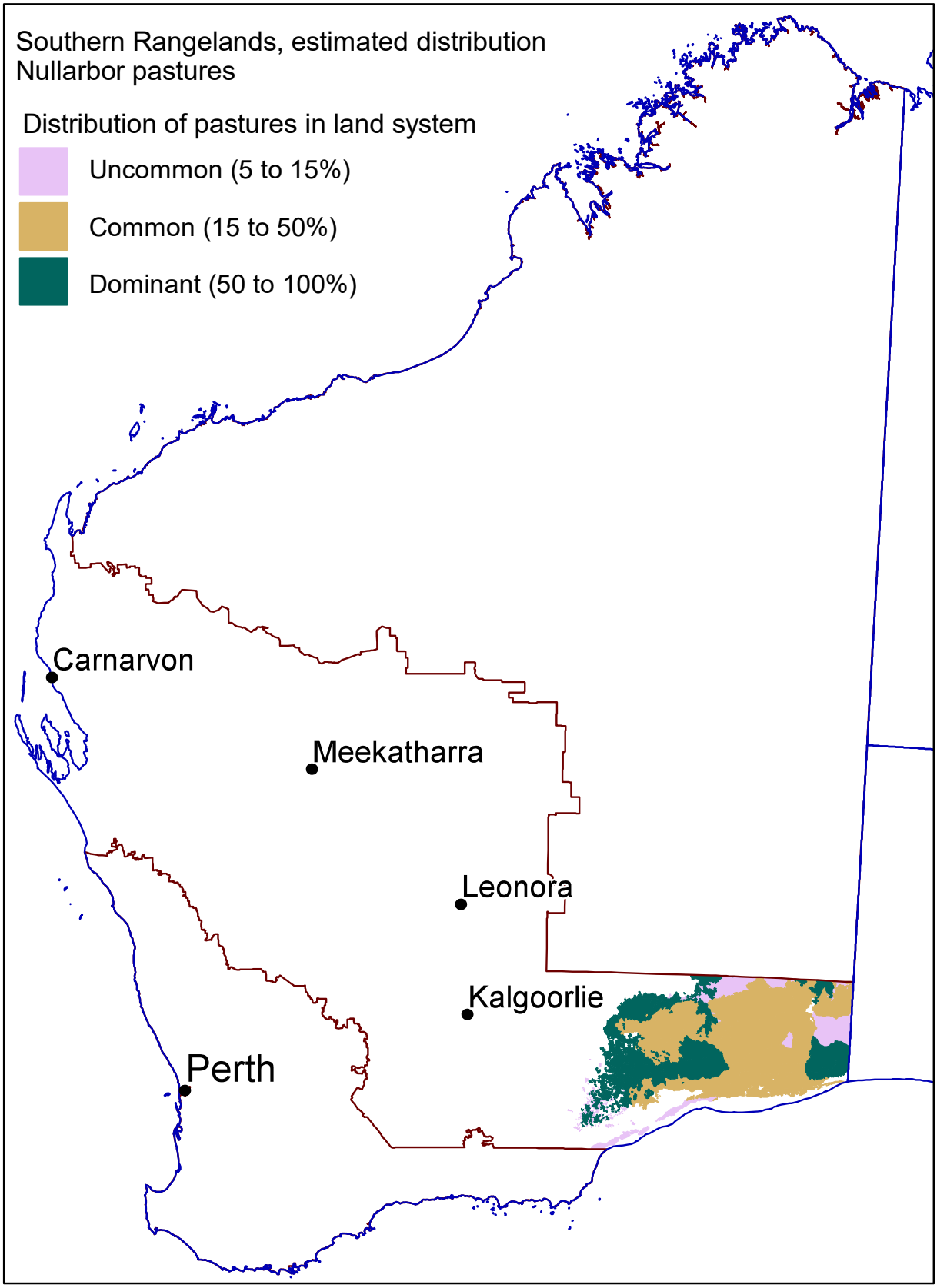


Figure B5: Estimated distribution of Nullarbor pastures in the southern rangelands. Nullarbor pastures are described in 36 land systems: the largest areas are in the Nyanga, Moonera, Morris, Gafa, Thampanna and Kinclaven land systems.

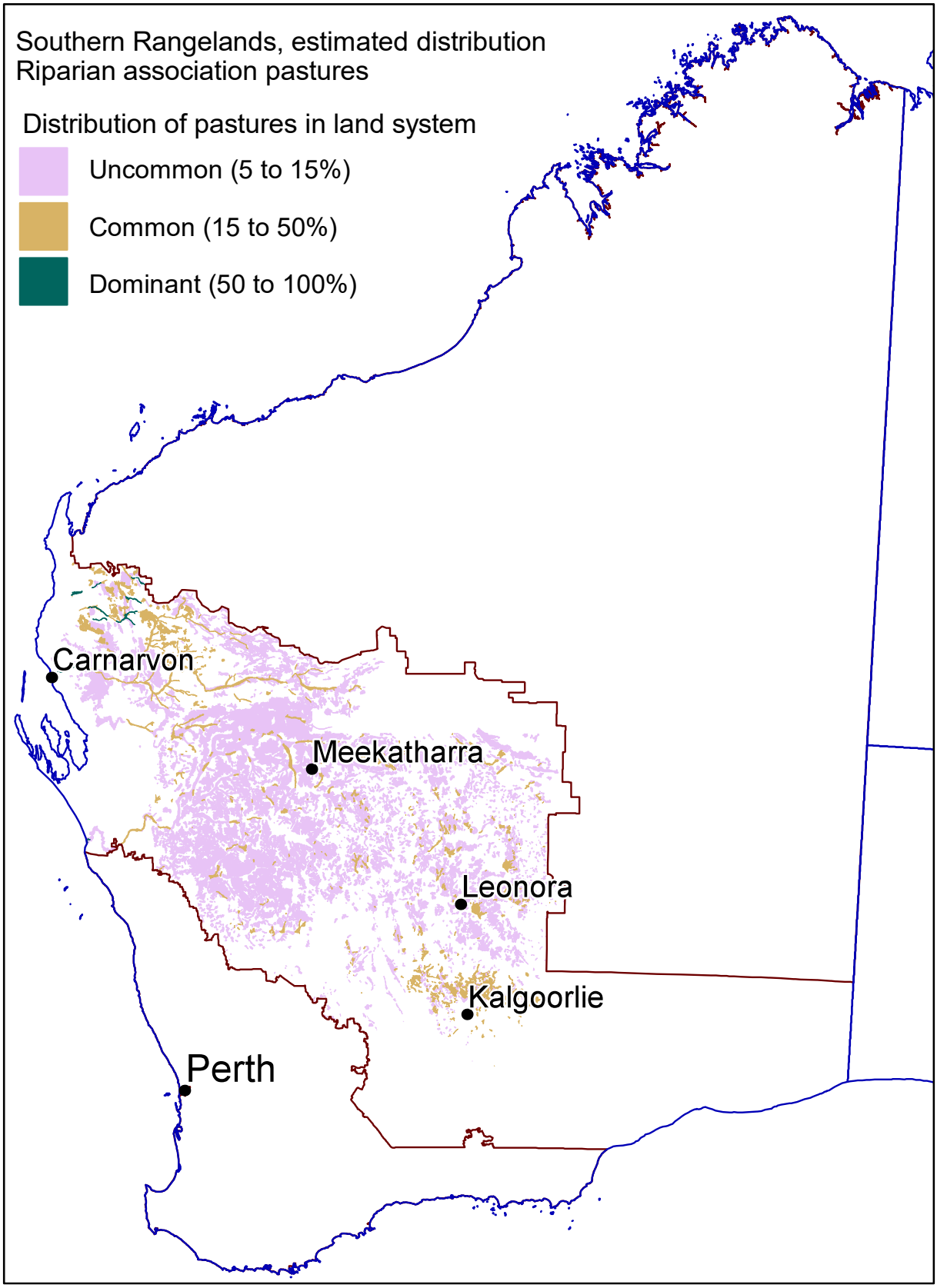


Figure B6: Estimated distribution of riparian association pastures in the southern rangelands. Riparian association pastures are described in 142 land systems: the largest areas are in the Gascoyne, Woodline, Yanganoo, Bullimore, Cunyu and Challenge land systems.

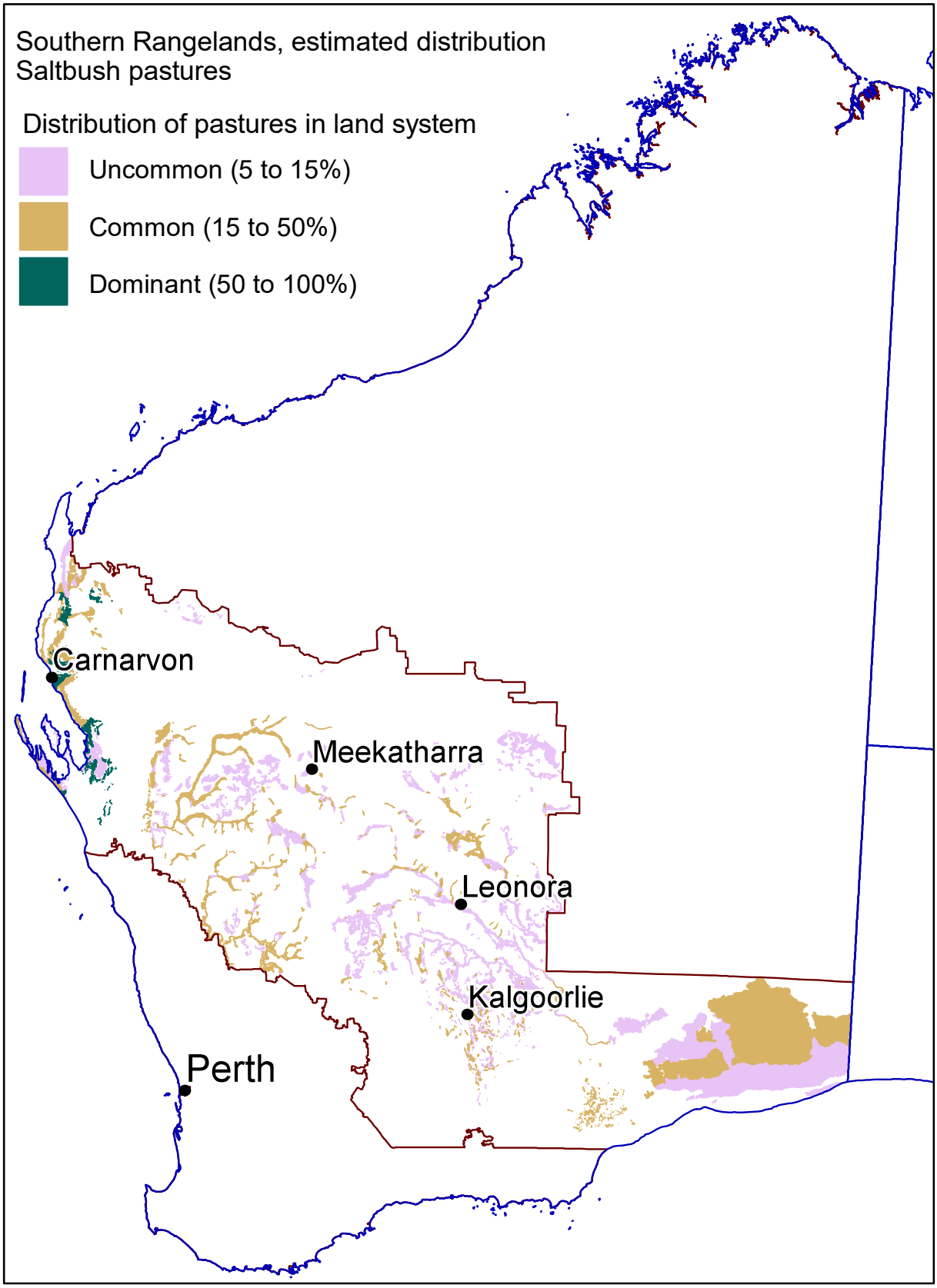


Figure B7: Estimated distribution of saltbush pastures in the southern rangelands. Saltbush pastures are described in 92 land systems: the largest areas are in the Carnegie, Bullseye, Gafa, Reid, Delta and Moonera land systems.

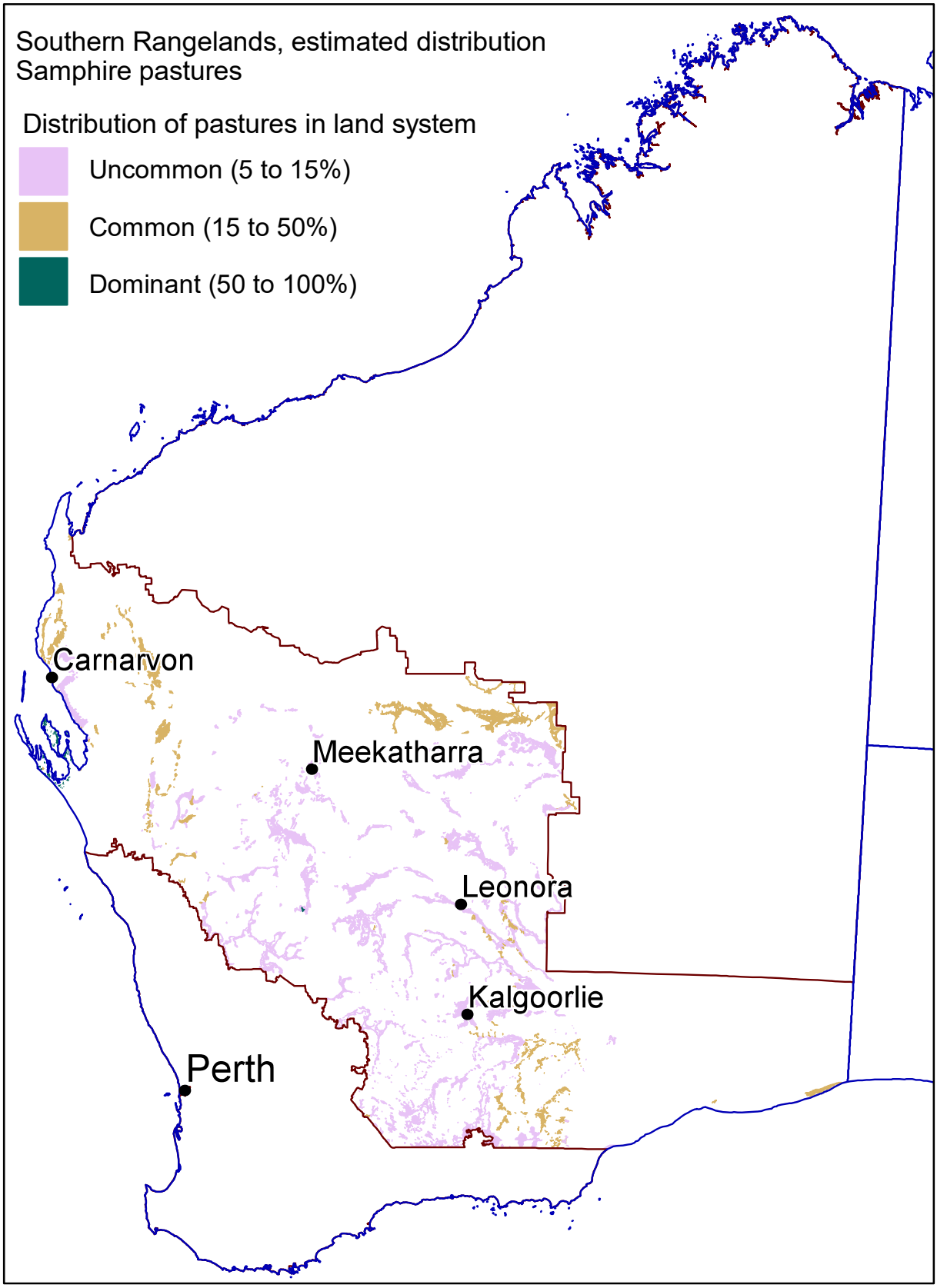


Figure B8: Estimated distribution of samphire pastures in the southern rangelands. Samphire pastures are described in 68 land systems: the largest areas are in the Carnegie, MacLeod, Mantle, Yardina, Yilgangi and Warroora land systems.

