A framework for regional soil conservation treatments in the medium and low rainfall agricultural districts

John Carder
John Grasby

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Western Australian Department of Agriculture

Research Report

A framework for regional soil conservation treatments in the medium and low rainfall agricultural districts

No. 1/86

By: J. Carder and J. Grasby
A framework for regional soil conservation treatments in the medium and low rainfall agricultural districts

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The authors

John Carder, Adviser and John Grasby, Senior Adviser, Division of Resource Management, Soil Conservation Service Branch, Western Australian Department of Agriculture.
A FRAMEWORK FOR REGIONAL SOIL CONSERVATION TREATMENTS
in the medium and low rainfall agricultural districts

by John Carder and John Grasby
Division of Resource Management
W.A. Department of Agriculture

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FOREWORD

It is a deplorable fact that the best soils information for the south-west of Western Australia remains Sheet 5 of the Atlas of Australian Soils. This was prepared by CSIRO almost twenty years ago in 1967, and at a scale of 1:2 million.

Although certainly some areas have since been surveyed in more detail, for most Advisory Districts the Atlas remains the ultimate authority.

Agriculture, and the use of agricultural land is becoming increasingly complex. New, large and diverse demands are being placed daily on our land resources. In addition to agricultural issues such as promoting new crops or farming systems, and releasing Vacant Crown Land to agriculture, there is pressure to subdivide land for hobby farms or urban uses, to conserve land for water catchments, groundwater management, nature conservation, forestry and recreation. Other Government departments are continually demanding land resource data upon which to base planning decisions.

All this points to the need for much greater information about the State's land resources.

In addition to the mapped data, we lack a systematic interpretation of the capability of each land unit or soil type to support a particular landuse.

John Carder and John Grasby have made a significant first step forward in preparing this Framework. While the Atlas still provided the soils base, the Framework brings together more than fifty years of experience in discussing the specific erosion difficulties and management requirements of the individual units.

It is hoped that the Framework will provide a valuable overview to eleven Advisory Districts. This overview is expected to be used by new and some not so new staff. The Framework will also serve as a guide to more detailed District assessments.

I encourage District Offices to expand upon this Framework. The Moora and Narrogin District Offices have already made steps in this direction.

The Land Evaluation Group of the Soil Conservation Branch is conducting regional surveys in the Busselton and Esperance areas. These surveys will provide a sound basis for the future. The Group is eager to help train staff from District Offices and assist and advise District Offices ready now to build upon the Framework of Carder and Grasby.

(G.A. Robertson)
COMMISSIONER FOR SOIL CONSERVATION

August 21, 1986
SUMMARY

In the cereal-growing districts of Western Australia, the need for, and the recommended types of, soil conservation treatments vary greatly. This variation is the result of a complex interaction of many factors which include landforms, soil types and agronomic feasibility which is affected by climate.

This publication draws upon existing data and considerable departmental experience to identify the land degradation problems and appropriate soil conservation treatments of various land units. The text and the accompanying maps provide an overview of eleven Department of Agriculture advisory districts.

The cereal-growing districts are divided into three geomorphic regions; the Old Plateau, the zones of rejuvenated natural drainage, and the coastal plains (west and south). The classification of valley forms given in Bettenay and Mulcahy (1972) is adopted in the regional descriptions. On those landforms characteristic groupings of soils are found, the general features of which are summarized from the Atlas of Australian Soils of Northcote et al. (1967) and A Factual Key for the Recognition of Australian Soils by Northcote (1965).

Twenty-two sub-regions or map units are derived from a combination of those physical factors. The main soil degradation problems of each unit are given district by district and possible conservation treatments (given their present agronomic use) or research needs are suggested in brief and general terms. It is hoped that the information thus collated will be useful as an overview and for broad-scale planning.

The map information is presented here as Department of Agriculture advisory district maps. But as it is held in digital form it is capable of being presented in different formats. For instance, an overall map has been produced. The map information is capable of analysis and collation with other distributional data. Such future applications could link the map units with, for example, rainfall, the distribution of recommended crop and pasture varieties or land-use statistics.
INTRODUCTION

This publication is an outcome of two Department of Agriculture workshops on land degradation problems and soil conservation treatments, held in 1983 at Moora and Lake Grace.

The workshops dealt with the conservation problems of the agricultural districts with medium (325 - 450 mm) and low (275 - 325 mm) annual rainfall. Issues related to the higher rainfall districts were not discussed.

This publication combines many separate map units of the CSIRO Soils Atlas into sub-regions.