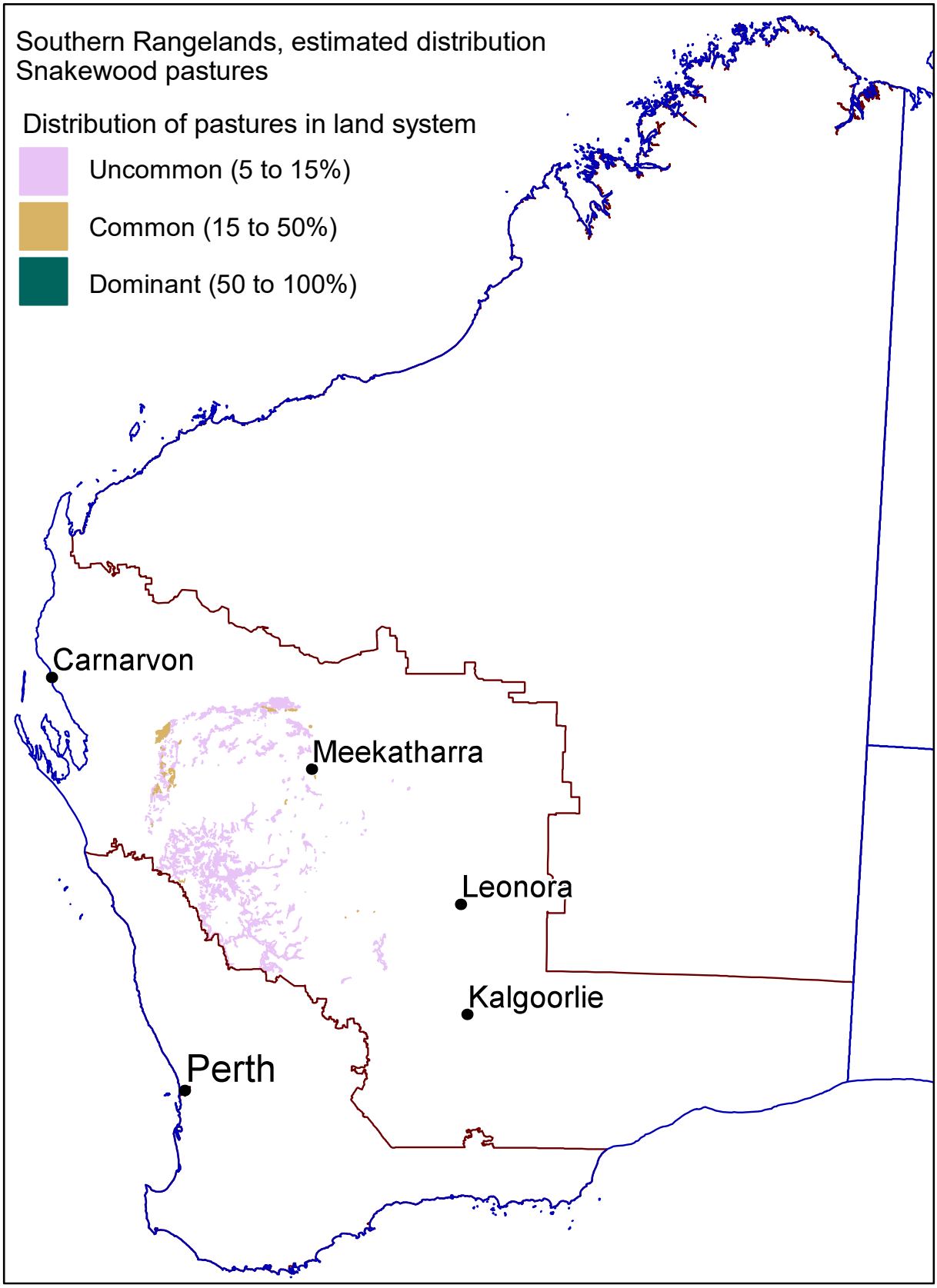


Figure B9: Estimated distribution of snakewood pastures in the southern rangelands. Snakewood pastures are described in 22 land systems: the largest areas are in the Tindalarra, Mindura, Challenge, Carnegie, Byro and Ero land systems.

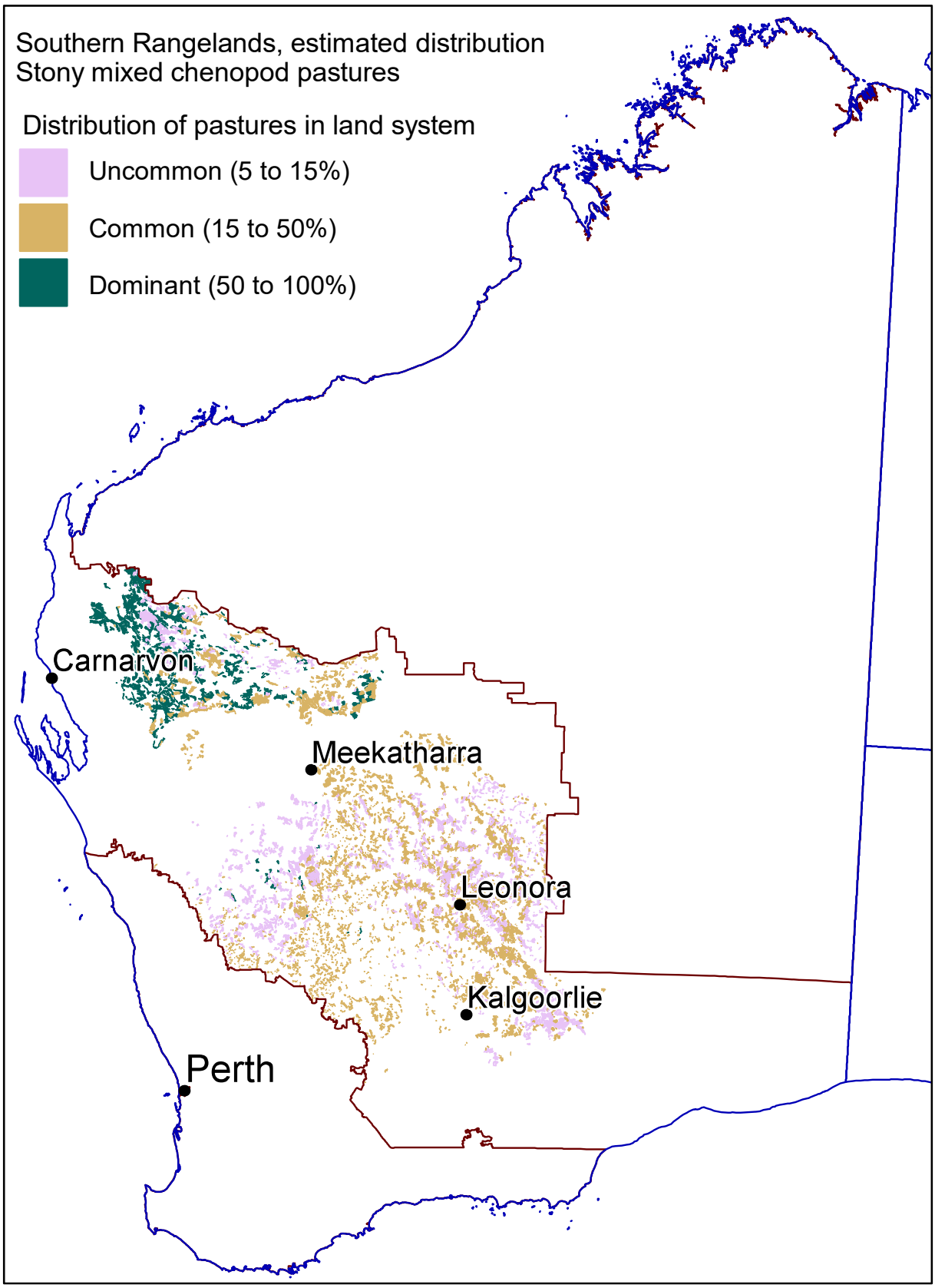


Figure B10: Estimated distribution of stony mixed chenopod pastures in the southern rangelands. Stony mixed chenopod pastures are described in 49 land systems: the largest areas are in the Durlacher, Sherwood, Jimba, Sandiman, Gundockerta and Thomas land systems.

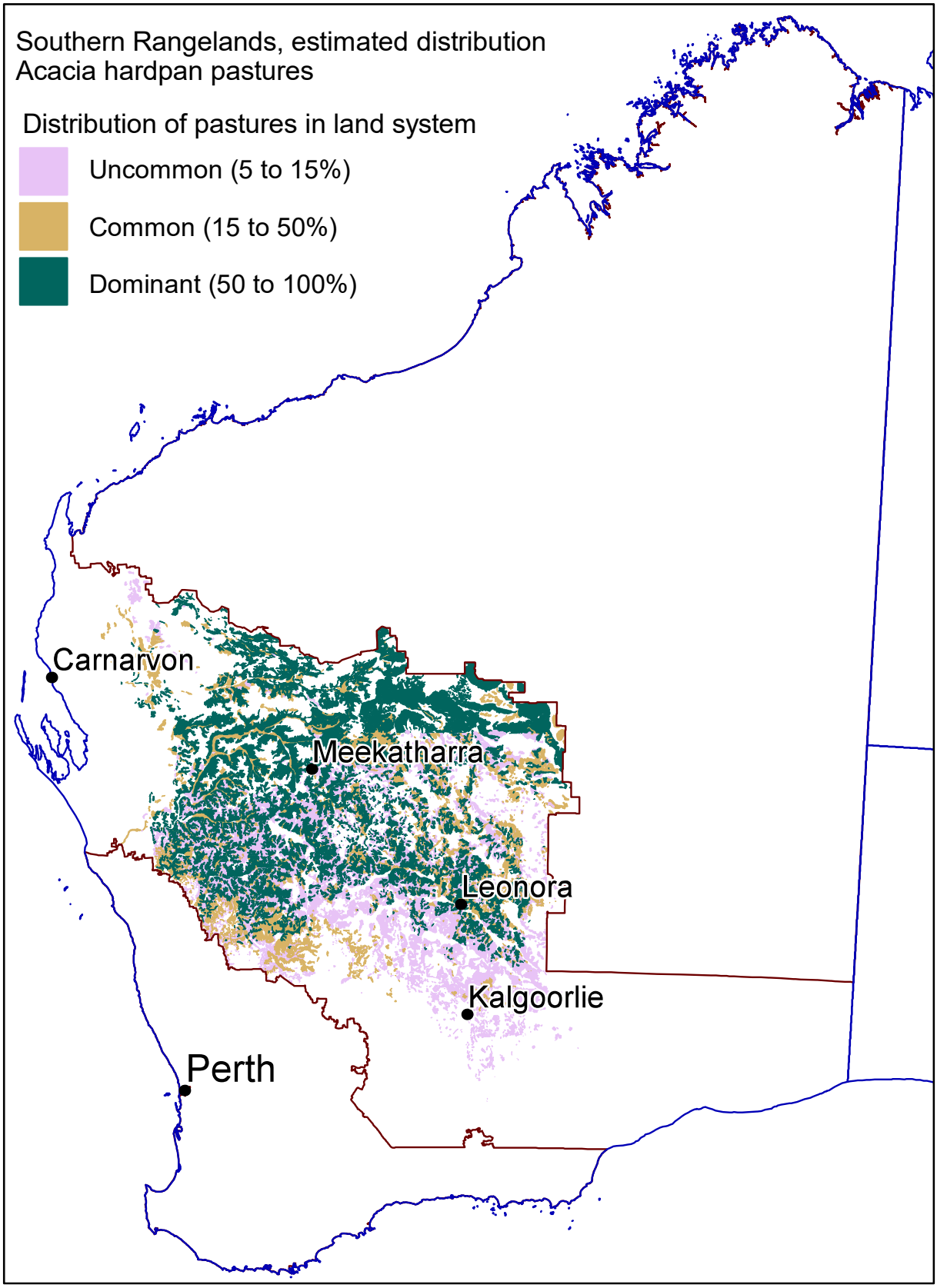


Figure B11: Estimated distribution of acacia hardpan pastures in the southern rangelands. Acacia hardpan pastures are described in 124 land systems: the largest areas are in the Yanganoo, Woodline, Tindalarra, Jundee, Monk, Yandil and Belele land systems.

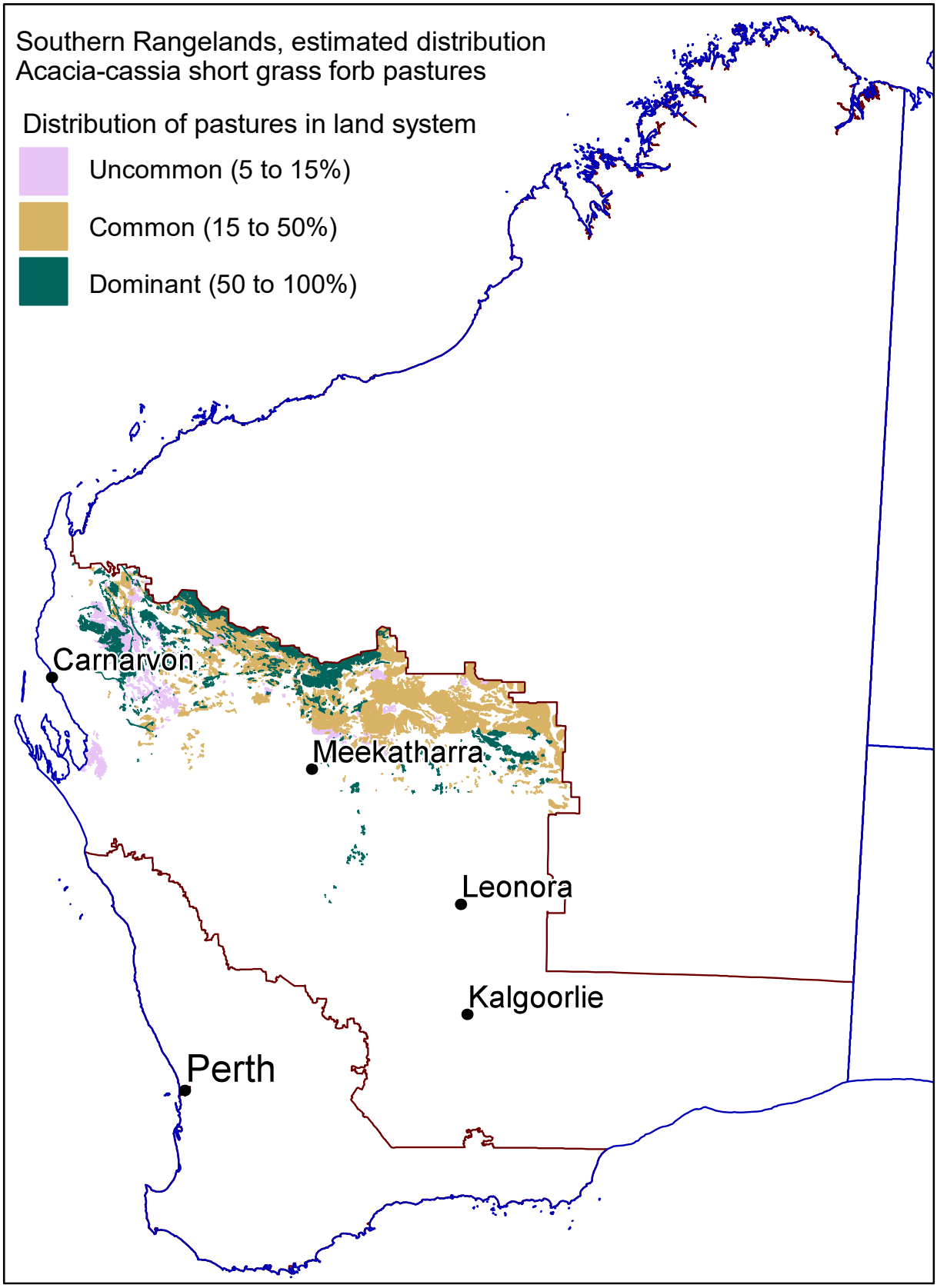


Figure B12: Estimated distribution of acacia–cassia short grass forb pastures in the southern rangelands. Acacia–cassia short grass forb pastures are described in 63 land systems: the largest areas are in the Augustus, Jamindie, Thomas, Moogooloo, Collier and George land systems.

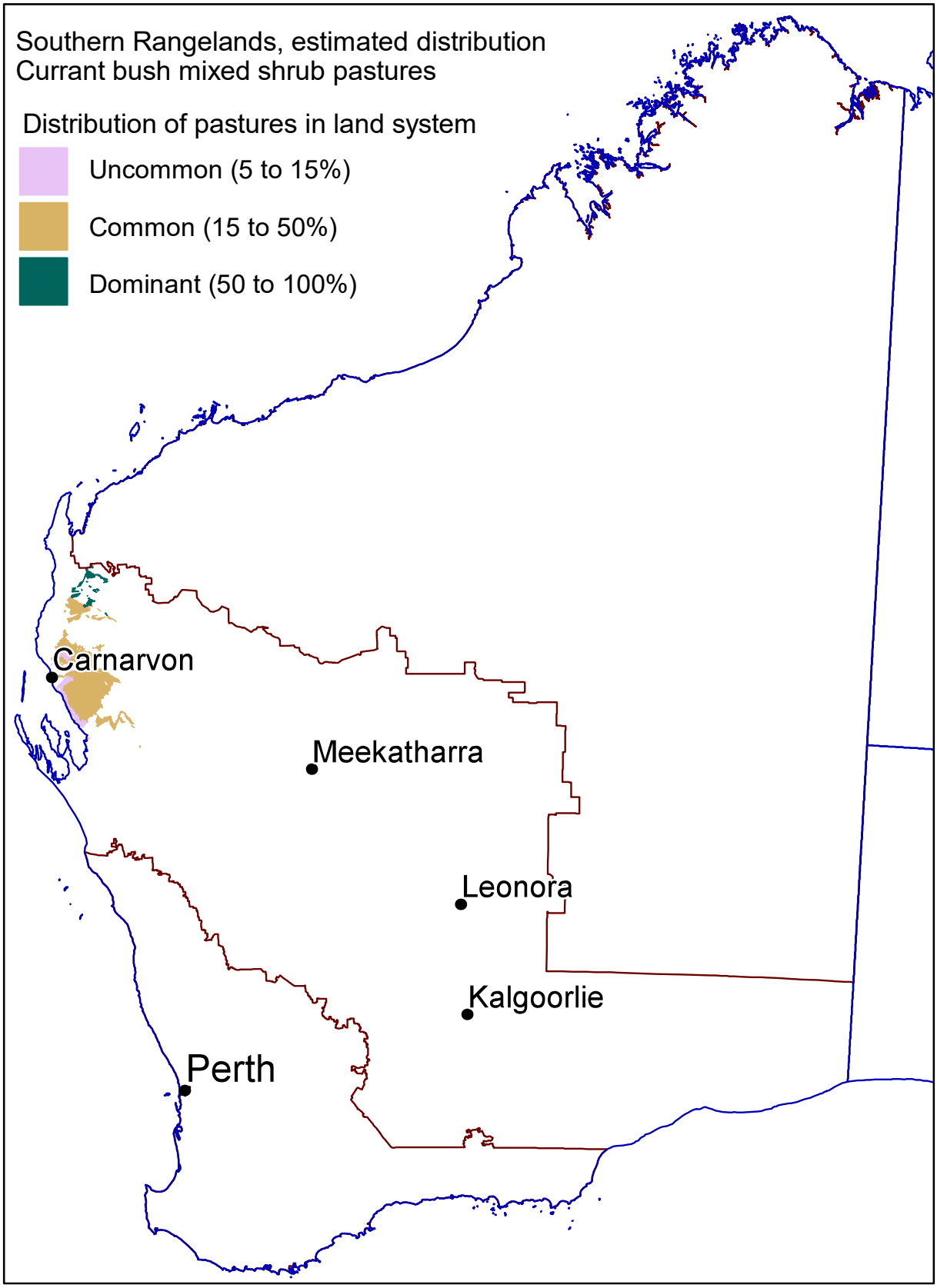


Figure B13: Estimated distribution of currant bush mixed shrub pastures in the southern rangelands. Currant bush mixed shrub pastures are described in the Sandal, Ella, Target, Spot, Lyons and Sable land systems: the majority of which are in the Sandal land system.

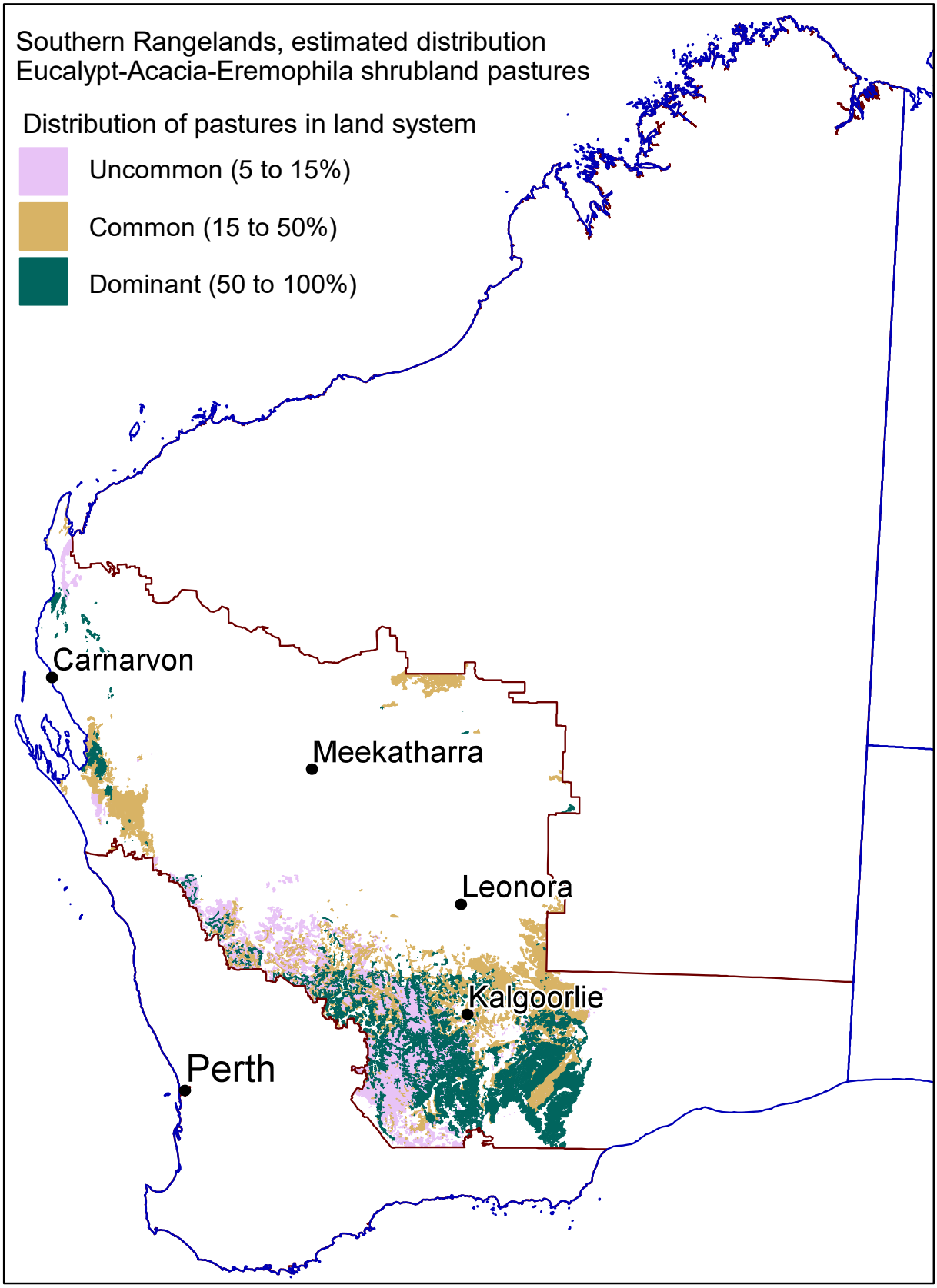


Figure B14: Estimated distribution of eucalypt–acacia–eremophila shrubland plain pastures in the southern rangelands. Eucalypt–acacia–eremophila shrubland plain pastures are described in 66 land systems: the largest areas are in the Doney, Dundas, Johnston, Pindar, Kirgella and Harms land systems.

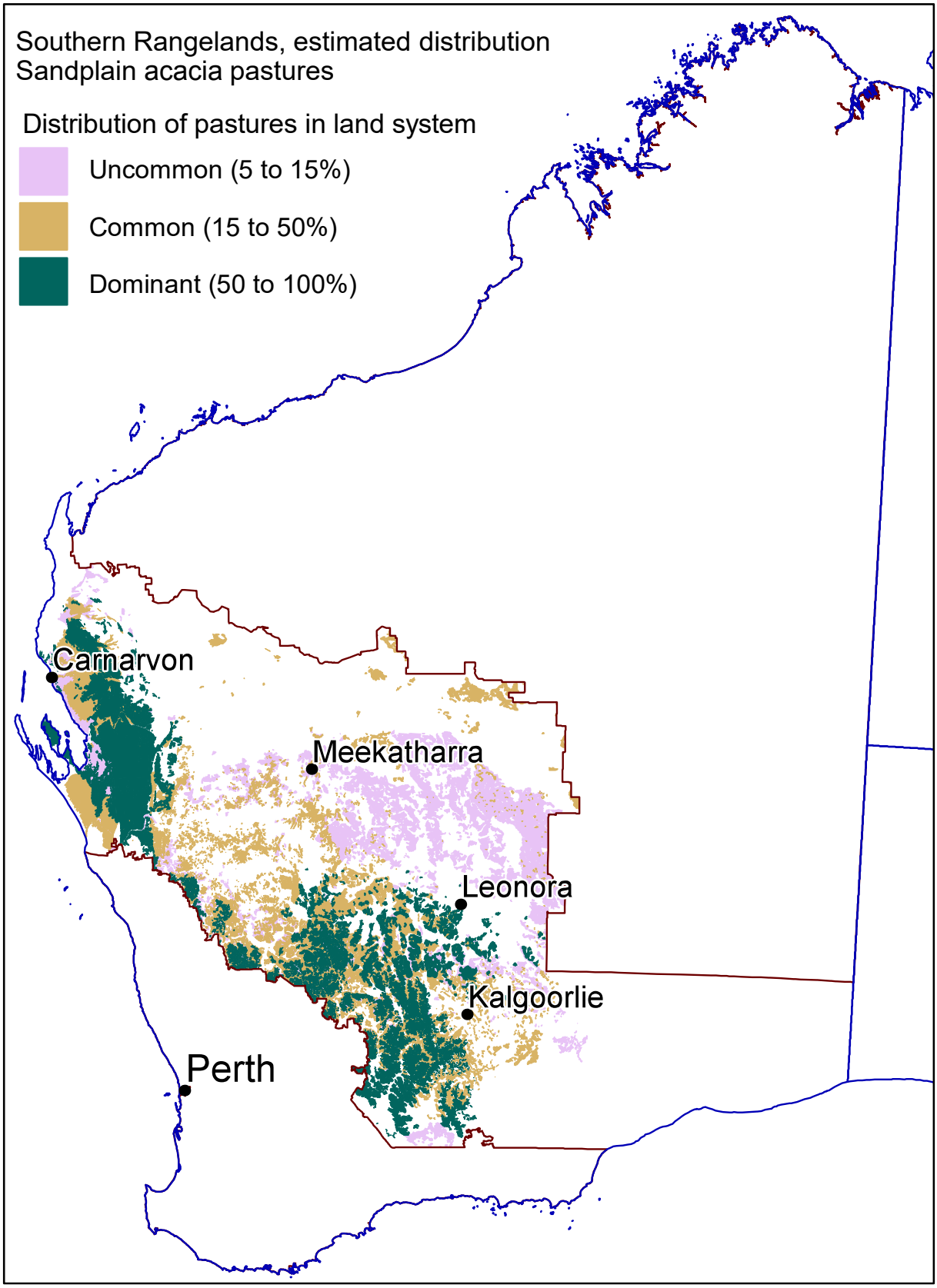


Figure B15: Estimated distribution of sandplain acacia pastures in the southern rangelands. Sandplain acacia pastures are described in 82 land systems: the largest areas are in the Joseph, Sandplain, Yalbalgo, Yowie, Bannar and Kalli land systems.

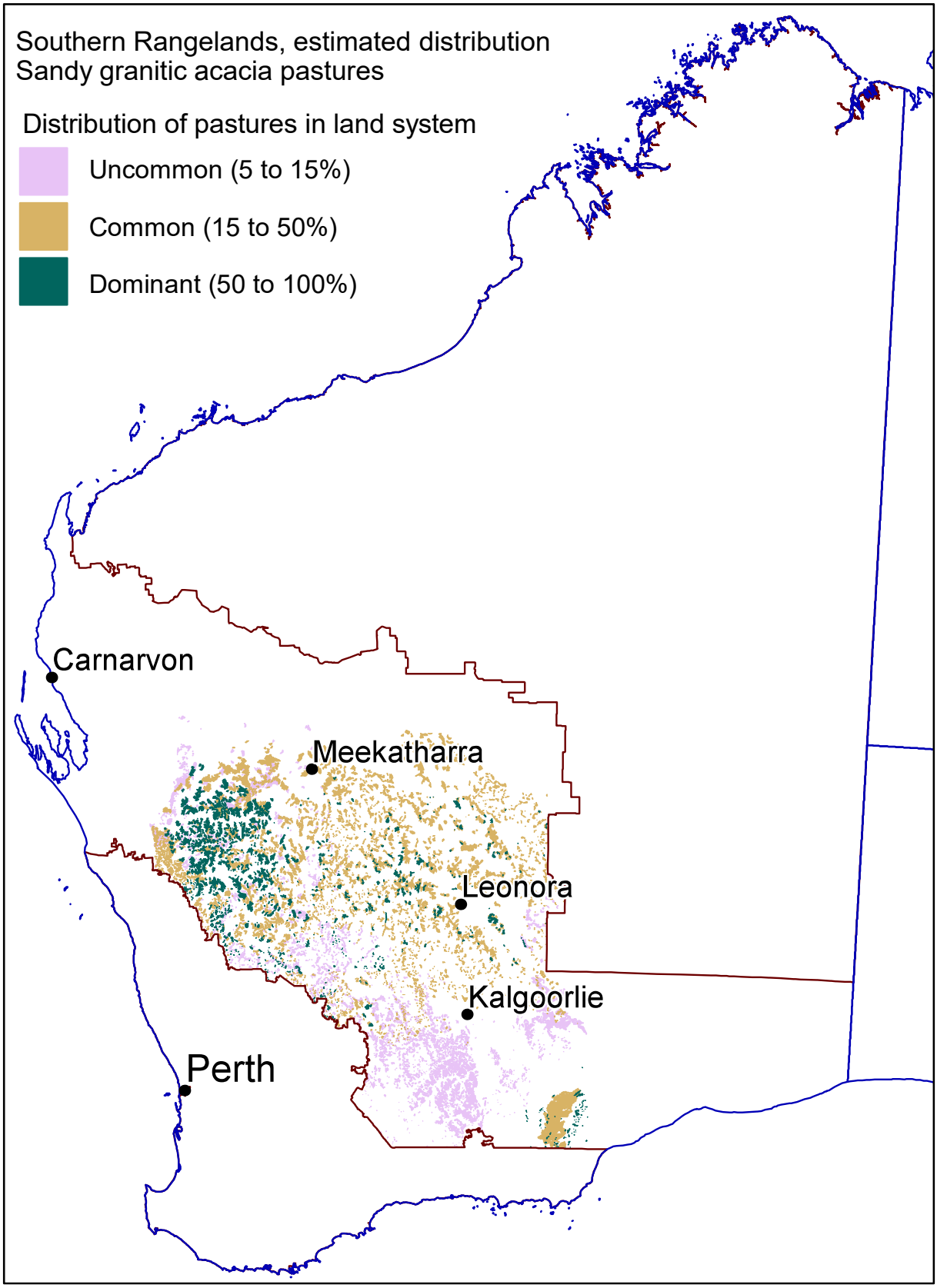


Figure B16: Estimated distribution of sandy granitic acacia pastures in the southern rangelands. Sandy granitic acacia pastures are described in 29 land systems: the largest areas are in the Challenge, Sherwood, Norie, Bandy, Charlina and Wyarri land systems.