Each sub-region has a particular combination of landforms, soils and land degradation problems. It follows that there are appropriate combinations of soil conservation treatments for each sub-region. Some treatments and techniques have been used for many years and can be confidently recommended for particular sub-regions. However, land degradation problems and possible treatments are related to rainfall patterns, changing agricultural technology, economic pressures, land-use and land development. Treatments which have worked well in the sub-regions for which they were developed are not necessarily appropriate for other regions. With changing technology already established treatments may need modification even in their original regions. These changes, and the need for research are noted.

The conservation treatment needs are expressed in general terms, necessarily so in view of the scale of this publication. What should and can be done on the ground depends on the judgement of the landholders in association with advisory staff in the field.

The Framework is offered in the hope that it will be useful for later more detailed surveys and evaluations.
The base maps showing district boundaries, State Forests, reserves etc. were derived from data supplied by courtesy of the Surveyor General, especially from the map Rural Land Use in Western Australia (Department of Lands and Surveys, 1981).

The district maps show the advisory districts of the Department of Agriculture, which are based mainly on groups of Shires. The exceptions, where Shire boundaries are not followed for operational convenience, are Dumbleyung and Kent Shires (divided between Katanning and Lake Grace advisory districts), Gnowangerup Shire (Katanning and Jerramungup advisory districts) and Ravensthorpe Shire (Jerramungup and Esperance advisory districts). Pastoral lease land and vacant Crown land beyond the present margin of agriculture are excluded from the maps.

The maps can be related, by overlays or computer techniques, to other maps such as those of rainfall or of regional recommendations for cereal and pasture varieties. It should always be borne in mind that the base scale of the maps in this publication is 1:2 million so that big enlargements will be unreliable.

The estimates of areas given with the maps were derived by computer from the maps themselves. The area data for the landscape/map units have been rounded to the nearest thousand hectares and the percentages to the nearest half of one per cent. The areas and percentages of unalienated land are those of the major reserves shown on the maps. Those figures do not account for the many small reserves of various types scattered throughout the agricultural districts and are therefore underestimates.
Landscape and map units

The landform (and soils) data presented are extracted and summarised from Sheet 5 of the 'Atlas of Australian Soils' published by CSIRO (Northcote, Bettenay, Churchward and McArthur, 1967) with acknowledgement of their valuable pioneer work in this field.

Though published at the small scale of 1:2 million, Sheet 5 provides coverage of all the agricultural districts whereas larger scale soil surveys cover only a tiny fraction of the districts with medium and low rainfall. The high-rainfall districts are better served by larger scale and more detailed surveys.

The map units of Sheet 5 are associations of soils generally delineated by landscapes.

In this publication the landform descriptions are summarized from the booklet 'Explanatory Data for Sheet 5' of the soils atlas (Legend 2).

The map units vary considerably in the complexity of the landscapes they represent. Some units represent complex assemblages of landforms, such as coastal dune systems or dissected terrain inland. Other units represent a much narrower range of landforms, upper parts of a landscape being shown as a separate unit from lower elements of the same landscape. Complexity mostly reflects the degree of detail of the original CSIRO survey.

Many of the CSIRO map units have some inclusions, not shown on the original map, of landforms or soils from adjacent units, especially at their margins. Such inclusions are mostly ignored in the following descriptive summaries unless they have some significance. For example, where lateritic breakaways or remnants of lateritic uplands create runoff and erosion problems they are included in the descriptions of non-lateritic units.

This publication combines many separate CSIRO map units into broad sub-regional groupings such as the major sandplain landscapes, the districts with dominant red earths, or the more dissected landscapes due to rejuvenation of natural drainage. These groupings have particular combinations of land degradation problems and possible conservation treatments. The groupings also serve as a summary framework to assist more detailed scrutiny of the original Sheet 5 map.

Some units have been omitted from the maps for simplicity of presentation, especially those which occur as "islands" within larger units. However they are described in the text, even if small in area, for completeness and to save cross-referencing. The principle followed is that units may be omitted from the maps but all the units shown are mapped as accurately as possible, given the small scale of the original. Where map units are common to two or more districts their descriptions are given in full for each district to avoid cross-referencing.

The regions and the map units within each region are arranged and described in order from the inland or the highest parts of the landscape to the lower parts or the coast.
A general description of the overall regional groupings is given in Appendix 1. A summary of descriptions of some typical valley forms, which are mentioned in the landscape notes and which are derived from Beaten and Mulcay (1972), are given in Appendix 2. Definitions of some less-familiar terms are given in Appendix 3.