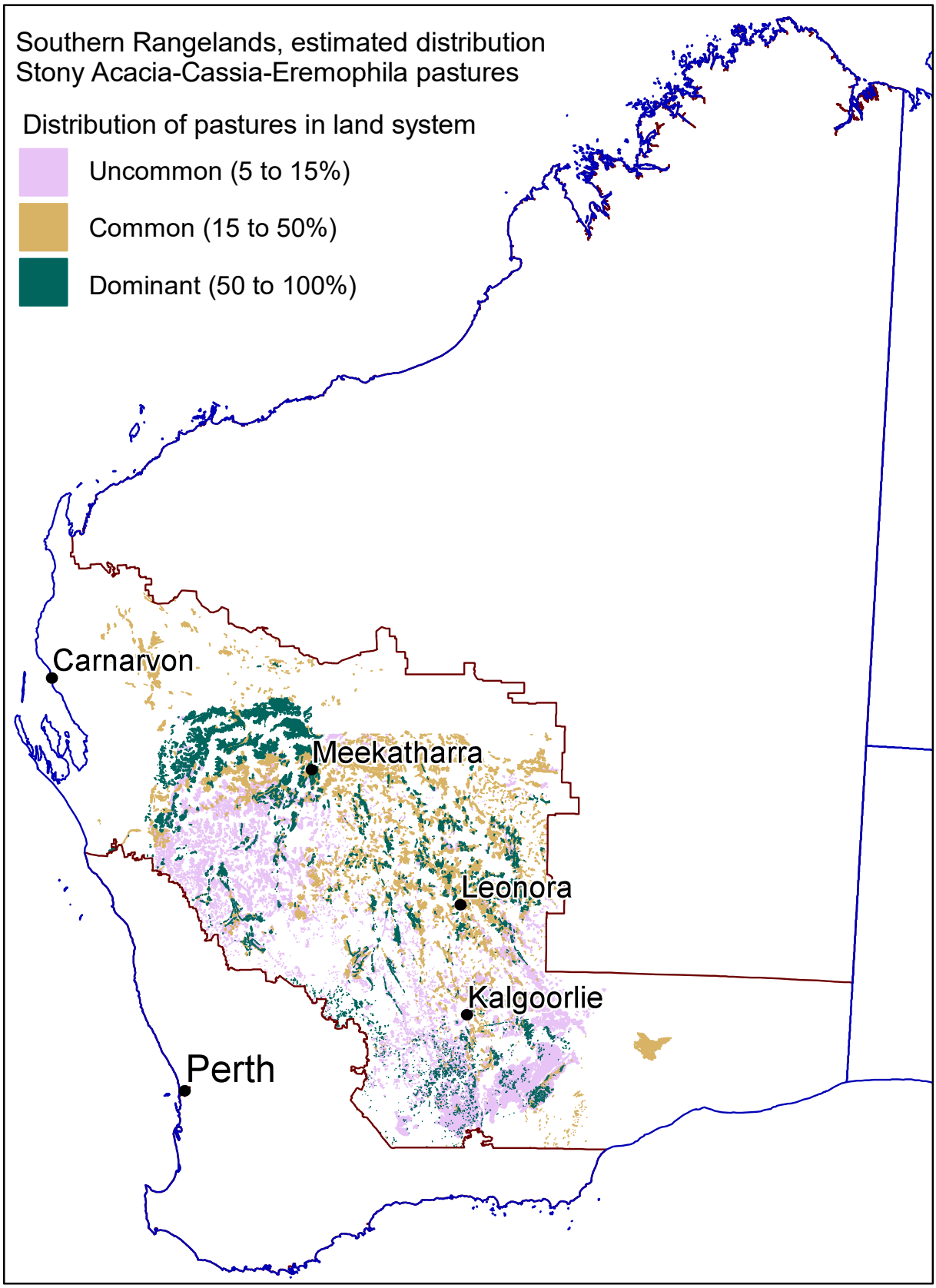


Figure B17: Estimated distribution of stony acacia–cassia–eremophila pastures in the southern rangelands. Stony acacia–cassia–eremophila pastures are described in 94 land systems: the largest areas are in the Koonmarra, Sherwood, Mindura, Violet, Narryer and Gabanintha land systems.

Notes on the extent of buffel grass pastures mapped in the southern rangelands of WA

Where's the buffel grass in the southern rangelands?

A map showing the estimated distribution of buffel grass pastures cannot be produced with reasonable accuracy for the purposes of this guide.

A recent review mapped buffel grass pastures by land system.

Based on limited recent inspections and the review, buffel grasses are present in varied amounts and land units of the Barrabiddy, Bidgemia, Cahill, Cardabia, Carleeda, Chargoo, Delta, Gascoyne, Gearle, River, Sandal, Spot and Target land systems. These are predominantly in, but not limited to, the Carnarvon basin and Gascoyne River catchment areas.

Ashburton River catchment review

The buffel grass pastures of the Ashburton River catchment were reviewed in detail in 2001.

Some increase in the extent of buffel grass pastures was recorded on alluvial plains, mulga creekline pastures in drainage lines and some soft spinifex pastures on sandy soils.

The increases recorded in the Ashburton River catchment are not necessarily transferable to similar pasture types of the southern rangelands included in this guide.

The suggested annualised carrying capacity for the Ashburton River catchment buffel grass pastures is unlikely to be realised in the climate of the southern rangelands.

How far will it spread?

- Annual rainfall 300–750mm range preferred
- Also occurs in lower rainfall areas in locations receiving water run-on
- Preference for alkaline or neutral soils with relatively high nutrient levels
- Low tolerance for flooding or waterlogging
- Capacity to adapt to hostile growing conditions over time and may hybridise, potentially increasing the expected range.

As at 2023

- Buffel grass pastures are established in parts of the Carnarvon Basin and Gascoyne Catchment survey areas
- These pastures are present in the Murchison region, but not yet significant or widespread
- Buffel grasses may colonise more pastures in the southern rangelands over time.

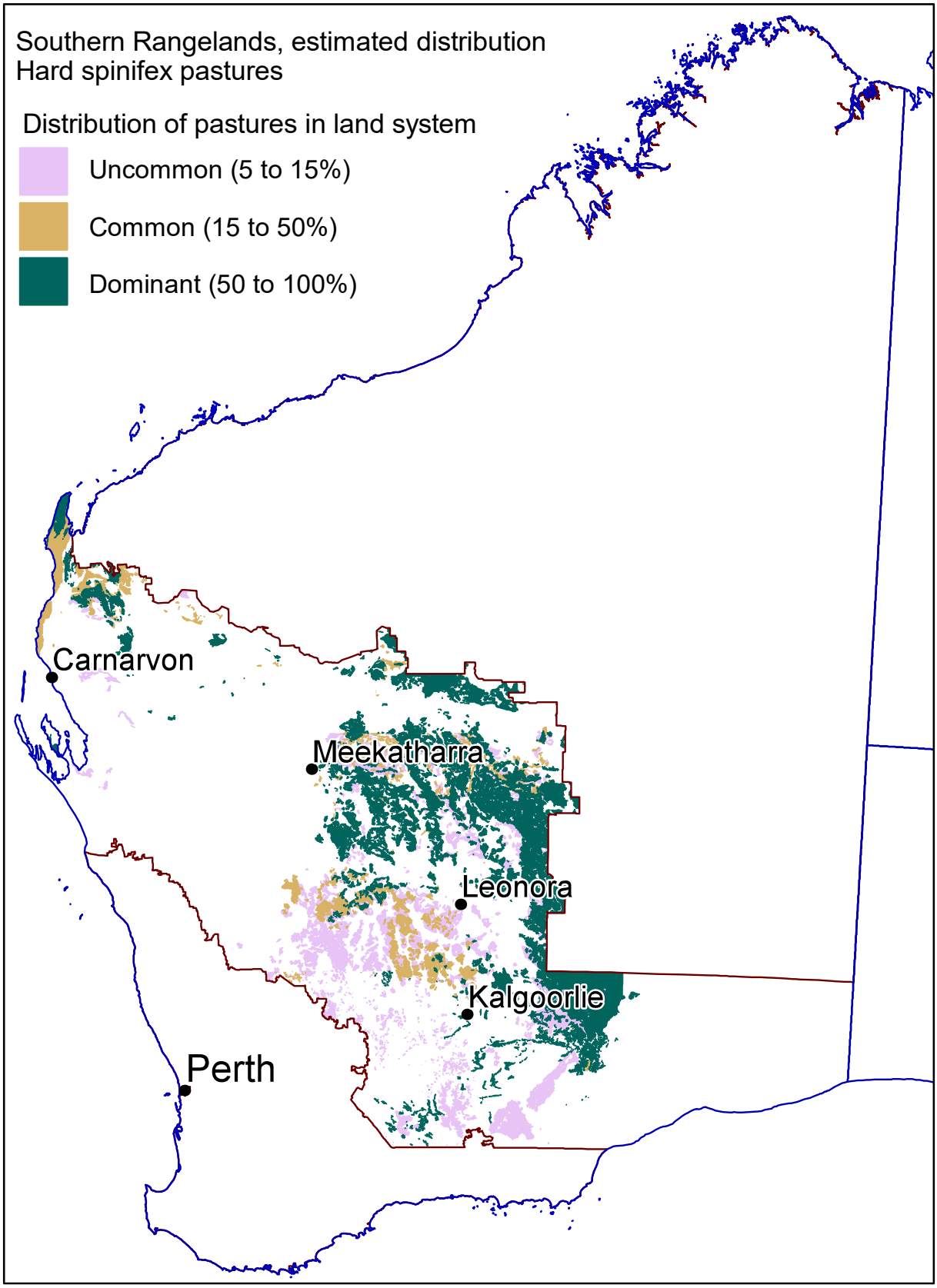


Figure B18: Estimated distribution of hard spinifex (including sandplain spinifex) pastures in the southern rangelands. Hard spinifex pastures are described in 77 land systems: the largest areas are in the Bullimore, Victoria, Marmion, Zanthus, Kirgella, Lakeside and Giralia land systems.

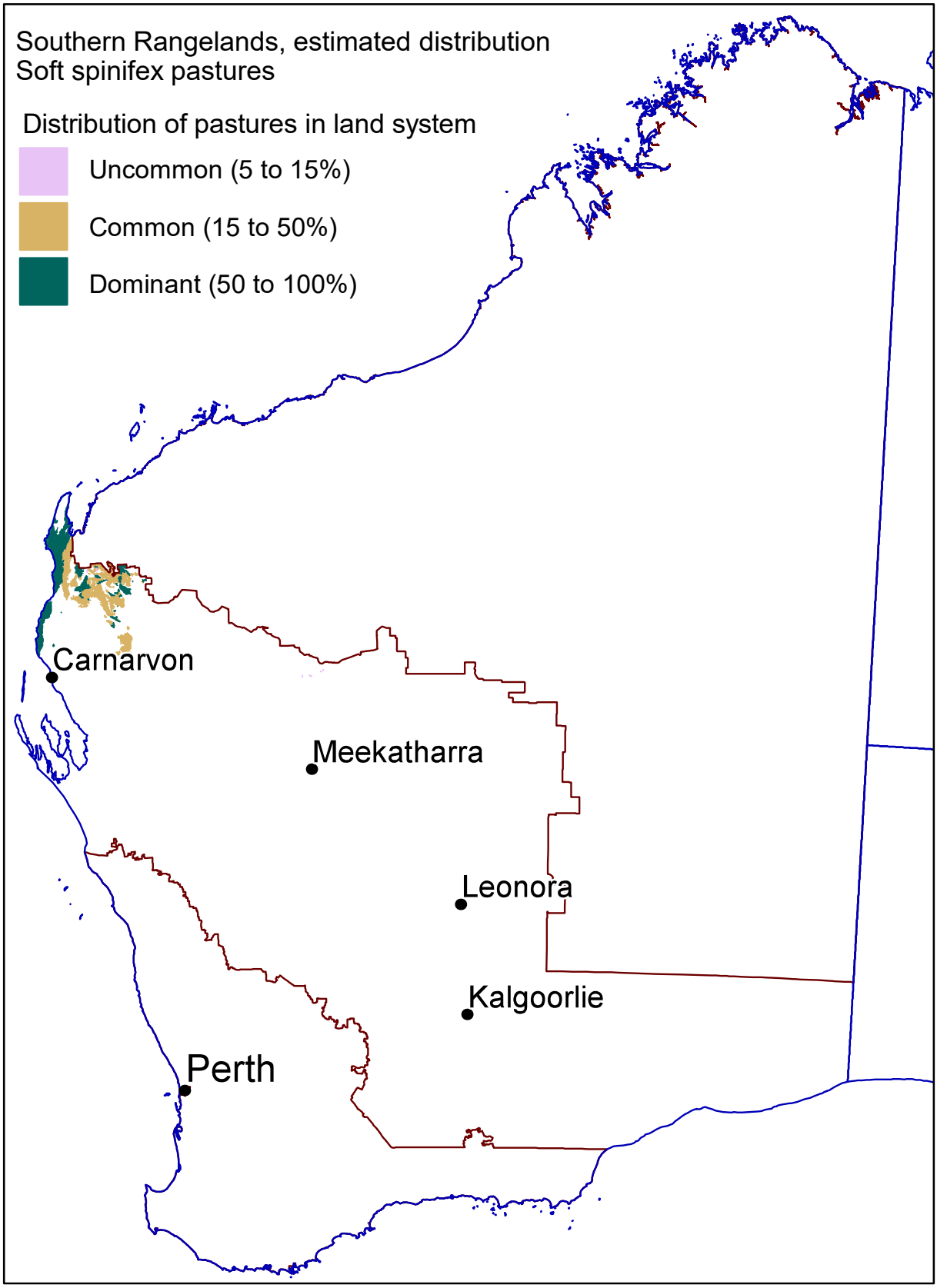


Figure B19: Estimated distribution of soft spinifex pastures in the southern rangelands. Soft spinifex pastures are described in 16 land systems: the largest areas are in the Cardabia, Uaroo, Giralia, Mallee, Kennedy and Donovan land systems.

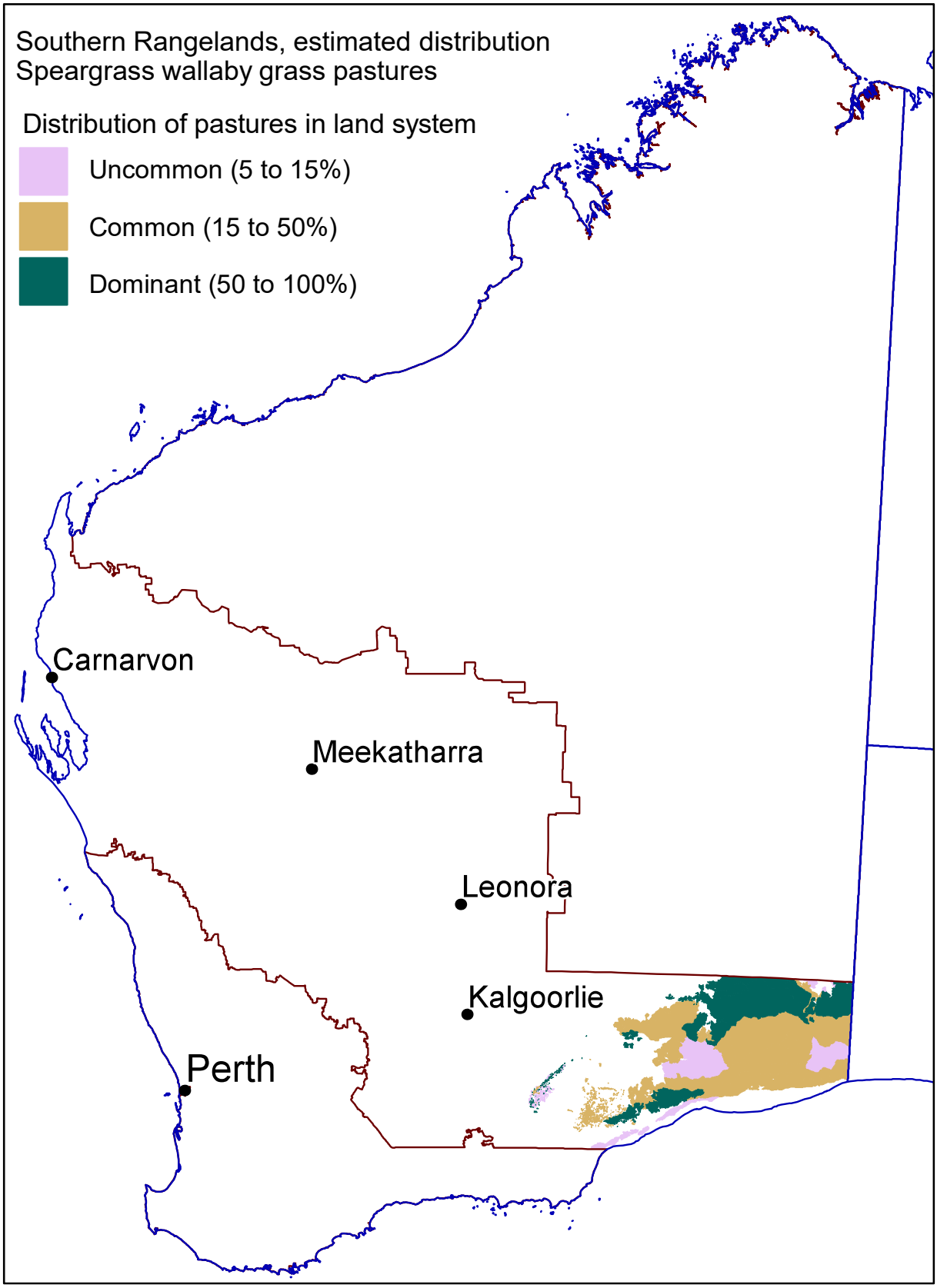


Figure B20: Estimated distribution of speargrass/wallaby grass pastures in the southern rangelands. Speargrass/wallaby grass pastures are described in 35 land systems: the largest areas are in the Bullseye, Gafa, Nightshade, Oasis, Shakehole and Skink land systems.

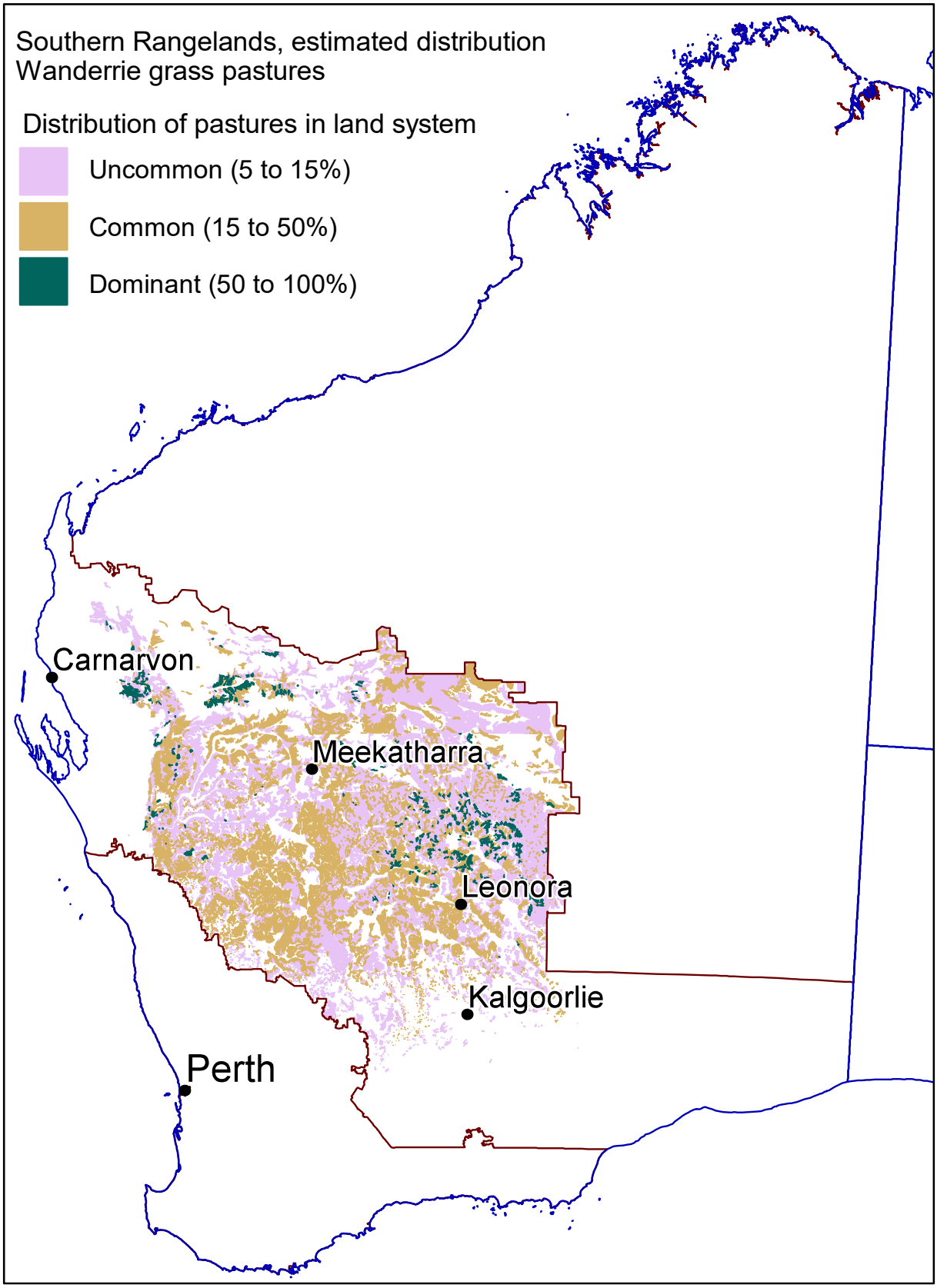


Figure B21: Estimated distribution of wanderrie grass pastures in the southern rangelands. Wanderrie grass pastures are described in 89 land systems: the largest areas are in the Bullimore, Monk, Yowie, Kalli, Yanganoo, Desdemona and Belele land systems.

Carnivorous sundew *Drosera finlaysoniana* plants with captured butterflies

Appendix C

Plant species mentioned in these guides

To make looking up plants easier, Table C1 has the scientific name of plants listed alphabetically, and Table C2 has the common names of plants listed alphabetically.

Table C1: List of scientific and common names of plants mentioned in these guides

Scientific name	Common name
Asphodelus fistulosus	Onion weed
Acacia acuminata	Jam
Acacia anceps	
Acacia ancistrocarpa	Fitzroy wattle
Acacia aneura[1]	Mulga
Acacia bivenosa	Two-veined wattle
Acacia burkittii	Fine leaf jam
Acacia citrinoviridis	Black mulga
Acacia colletioides	
Acacia coolgardiensis	Sugar brother
Acacia craspedocarpa	Hop mulga
Acacia cuspidifolia	Wait-a-while
Acacia demissa	Murchison willow
Acacia effusifolia	Sugar brother
Acacia eremaea/A. xiphophylla	Snakewood
Acacia erinacea	Hedgehog acacia
Acacia grasbyi	Minniritchie
Acacia hemiteles	Tan wattle
Acacia kempeana	Witchetty bush, granite wattle
Acacia ligulata	Umbrella wattle
Acacia murrayana	Sandplain wattle
Acacia nyssophylla	Spine bush
Acacia oswaldii	Miljee
Acacia papyrocarpa	Western myall
Acacia pruinocarpa	Gidgee
Acacia pyrifolia	Ranji bush
Acacia quadrimarginea	Granite wattle
Acacia ramulosa[2]	Bowgada, horse mulga, wanyu
Acacia ramulosa var. *linophylla*	Bowgada, wanyu
Acacia rostellifera	Summer-scented wattle

Scientific name	Common name
Acacia sclerosperma	Limestone wattle
Acacia spathulifolia	Spoon-leaf wattle
Acacia spp.	Wattles
Acacia stellaticeps	Poverty wattle
Acacia subtessarogona	Spreading gidgee
Acacia synchronicia/A. victoriae	Bardie bush
Acacia tetragonophylla	Curara
Adenanthos forrestii	
Alectryon oleifolius	Mingah bush, bullock bush
Allocasuarina spp.	Sheoaks
Amphipogon caricinus	Greybeard grass
Amphipogon spp.	Greybeard grasses
Aristida contorta	Wind grass
Aristida holathera	Erect kerosene grass
Aristida spp.	Threeawns
Atriplex acutibractea	Toothed saltbush
Atriplex amnicola	Swamp saltbush
Atriplex bunburyana	Silver saltbush
Atriplex cinerea	Grey saltbush
Atriplex cryptocarpa	Rough saltbush
Atriplex isatidea	
Atriplex nummularia	Old man saltbush
Atriplex stipitata	Kidney saltbush
Atriplex vesicaria	Bladder saltbush
Austrostipa elegantissima	Feather speargrass
Austrostipa platychaeta	Cane speargrass
Austrostipa scabra	Rough speargrass
Austrostipa spp.	Annual speargrass
Austrostipa spp.	Speargrasses
Baeckea spp.	
Banksia ashbyi	Ashby's banksia
Banksia attenuata	Slender banksia
Banksia media	Southern plains banksia
Beaufortia empetrifolia	
Brachychiton gregorii	Desert kurrajong
Bursaria occidentalis	Australian blackthorn

Scientific name	Common name
Callitris columellaris	Native pine
Callitris spp.	Native pine
Calothamnus blepharospermus	Bottlebrush
Carrichtera annua	Ward's weed
Casuarina pauper	Black oak
Cenchrus ciliaris	Buffel grass
Cenchrus setiger	Birdwood grass
Cenchrus spp. and hybrids	Buffel/birdwood grasses
Chamelaucium spp.	
Chenopodium curvispicatum	Scrambling saltbush
Chenopodium gaudichaudianum	Cottony saltbush
Chrysopogon fallax	Ribbon grass
Codonocarpus cotinifolius	Native poplar
Commicarpus australis	Native tar vine
Conospermum spp.	Smokebushes
Corchorus walcottii	Woolly corchorus
Cratystylis conocephala	False bluebush
Cratystylis subspinescens	Sage
Cullen martinii	
Cymbopogon ambiguus	Lemon-scented grass
Dampiera spicigera	Spiked dampiera
Dipteracanthus australasicus	
Disphyma crassifolium	Pigface
Dodonaea lobulata	Bead hopbush
Ecdeiocolea monostachya	
Enchylaena tomentosa	Ruby saltbush
Enneapogon caerulescens	Limestone grass
Enneapogon cylindricus	Jointed nineawn
Enteropogon ramosus	Curly windmill grass
Eragrostis dielsii	Murchison red grass
Eragrostis eriopoda	Woollybutt grass
Eragrostis lanipes	Creeping wanderrie grass
Eragrostis setifolia	Neverfail
Eragrostis spp.	Lovegrasses
Eragrostis xerophila	Roebourne plains grass
Eremophila abietina	Fir-like eremophila

Scientific name	Common name
Eremophila alternifolia	Poverty bush
Eremophila caperata	
Eremophila clarkei	Turpentine bush
Eremophila compacta	Compact poverty bush, felty fuchsia bush
Eremophila crenulata	Waxy leaf poverty bush
Eremophila cuneifolia	Royal poverty bush
Eremophila decipiens	Slender fuchsia bush
Eremophila forrestii	Wilcox bush
Eremophila fraseri	Turpentine bush
Eremophila phyllopoda	Limestone fuchsia
Eremophila georgei	Fine-toothed poverty bush
Eremophila gilesii	Turkey bush
Eremophila glabra	Tar bush, fuchsia bush
Eremophila glandulifera	Pink poverty bush
Eremophila granitica	Thin-leaved poverty bush
Eremophila ionantha	Violet-flowered eremophila
Eremophila laanii	Fuchsia bush
Eremophila lachnocalyx	Woolly poverty bush
Eremophila lanceolata	
Eremophila latrobei	Warty-leaf eremophila
Eremophila longifolia	Berrigan
Eremophila macmillaniana	Grey turpentine bush
Eremophila maculata	Emu bush
Eremophila maitlandii	Shark Bay poverty bush
Eremophila malacoides	
Eremophila margarethae	Sandbank poverty bush
Eremophila muelleriana	Round-leaved eremophila
Eremophila oldfieldii	Pixie bush
Eremophila oppositifolia	Weeooka
Eremophila pantonii	Limestone poverty bush
Eremophila parvifolia	Small-leaved poverty bush
Eremophila platycalyx	Granite poverty bush
Eremophila pterocarpa	Silver poverty bush
Eremophila punicea	Crimson eremophila
Eremophila scoparia	Broom bush
Eremophila serrulata	Green fuchsia bush

Scientific name	Common name
Eremophila spathulata	Spoon-leaf eremophila
Eremophila spectabilis	Showy poverty bush
Eremophila spp.	Poverty bushes
Eriachne aristidea	Three-awned wanderrie grass
Eriachne flaccida	Claypan grass
Eriachne helmsii	Buck wanderrie grass
Eriachne obtusa	Wire grass
Eriochiton sclerolaenoides	Woolly bindii
Eucalyptus camaldulensis	River red gum
Eucalyptus coolabah	Coolibah
Eucalyptus eudesmioides	
Eucalyptus gongylocarpa	Marble gum
Eucalyptus gracilis	Yorrell, snap and rattle
Eucalyptus kingsmillii	Kingsmill's mallee
Eucalyptus loxophleba	York gum
Eucalyptus oleosa	Giant mallee
Eucalyptus prominens	
Eucalyptus spp.	Eucalypts, gums, mallees
Eucalyptus yalatensis	Yalata mallee
Eulalia aurea	Silky browntop
Euphorbia drummondii	Balsam
Exocarpos aphyllus	Naked lady
Frankenia spp.	Frankenias
Grevillea spp.	Grevilleas
Grevillea striata	Beefwood
Gunniopsis calcarea	Nullarbor gunniopsis
Gunniopsis quadrifida	Sweet samphire
Gyrostemon ramulosus	Fire bush
Hakea nitida	Frog hakea
Hakea preissii	Needlebush
Hakea pycnoneura	
Lawrencia squamata	Sunglasses bush
Lycium australe	Waterbush
Maireana amoena	Brittle bluebush
Maireana aphylla	Spiny bluebush
Maireana atkinsiana	Bronze bluebush

Scientific name	Common name
Maireana brevifolia	Small leaf bluebush
Maireana convexa	Mulga bluebush
Maireana erioclada	Rosy bluebush
Maireana georgei	Golden bluebush, George's bluebush
Maireana glomerifolia	Ball leaf bluebush
Maireana integra	
Maireana melanocoma	Pussy bluebush
Maireana pentatropis	Erect bluebush
Maireana planifolia	Flat leaf bluebush
Maireana platycarpa	Shy bluebush
Maireana polypterygia	Gascoyne bluebush
Maireana pyramidata	Sago bush
Maireana radiata	Grey bluebush
Maireana sedifolia	Pearl bluebush
Maireana spp.	Bluebushes
Maireana thesioides	Lax bluebush
Maireana tomentosa	Felty leaf bluebush
Maireana trichoptera	Pink-seeded bluebush, downy bluebush
Maireana triptera	Three-winged bluebush
Maireana villosa	Silky bluebush
Melaleuca cardiophylla	Low paperbark
Melaleuca spp.	Paperbarks
Micromyrtus flaviflora	Heath-myrtle
Monachather paradoxus	Broad leaf wanderrie grass
Myoporum platycarpum	Sugarwood
Neptunia dimorphantha	Sensitive plant
Nitraria billardierei	Nitre bush
Olearia axillaris	Coast daisy bush
Olearia muelleri	Goldfields daisy
Paraneurachne muelleri	Hopalong grass
Petalostylis labicheoides	Butterfly bush
Petrophile conifera	
Phebalium spp.	
Pimelea spp.	Rice flowers
Pittosporum angustifolium	Weeping pittosporum
Pittosporum spp.	Native willows

Scientific name	Common name
Pomaderris spp.	
Prostanthera spp.	Native mints
Psydrax latifolia	Native plum
Psydrax suaveolens	Native currant
Ptilotus beardii	Low mulla mulla
Ptilotus divaricatus	Climbing mulla mulla
Ptilotus exaltatus	Tall mulla mulla
Ptilotus xerophilus	Green mulla mulla
Ptilotus obovatus	Cotton bush
Ptilotus polakii	Gascoyne mulla mulla
Ptilotus roei	
Ptilotus rotundifolius	Royal mulla mulla
Ptilotus schwartzii	Horse mulla mulla
Ptilotus spp.	Mulla mullas
Rhagodia crassifolia	Fleshy saltbush
Rhagodia drummondii	Drummond's rhagodia
Rhagodia eremaea	Tall saltbush
Rhagodia spp.	Rhagodias
Rhodanthe floribunda	Everlasting
Roepera aurantiaca	Shrubby twinleaf
Roepera iodocarpa	Violet twinleaf
Rumex vesicarius	Wild hops
Rytidosperma caespitosum	Wallaby grass
Salsola tragus	Roly poly
Santalum spicatum	Sandalwood
Scaevola canescens	Grey fanflower
Scaevola crassifolia	Thick leaf fanflower
Scaevola parvifolia	Camel weed
Scaevola spinescens	Currant bush
Scaevola tomentosa	Ragged leaf fanflower
Scholtzia umbellifera	
Sclerolaena densiflora	Hairy bindii
Sclerolaena diacantha	Horned bindii
Sclerolaena obliquicuspis	Limestone bindii
Sclerolaena patenticuspis	Spear-fruit copperburr
Sclerolaena spp.	Bindiis

Scientific name	Common name
Senna artemisioides subsp. *filifolia*	Desert cassia
Senna artemisioides subsp. *helmsii*	Crinkle leaf cassia
Senna artemisioides subsp. *oligophylla*	Bloodbush
Senna artemisioides subsp. *x artemisioides*	Silver cassia, banana-leaf cassia
Senna artemisioides subsp. *x coriacea*	Grey cassia, desert cassia
Senna artemisioides subsp. *x sturtii*	Straight leaf cassia, variable cassia
Senna cardiosperma	Curved-leaf senna
Senna charlesiana	Split leaf buttercup bush
Senna glutinosa subsp. *chatelainiana*	Green cassia
Senna glutinosa subsp. *pruinosa*	White cassia
Senna glutinosa subsp. x *luerssenii*	White cassia
Senna hamersleyensis	Creeping cassia
Senna notabilis	Cockroach bush
Senna sp. Meekatharra	Straight leaf cassia
Senna spp.	Cassias
Sida calyxhymenia	Tall sida
Sida fibulifera	Pin sida
Sida spp.	Sidas
Solanum lasiophyllum	Flannel bush
Solanum orbiculatum	Tomato bush
Stylobasium spathulatum	Pebble bush
Tecticornia disarticulata	Samphire
Tecticornia doliiformis	Samphire
Tecticornia halocnemoides	Samphire
Tecticornia indica	Samphire
Tecticornia pergranulata	Samphire
Tecticornia pruinosa	Samphire
Tecticornia spp.	Samphires
Tecticornia verrucosa	Samphire
Tephrosia rosea	Flinders River poison
Teucrium teucriiflorum	Mulga broombush
Threlkeldia diffusa	Coast bonefruit
Thryptomene spp.	Myrtles
Thyridolepis mitchelliana	Soft wanderrie grass
Thyridolepis multiculmis	Soft wanderrie grass
Tribulus platypterus	Corkybark caltrop, fish poison

Scientific name	Common name
Triodia basedowii	Hard spinifex
Triodia concinna	Spinifex
Triodia danthonioides	Spinifex
Triodia desertorum	Spinifex
Triodia epactia	Soft spinifex
Triodia irritans	Porcupine spinifex
Triodia lanigera	Hard spinifex
Triodia longiceps	Giant grey spinifex
Triodia melvillei	Spinifex
Triodia plurinervata	Spinifex
Triodia pungens	Soft spinifex
Triodia rigidissima	Spinifex
Triodia scariosa	Buck spinifex
Triodia schinzii	Oat-eared spinifex
Triodia spp.	Spinifexes
Triodia tomentosa	Spinifex
Triodia wiseana	Limestone spinifex

1 Mulga as *Acacia aneura* has been split into multiple species, including *A. aneura, A. aptaneura, A. caesaneura, A. fuscaneura, A. incurvaneura, A. macraneura, A. mulganeura, A. pteraneura.*

2 *Acacia ramulosa* includes 2 subspecies, *A.r.* subsp*. ramulosa* and *A.r.* subsp*. linophylla*. Common names include bowgada, wanyu and horse mulga and are applied to both subspecies. A described species *Acacia wanyu* from the Pilbara and northern Gascoyne is also called wanyu. Bowgada in this publication applies to *A. ramulosa* in the broad sense.

Table C2: List of common and scientific names of plants mentioned in these guides

Common name	Scientific name
	Acacia anceps
	Acacia colletioides
	Adenanthos forrestii
	Atriplex isatidea
	Baeckea spp.
	Beaufortia empetrifolia
	Chamelaucium spp.
	Cullen martinii
	Dipteracanthus australasicus
	Ecdeiocolea monostachya
	Eremophila caperata
	Eremophila lanceolata
	Eremophila malacoides
	Eucalyptus eudesmioides
	Eucalyptus prominens
	Hakea pycnoneura
	Maireana integra
	Petrophile conifera
	Phebalium spp.
	Pomaderris spp.
	Ptilotus roei
	Scholtzia umbellifera
Annual speargrass	*Austrostipa* spp.
Ashby's banskia	*Banksia ashbyi*
Australian blackthorn	*Bursaria spinosa*
Ball leaf bluebush	*Maireana glomerifolia*
Balsam	*Euphorbia drummondii*
Bardie bush	*Acacia synchronicia*
Bardie bush	*Acacia victoriae*
Bead hopbush	*Dodonaea lobulata*
Beefwood	*Grevillea striata*
Berrigan	*Eremophila longifolia*
Bindiis	*Sclerolaena* spp.
Birdwood grass	*Cenchrus setiger*
Black mulga	*Acacia citrinoviridis*

Common name	Scientific name
Black oak	*Casuarina pauper*
Bladder saltbush	*Atriplex vesicaria*
Bloodbush	*Senna artemisioides* subsp. *oligophylla*
Bluebushes	*Maireana* spp.
Bottlebrush	*Calothamnus blepharospermus*
Bowgada, horse mulga, wanyu	*Acacia ramulosa*
Bowgada, wanyu	*Acacia ramulosa* var. *linophylla*
Brittle bluebush	*Maireana amoena*
Broad leaf wanderrie grass	*Monachather paradoxus*
Bronze bluebush	*Maireana atkinsiana*
Broom bush	*Eremophila scoparia*
Buck spinifex	*Triodia scariosa*
Buck wanderrie grass	*Eriachne helmsii*
Buffel grass	*Cenchrus ciliaris*
Buffel/birdwood grasses	*Cenchrus* spp. and hybrids
Butterfly bush	*Petalostylis labicheoides*
Camel weed	*Scaevola parviflora*
Cane speargrass	*Austrostipa platychaeta*
Cassias	*Senna* spp.
Claypan grass	*Eriachne flaccida*
Climbing mulla mulla	*Ptilotus divaricatus*
Coast bonefruit	*Threlkeldia diffusa*
Coast daisy bush	*Olearia axillaris*
Cockroach bush	*Senna notabilis*
Compact poverty bush, felty fuchsia bush	*Eremophila compacta*
Coolibah	*Eucalyptus coolabah*
Corkybark caltrop, fish poison	*Tribulus platypterus*
Cotton bush	*Ptilotus obovatus*
Cottony saltbush	*Chenopodium gaudichaudianum*
Creeping cassia	*Senna hamersleyensis*
Creeping wanderrie grass	*Eragrostis lanipes*
Crimson eremophila	*Eremophila punicea*
Crinkle leaf cassia	*Senna artemisioides* subsp. *helmsii*
Curara	*Acacia tetragonophylla*
Curly windmill grass	*Enteropogon ramosus*
Currant bush	*Scaevola spinescens*

Common name	Scientific name
Curved-leaf senna	*Senna cardiosperma*
Desert cassia	*Senna artemisioides* subsp. *filifolia*
Desert kurrajong	*Brachychiton gregorii*
Drummond's rhagodia	*Rhagodia drummondii*
Emu bush	*Eremophila maculata*
Erect bluebush	*Maireana pentatropis*
Erect kerosene grass	*Aristida holathera*
Eucalypts, gums, mallees	*Eucalyptus* spp.
Everlasting	*Rhodanthe floribunda*
False bluebush	*Cratystylis conocephala*
Feather speargrass	*Austrostipa elegantissima*
Felty leaf bluebush	*Maireana tomentosa*
Fine leaf jam	*Acacia burkittii*
Fine-toothed poverty bush	*Eremophila georgei*
Fire bush	*Gyrostemon ramulosus*
Fir-like eremophila	*Eremophila abietina*
Fitzroy wattle	*Acacia ancistrocarpa*
Flannel bush	*Solanum lasiophyllum*
Flat leaf bluebush	*Maireana planifolia*
Fleshy saltbush	*Rhagodia crassifolia*
Flinders River poison	*Tephrosia rosea*
Frankenias	*Frankenia* spp.
Frog hakea	*Hakea nitida*
Fuchsia bush	*Eremophila laanii*
Gascoyne bluebush	*Maireana polypterygia*
Gascoyne mulla mulla	*Ptilotus polakii*
Giant grey spinifex	*Triodia longiceps*
Giant mallee	*Eucalyptus oleosa*
Gidgee	*Acacia pruinocarpa*
Golden bluebush, George's bluebush	*Maireana georgei*
Goldfields daisy	*Olearia muelleri*
Granite poverty bush	*Eremophila platycalyx*
Granite wattle	*Acacia quadrimarginea*
Green cassia	*Senna glutinosa* subsp. *chatelainiana*
Green fuchsia bush	*Eremophila serrulata*
Green mulla mulla	*Ptilotus macrocephalus*

Common name	Scientific name
Grevilleas	*Grevillea* spp.
Grey bluebush	*Maireana radiata*
Grey cassia, desert cassia	*Senna artemisioides* subsp. *x coriacea*
Grey fanflower	*Scaevola canescens*
Grey saltbush	*Atriplex cinerea*
Grey turpentine bush	*Eremophila macmillaniana*
Greybeard grass	*Amphipogon caricinus*
Greybeard grasses	*Amphipogon* spp.
Hairy bindii	*Sclerolaena densiflora*
Hard spinifex	*Triodia basedowii*
Hard spinifex	*Triodia lanigera*
Heath-myrtle	*Micromyrtus flaviflora*
Hedgehog acacia	*Acacia erinacea*
Hop mulga	*Acacia craspedocarpa*
Hopalong grass	*Paraneurachne muelleri*
Horned bindii	*Sclerolaena diacantha*
Horse mulla mulla	*Ptilotus schwartzii*
Jam	*Acacia acuminata*
Jointed nineawn	*Enneapogon cylindricus*
Kidney saltbush	*Atriplex stipitata*
Kingsmill's mallee	*Eucalyptus kingsmillii*
Lax bluebush	*Maireana thesioides*
Lemon-scented grass	*Cymbopogon ambiguus*
Limestone bindii	*Sclerolaena obliquicuspis*
Limestone fuchsia	*Eremophila freelingii*
Limestone grass	*Enneapogon caerulescens*
Limestone poverty bush	*Eremophila pantonii*
Limestone spinifex	*Triodia wiseana*
Limestone wattle	*Acacia sclerosperma*
Lovegrasses	*Eragrostis* spp.
Low mulla mulla	*Ptilotus beardii*
Low paperbark	*Melaleuca cardiophylla*
Marble gum	*Eucalyptus gongylocarpa*
Miljee	*Acacia oswaldii*
Mingah bush, bullock bush	*Alectryon oleifolius*
Minniritchie	*Acacia grasbyi*

Common name	Scientific name
Mulga	*Acacia aneura*
Mulga bluebush	*Maireana convexa*
Mulga broombush	*Teucrium teucriiflorum*
Mulla mullas	*Ptilotus* spp.
Murchison red grass	*Eragrostis dielsii*
Murchison willow	*Acacia demissa*
Myrtles	*Thryptomene* spp.
Naked lady	*Exocarpos aphyllus*
Native currant	*Psydrax suaveolens*
Native mints	*Prostanthera* spp.
Native pine	*Callitris columellaris*
Native pine	*Callitris* spp.
Native plum	*Psydrax latifolia*
Native poplar	*Codonocarpus cotinifolius*
Native tar vine	*Commicarpus australis*
Native willows	*Pittosporum* spp.
Needlebush	*Hakea preissii*
Neverfail	*Eragrostis setifolia*
Nitre bush	*Nitraria schoberi*
Nullarbor gunniopsis	*Gunniopsis calcarea*
Oat-eared spinifex	*Triodia schinzii*
Old man saltbush	*Atriplex nummularia*
Onion weed	*Asphodelus fistulosus*
Paperbarks	*Melaleuca* spp.
Pearl bluebush	*Maireana sedifolia*
Pebble bush	*Stylobasium spathulatum*
Pigface	*Disphyma crassifolium*
Pin sida	*Sida fibulifera*
Pink poverty bush	*Eremophila glandulifera*
Pink-seeded bluebush, downy bluebush	*Maireana trichoptera*
Pixie bush	*Eremophila oldfieldii*
Porcupine spinifex	*Triodia irritans*
Poverty bush	*Eremophila alternifolia*
Poverty bushes	*Eremophila* spp.
Poverty wattle	*Acacia stellaticeps*
Pussy bluebush	*Maireana melanocoma*

Common name	Scientific name
Ragged leaf fanflower	*Scaevola tomentosa*
Ranji bush	*Acacia pyrifolia*
Rhagodias	*Rhagodia* spp.
Ribbon grass	*Chrysopogon fallax*
Rice flowers	*Pimelea* spp.
River red gum	*Eucalyptus camaldulensis*
Roebourne plains grass	*Eragrostis xerophila*
Roly poly	*Salsola tragus*
Rosy bluebush	*Maireana erioclada*
Rough saltbush	*Atriplex cryptocarpa*
Rough speargrass	*Austrostipa scabra*
Round-leaved eremophila	*Eremophila muelleriana*
Royal mulla mulla	*Ptilotus rotundifolius*
Royal poverty bush	*Eremophila cuneifolia*
Ruby saltbush	*Enchylaena tomentosa*
Sage	*Cratystylis subspinescens*
Sago bush	*Maireana pyramidata*
Samphire	*Tecticornia disarticulata*
Samphire	*Tecticornia doliiformis*
Samphire	*Tecticornia halocnemoides*
Samphire	*Tecticornia indica*
Samphire	*Tecticornia pergranulata*
Samphire	*Tecticornia pruinosa*
Samphire	*Tecticornia verrucosa*
Samphires	*Tecticornia* spp.
Sandalwood	*Santalum spicatum*
Sandbank poverty bush	*Eremophila margarethae*
Sandplain wattle	*Acacia murrayana*
Scrambling saltbush	*Chenopodium curvispicatum*
Sensitive plant	*Neptunia dimorphantha*
Shark Bay poverty bush	*Eremophila maitlandii*
Sheoaks	*Allocasuarina* spp.
Showy poverty bush	*Eremophila spectabilis*
Shrubby twinleaf	*Roepera aurantiaca*
Shy bluebush	*Maireana platycarpa*
Sidas	*Sida* spp.

Common name	Scientific name
Silky bluebush	*Maireana villosa*
Silky browntop	*Eulalia aurea*
Silver cassia, banana-leaf cassia	*Senna artemisioides* subsp. *x artemisioides*
Silver poverty bush	*Eremophila pterocarpa*
Silver saltbush	*Atriplex bunburyana*
Slender banksia	*Banksia attenuata*
Slender fuchsia bush	*Eremophila decipiens*
Small leaf bluebush	*Maireana brevifolia*
Small-leaved poverty bush	*Eremophila parvifolia*
Smokebushes	*Conospermum* spp.
Snakewood	*Acacia eremaea*
Snakewood	*Acacia xiphophylla*
Soft spinifex	*Triodia epactia*
Soft spinifex	*Triodia pungens*
Soft wanderrie grass	*Thyridolepis mitchelliana*
Soft wanderrie grass	*Thyridolepis multiculmis*
Southern plains banksia	*Banksia media*
Spear-fruit copperburr	*Sclerolaena patenticuspis*
Speargrasses	*Austrostipa* spp.
Spiked dampiera	*Dampiera spicigera*
Spine bush	*Acacia nyssophylla*
Spinifex	*Triodia concinna*
Spinifex	*Triodia danthonioides*
Spinifex	*Triodia desertorum*
Spinifex	*Triodia melvillei*
Spinifex	*Triodia plurinervata*
Spinifex	*Triodia rigidissima*
Spinifex	*Triodia tomentosa*
Spinifexes	*Triodia* spp.
Spiny bluebush	*Maireana aphylla*
Split leaf buttercup bush	*Senna charlesiana*
Spoon-leaf eremophila	*Eremophila spathulata*
Spoon-leaf wattle	*Acacia spathulifolia*
Spreading gidgee	*Acacia subtessarogona*
Straight leaf cassia	*Senna* sp. Meekatharra
Straight leaf cassia, variable cassia	*Senna artemisioides* subsp. *x sturtii*

Common name	Scientific name
Sugar brother	*Acacia coolgardiensis*
Sugar brother	*Acacia effusifolia*
Sugarwood	*Myoporum platycarpum*
Summer-scented wattle	*Acacia rostellifera*
Sunglasses bush	*Lawrencia squamata*
Swamp saltbush	*Atriplex amnicola*
Sweet samphire	*Gunniopsis quadrifida*
Tall mulla mulla	*Ptilotus exaltatus*
Tall saltbush	*Rhagodia eremaea*
Tall sida	*Sida calyxhymenia*
Tan wattle	*Acacia hemiteles*
Tar bush, fuchsia bush	*Eremophila glabra*
Thick leaf fanflower	*Scaevola crassifolia*
Thin-leaved poverty bush	*Eremophila granitica*
Three-awned wanderrie grass	*Eriachne aristidea*
Threeawns	*Aristida* spp.
Three-winged bluebush	*Maireana triptera*
Tomato bush	*Solanum orbiculatum*
Toothed saltbush	*Atriplex acutibractea*
Turkey bush	*Eremophila gilesii*
Turpentine bush	*Eremophila clarkei*
Turpentine bush	*Eremophila fraseri*
Two-veined wattle	*Acacia bivenosa*
Umbrella wattle	*Acacia ligulata*
Violet twinleaf	*Roepera iodocarpa*
Violet-flowered eremophila	*Eremophila ionantha*
Wait-a-while	*Acacia cuspidifolia*
Wallaby grass	*Rytidosperma caespitosum*
Ward's weed	*Carrichtera annua*
Warty-leaf eremophila	*Eremophila latrobei*
Waterbush	*Lycium australe*
Wattles	*Acacia* spp.
Waxy leaf poverty bush	*Eremophila crenulata*
Weeooka	*Eremophila oppositifolia*
Weeping pittosporum	*Pittosporum angustifolium*
Western myall	*Acacia papyrocarpa*

Common name	Scientific name
White cassia	*Senna glutinosa* subsp. *pruinosa*
White cassia	*Senna glutinosa* subsp. *x luerssenii*
Wilcox bush	*Eremophila forrestii*
Wild hops	*Rumex vesicarius*
Wind grass	*Aristida contorta*
Wire grass	*Eriachne obtusa*
Witchetty bush, granite wattle	*Acacia kempeana*
Woolly bindii	*Eriochiton sclerolaenoides*
Woolly corchorus	*Corchorus walcottii*
Woolly poverty bush	*Eremophila lachnocalyx*
Woollybutt grass	*Eragrostis eriopoda*
Yalata mallee	*Eucalyptus yalatensis*
York gum	*Eucalyptus loxophleba*
Yorrell, snap and rattle	*Eucalyptus gracilis*

Appendix D

Economics assumptions and notes

Four of the 11 years analysed had a negative estimated annual farm profit at full equity. If the forgone income due to degradation were realised, the estimated annual business profit at full equity would have been positive, except in 2011.[1]

Limitations and assumptions of modelled economic values

- Caution should be exercised when using these figures. The data from AgSurf is from an average sample size of less than 20 businesses (range 8–16). This is a small sample of about 280 pastoral businesses running on the estimated 308 stations.
- There is significant uncertainty in the AgSurf data: each region has different levels of profitability; each station business has a different vegetative capacity, different land area and different business models.
- The standard errors for some of the values from AgSurf are as high as 1,880% but are generally between 20% and 150%.
- The opportunity costs are a snapshot in time. Production figures and prices vary from year to year.
- AgSurf cattle numbers have been converted to dry sheep equivalents (DSE) assuming an average cattle herd has a DSE of 8.3 per animal, and an average sheep flock has a DSE of 1.3 per animal.
- The model assumes that stations are stocked to the current carrying capacity (CCC), which is about 70% of the potential carrying capacity (PCC) and assumes that stations would stock to the potential carrying capacity if all pastures were in good condition and accessible. That is, when CCC equals PCC.

Opportunity costs are for changes in pastoral production due to vegetation changes. They do not consider other costs such as loss of species, biodiversity or the soil resource.

1. Below-average seasons in some areas in 2010 and a dramatic drop in the number of live animals exported from Western Australia in 2011 meant reduced livestock turn-off due to rebuilding of stock numbers and reduced market opportunities (DPIRD 2018).

Appendix E

Grass growth

The growth of grass in both the temperate (C3) and tropical (C4) pathways can be divided into distinct phases, each with its unique characteristics and implications for plant development (Figure E1). Initial growth is vital for capturing solar energy through photosynthesis, enabling the continued expansion of leaves, shoots and root systems. As more green leaves and stems are exposed to sunlight, the plant maximises its energy absorption. Nutrient levels are high in the leaves and stems during this phase as roots extract nutrients from the soil and transport them to the crown, leaves and stems. The growth of fine roots plays a crucial role in supplying moisture and nutrients necessary for further leaf and shoot development. C3 grasses demonstrate a distinct bimodal growth pattern (Figure E2).

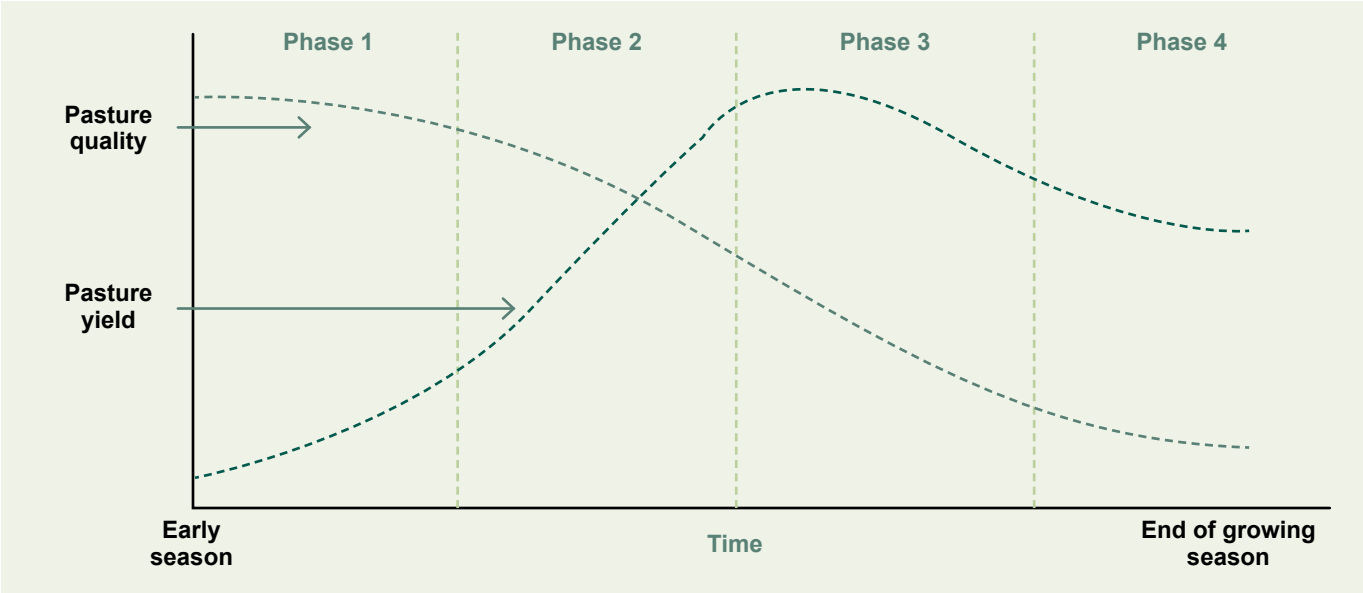


Figure E1: Grass growth phase diagram

Source: MLA (n.d.)

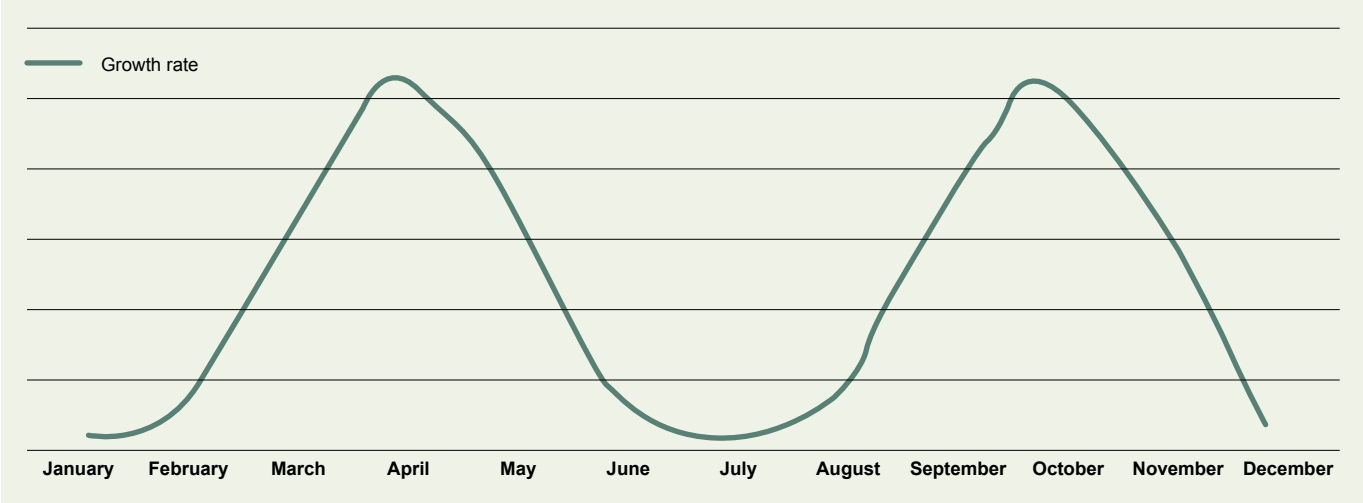


Figure E2: Conceptual C3 grass growth diagram – C3 grasses generally have growth spurts in spring and autumn

The following is adapted from Phelps (n.d.).

During Phase 1 plants use stored energy reserves to grow their first green leaves and shoots after a dormant period. This first growth captures the sun's energy through photosynthesis to promote continued growth of leaves and shoots and start root growth. The greater the area of green leaves and stems exposed to the sun, the greater the capture of energy. Nutrient levels are high in the leaves and stems as the roots start to extract nutrients from the soil and move these into the crown and leaves and stems.

Roots seek moisture and nutrients by extending through the soil and growing numerous fine roots at the tips of the larger roots – these fine roots absorb nutrients from the soil water. It is the constant growth of these fine roots that provides the moisture and nutrients to help the plant grow more leaves and stems.

When fresh leaves and shoots are constantly grazed off the plant becomes less effective at capturing the sun's energy and root growth slows. The plant loses vigour, is less efficient at using soil moisture and less efficient at absorbing the nutrients needed for leaf and shoot growth.

During Phase 2 growth – both above and below the ground – accelerates and the plant starts to form seed heads within the stems. Leaves are efficiently converting sunlight into energy to promote faster root growth. Faster root growth means more nutrients are being absorbed to promote leaf and shoot growth. Stem growth starts to outpace leaf growth as the plant readies for seeding towards the end of Phase 2. The removal of stems and leaves has a reduced impact on plant growth as compared with grazing in Phase 1 of growth, but overgrazing will still deplete the plant's reserves.

During Phase 3 growth slows and most energy and nutrients are diverted to seed production. The maximum plant weight is reached in Phase 3 at about the time of flowering. Much of the weight is now in the stems, especially in the fibrous components of stems needed to support the weight of seed heads. Seed heads emerge from the stems, flower and mature during Phase 3. The quality of the plant to animal diet is reduced and so is susceptibility to grazing pressure.

Most grasses can generally be grazed safely during Phase 3 once the seed heads have emerged from the tillers (stems).

During Phase 4 growth has stopped, seed heads have matured and seed starts to fall. Perennial plants are generally dormant and annual plants have died. Plant weight and quality declines and plants are relatively insensitive to grazing. It is important to retain as much stubble as possible ready for Phase 1 after the next effective rainfall.

Appendix F

Wanderrie grass pastures diagram

The diagram below shows wanderrie grass pastures with mulga groves in:

- good condition (Figure F1 A) – intact duplex soils with sand sheet over hardpan with distinct wanderrie banks supporting mulga and shrubs
- fair condition (Figure F1 B) – browse lines developing with grazing and trampling leading to wanderrie banks becoming fragmented as topsoils erode, hardpan becoming exposed between wanderrie banks
- poor condition (Figure F1 C) – understorey degraded and wanderrie banks isolated between large areas of exposed hardpan
- very poor condition (Figure F1 D) – topsoil significantly diminished or lost, dehydrated plants dying or dead, land surface dominated by water-shedding hardpan and at risk of irreversible transition in to a less productive state.

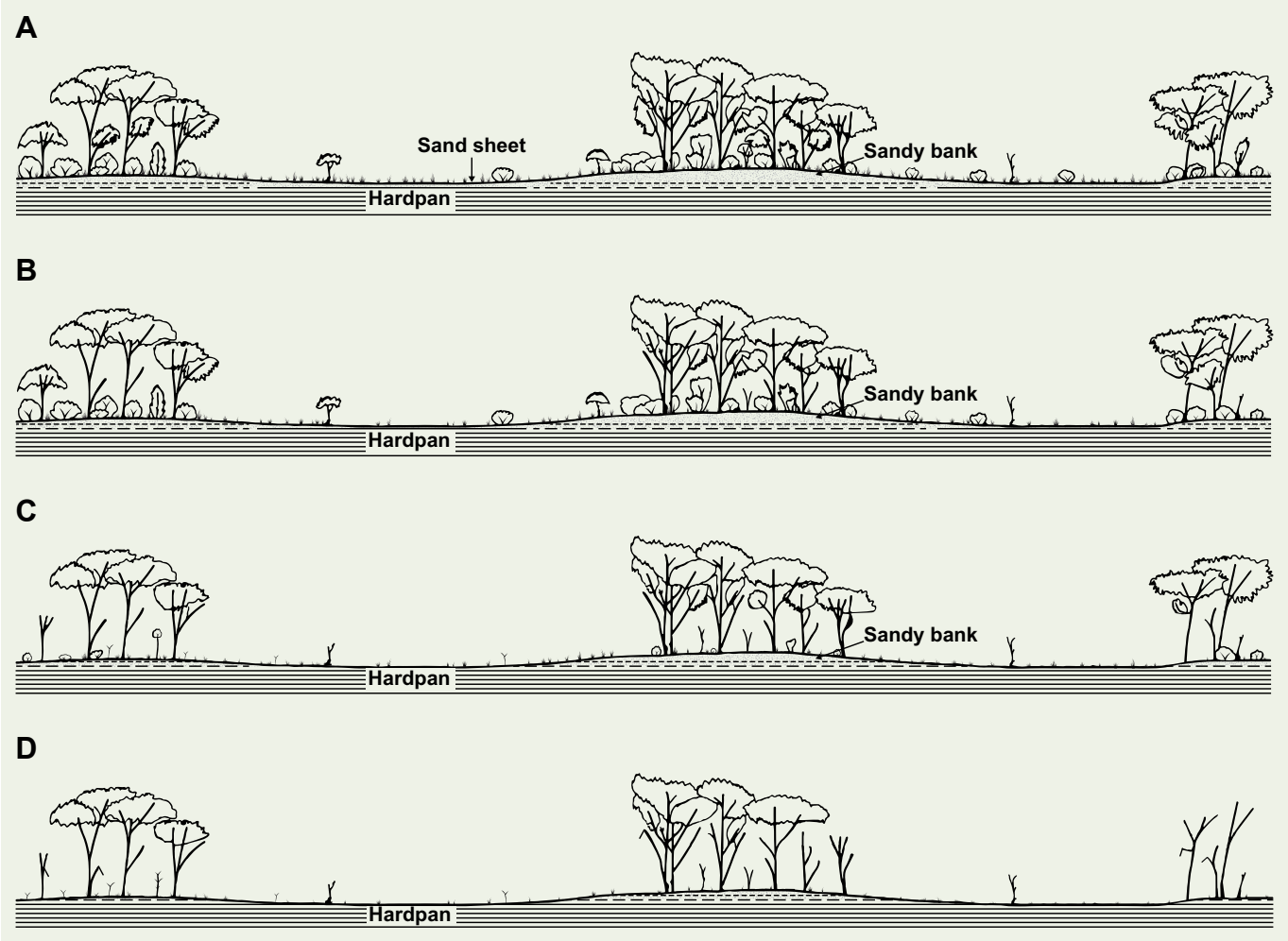


Figure F1: Schematic diagram showing wanderrie grass pastures with mulga groves in (A) good condition, (B) fair condition, (C) poor condition and (D) very poor condition.

Shortened forms

Short form	Long form
<	less than
>	more than
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
CCC	current carrying capacity
DPIRD	Department of Primary Industries and Regional Development
ha/AE	hectares per animal equivalent
ha/CU	hectares per cattle unit
ha/DSE	hectares per dry sheep equivalent
Mha	million hectares
PCC	potential carrying capacity
PFC	projected foliar cover
sp.	species, singular
spp.	species, plural
subsp.	subspecies, singular
WARMS	Western Australian Rangeland Monitoring System

References

Alchin M, Addison J, Shrubb V, Cockerill Z, Young M, Johnson T and Brennan G (2008) *Pastoral profits guide – A paddock guide to achieving sustainable livestock productivity*, Department of Agriculture and Food, Western Australian Government.

Beard JS (1976) 'The vegetation of the Murchison Region, Explanatory notes to Sheet 6', *Vegetation survey of Western Australia, 1:1,000,000 Vegetation Series*, University of Western Australia Press.

Burnside DG, Holm AMcR, Payne AL and Wilson GM (1995) *Reading the rangeland: a guide to the arid shrublands of Western Australia*, Department of Agriculture, Western Australian Government.

Chilcott CR, Rodney JP, Kennedy AJ and Bastin GN (2005) *Grazing land management – Central Australian version: workshop notes*, Meat and Livestock Australia, Sydney.

Clinch MJ (n.d.) *Cattle breeder management system: a case study for the Bullseye Project* [unpublished report], Gascoyne Catchments Group.

Cotching WE (2005) 'An inventory of rangelands in part of the Broome Shire Western Australia', *Technical bulletin 93*, Department of Agriculture, Western Australian Government.

Curry PJ, Hennig P, Blood DA and Leighton KA (1994) 'An inventory and condition survey of the Murchison River catchment Western Australia', *Technical bulletin 84*, Department of Agriculture, Western Australian Government.

Curry PJ, Payne AL and Wilcox DG (1983) 'Suggested descriptive terms for classes of foliar cover in arid zone shrublands', *Range Management Newsletter*, 83(3):12–13.

CSIRO (Commonwealth Scientific and Research Organisation) (2018) *Hummock grasslands Ecosystem Dynamics*, CSIRO Land and Water.

Pastoral Lands Board (2021) *PLB policy structure*, Western Australia government website, accessed 26 May 2023.

DPIRD (Department of Primary Industries and Regional Development Western Australia) (2018) *Status of the Western Australian pastoral rangelands*, DPIRD, Western Australian Government.

Fletcher R (2022) *Framework for sustainable pastoral management – revised edition*, Department of Primary Industries and Regional Development, Western Australian Government.

Fletcher W (1995) 'Yerilla goat grazing study 1998–1990 – a summary of results findings and observations', *Miscellaneous publication 20/95*, Agriculture Western Australia, Western Australian Government.

Garner W and Steinberger Y (1988) 'A proposed mechanism for the formation of "Fertile Islands" in the desert ecosystem', *Journal of Arid Environment*s, 16:257–262.

Hall TJ, McIvor J, Jones P, MacLeod N, McDonald C, Reid D, Smith D and Delaney K (2010) *Volume I – Investigating intensive grazing systems in Northern Australia*, Final report project B.NBP.0353, Meat and Livestock Australia Sydney.

Heshmatti GA (1997) *Plant and soil indicators for detecting zones around water points in arid perennial chenopod shrublands of South Australia* [doctoral thesis], University of Adelaide.

Heshmatti GA, Facelli JM and Conran JG (2002) 'The biosphere revisited: plant species patterns close to water points in small fenced paddocks in chenopod shrub lands of South Australia', *Journal of Arid Environments*, 51:547–560.

Hennig P (2009) 'An inventory and condition survey of the lower Murchison River area Western Australia', *Technical bulletin 96*, Department of Agriculture and Food, Western Australian Government.

Holm AMcR (1994) *Boolathana grazing study final report 1983–1993*, Western Australian Department of Agriculture report to the Australian Wool Research and Promotion Organisation, Perth.

Hunt LP (1992) 'Piospheres and the state-and-transition model of vegetation change in chenopod shrublands', *7th Biennial conference proceedings*, pp 5–9, Cobar Australian Rangeland Society.

Jones P and Burrows WH (1994) 'State and transition models for rangelands: A state and transition model for the mulga zone of south-west Queensland', *Tropical Grasslands*, 28:279–283.

Khangura R (2021) *Regenerative agriculture – principles practices purported mechanisms and benefits* [Department of Primary Industries and Regional Development (DPIRD) webinar Science Seminar – Dr Ravjit Khangura plant pathologist], DPIRD, accessed 27 October 2021.

Mabbutt JA, Litchfield WH, Speck NH, Wright RL, Wilcox DG, Arnold JM, Brookfield M and Sofoulis J (1958) 'No 7 General report on lands of the Wiluna–Meekatharra Area Western Australia'*, CSIRO Land Research Surveys*, doi:10.1071/LRS07.

MLA (Meat and Livestock Australia) (n.d.) *Pasture growth*, MLA website, accessed 26 May 2023.

Milton SJ, Richard W, Dean J, du Plessis MA and Siegfried WR (1994) 'A Conceptual Model of Arid Rangeland Degradation: The escalating cost of declining productivity', *BioScience* 44(2):70–76, doi:10.2307/1312204.

Mitchell AA, Payne AL and Holman WF (1988) 'An inventory and condition survey of rangelands in the Ashburton River catchment Western Australia', *Technical bulletin 62*, Department of Agriculture, Western Australian Government.

Mitchell AA and Wilcox DG (1994) *Arid shrubland plants of Western Australia*, 2nd edn, University of Western Australia Press, Nedlands.

Morrissey JG and O'Connor REY (1988) '28 years of station management: Fair use or fair go?' [conference paper], *5th Biennial Conference Australian Rangeland Society*, Longreach, Queensland.

Payne AL and Mitchell AA (2002) 'Pasture condition guides for the Pilbara', *Miscellaneous publication 19/2002*, Department of Agriculture and Food, Western Australian Government.

Payne AL, Spencer GF and Curry PJ (1987) 'An inventory and condition survey of rangelands in the Carnarvon Basin Western Australia', *Technical bulletin 73*, Department of Agriculture, Western Australian Government.

Payne AL, Van Vreeswyk AME, Leighton KA, Pringle HJ and Hennig P (1998) 'An inventory and condition survey of the Sandstone-Yalgoo-Paynes Find area, Western Australia', *Technical bulletin 90*, Department of Agriculture, Western Australian Government.

Phelps D (n.d.) *Mitchell grass phases of growth: a visual aid to restocking after wet season spelling*, Department of Employment, Economic Development and Innovation, accessed 23 May 2023.

Pringle HJR (1994) 'Pastoral resources and their management in the north-eastern Goldfields, Western Australia', *Miscellaneous publication 22/94*, Department of Agriculture, Western Australian Government.

Pringle HJ, Gilligan SA and Van Vreeswyk AME (1994) 'An inventory and condition survey of rangelands in the north-eastern Goldfields, Western Australia', T*echnical bulletin 87*, Department of Agriculture, Western Australian Government.

Sudmeyer R, Parker J, Nath T and Ghose A (2014) 'Carbon farming in relation to Western Australian agriculture', *Bulletin 4856*, Department of Agriculture and Food, Western Australian Government.

Suijendorp H (1967) *A study of the influence of management practices on "spinifex" Triodia pungens grazing* [master's thesis], University of Western Australia, Perth.

Tongway DJ (1994) *'Rangeland soil condition assessment manual'*, CSIRO Australia, Division of Wildlife and Ecology, Canberra.

Van Vreeswyk AME and Godden PT (1998) 'Pastoral resources and their management in the Sandstone-Yalgoo-Paynes Find area, Western Australia', *Miscellaneous publication 1/98*, Agriculture Western Australia, Western Australian Government.

Van Vreeswyk AME, Leighton KA, Payne AL and Hennig P (2004a) 'An inventory and condition survey of the Pilbara region Western Australia', *Technical bulletin 92*, Department of Agriculture, Western Australian Government.

Van Vreeswyk AME, Payne AL and Leighton KA (2004b) 'Pastoral resources and their management in the Pilbara region of Western Australia', *Miscellaneous publication 21/2004*, Agriculture Western Australia, Western Australian Government.

Waddell PA and Galloway PD (in press) 'Land systems, soils and vegetation of the southern Goldfields and Great Western Woodlands of Western Australia', *Technical bulletin 99*, Department of Primary Industries and Regional Development, Western Australian Government.

Waddell PA, Gardner AK and Hennig P (2010) ‘An inventory and condition survey of the Western Australian part of the Nullarbor region’, *Technical bulletin 97*, Department of Agriculture and Food, Western Australian Government.

Waddell PA, Thomas PWE and Findlater PA (2012) ‘A report on the Gascoyne River catchment following the 2010/11 flood events’, *Resource management technical report 382*, Department of Agriculture and Food, Western Australian Government.

Westoby MB, Walker B and Noy-Meir I (1989) ‘Opportunistic management for rangelands not at equilibrium’, *Journal of Range Management*, 42(4):266–274.

Wilcox DG (1960) ‘The grazing of Wandarrie grass associations’, *Journal of the Department of Agriculture*, Western Australia, 4(1):6, article 4.

Wilcox DG and McKinnon EA (1972) *A report on the condition of the Gascoyne catchment*, Department of Agriculture, Western Australian Government.

Yan ZG, Holm AMcR, Mitchell AA (1996) ‘The population dynamics of perennial shrubs in Western Australian chenopod shrublands in relation to grazing and seasonal conditions’, *Australian Rangeland Journal*, 18(1):10–22.

Department of Primary Industries and Regional Development

+61 1300 374 731 | enquiries@dpird.wa.gov.au | dpird.wa.gov.au

PR010-24 AUG 2024