Soils

Legend No. 1 on the CSIRO Sheet 5 map can be misinterpreted if not closely scrutinised and if no reference is made to Legend 2 in the booklet of explanatory data. The map units, labelled Ms7, Ms8, AZ1, SV1, etc., are related to landscape forms, as noted above. Legend No. 1 refers only to the dominant soils of the map units. Thus the dominant soils of map units Ms7 to Ms12 are yellow earths. They are coded as Gn 2.2 in "A Factual Key for the Recognition of Australian Soils" (Northcote) or, more specifically, as yellow earths with an acid reaction trend (Gn 2.21). But they are not the only soils to be found in the areas denoted as Ms units, as CSIRO's Legend 2 shows. It is an error to refer to "Ms7 soils" or "Ms8 soils". The double columns of the regional descriptions in this publication are intended to make that distinction clear. The term "main soils" is used as a column heading to refer to the variety of soils in a map unit, as distinct from the dominant soils of Legend No. 1 on the Sheet 5 map.

The soil descriptions are in general terms sufficient only to suggest broadly their agronomic and conservation features. For correct description and identification of soils reference must be made to the Factual Key and to an experienced soil surveyor.

The field situation is usually more complex than may be suggested by the mention of a primary soil profile form in relation to a map unit. Finer distinctions may be made for specific purposes such as the characterisation of an experimental site. For example, in a benchmark soil survey of the East Chapman research block south of Yuna the soils were generalised as yellow earthy sands (Northcote Factual Key Uc 5.22). But the surveyors recognised four main groups within which were eight surface soil types or phases overlying a deep lateritic profile (see Division of Resource Management Research Summary, 1983 pages 62-68).

The primary profile forms of the Factual Key are summarised below and all the forms mentioned in this framework are shown in a classified list in Appendix 4.

Primary soil-profile forms

U - Uniform texture throughout the soil profile.

Uc (coarse) sands, sandy loams.
Um (medium) loams, clay loams.
Uf (fine) clays: non-cracking
Ug clays: cracking seasonally.

G - Gradational changes in texture throughout the soil profile.

Gc calcareous throughout the soil profile
Gn non-calcereous in part or whole of the soil profile.
D - Duplex soils with a texture contrast in the soil profile.

Dr  red coloured upper subsoil
Dy  yellow coloured upper subsoil
Dg (gley)  dull greyish colours due to waterlogging.
Dd (dark)  dark other than gley colours.

KS - prefix

Ironstone gravel comprises 60 per cent or more of the mineral material of the soil. The code following Ks - describes the other mineral material (the matrix).
GERALDTON ADVISORY DISTRICT

EASTERN FRINGE (GE 1)

Landscape/map units

Ms12  Undulating plateau with ironstone gravel pavement and some low dunes.

Main soils

Acidic yellow earth (Gn 2.21) often with much ironstone gravel and underlain by red-brown hardpan at 0.5 m.

On erosional sites: gravel (KS-Uc 5.22).

Small flats: neutral and alkaline earths (Gn 2.12, 2.13).

AZ1  Undulating or low hills: gravel pavements common.

On crests: ironstone gravel forms of shallow earthy sand (KS-Uc 5.22).

On slopes: various sands and duplex.

SV4  Saline valleys with salt lakes and channels with dunes and lunettes. (Baandee-type valley forms).

Adjacent soils vary, but mainly neutral earths (Gn 2.13, 2.12) often underlain by calcrete.

On fringes of lakes and channels: gypseous and saline loams (Um 1.1, 1.2).

On dunes and lunettes: sand (e.g. Uc 1.21) and some red duplex.

SV1  Saline valleys with salt lakes and channels and their fringing areas, with remnants of old lateritic profile and some rock outcrops. (Baandee-type valley forms).

Fringe areas: various re-salinized yellow duplex soils.

On riverine wash: gypseous and saline loams (Um 1.1, 1.2) usually underlain by clay or sand strata at about 30cm.

On dunes and lunettes: various soils with slight development - Uc, Um, Uf.

Deposits of common salt, gypsum, lime, alunite.
PROBLEMS

* Low average rainfall with high-intensity summer storms.

* Dominant soils are of low fertility, often very shallow, usually acid at the surface with acidity increasing with depth, and often difficult to wet.

* No confident recommendations for pasture legume species.

* Wind erosion from intense cropping in the 1970s and 1980s. (There is also a potential hazard of wind erosion from autumn grazing but sheep numbers have been low in that period).

* Sheet erosion by water.

* Lack of grassed waterways.

NOTES

* Gullying is usually minor and is related to concentration of water by structures, e.g. culverts.

* Salinity appears a minor problem.

TREATMENTS

* Alternative cropping systems need to be developed.

* Minimum cultivation systems with early seeding of crops.

* Stubble management systems (early stubble burning is hazardous).
GERALDTON ADVISORY DISTRICT

RED EARTHS ZONE (GE 2)

Landscape/map units

MZ1 Lateritic ridges.
Main soils
Ironstone gravel with earthy matrix (KS-Gn 2.21, 2.1) or sandy matrix (KS-Uc 2.12).

F9 Gently undulating with gneissic rock outcrops.
Shallow dense loams (Um 5.41, 5.51, 1.43).

My48 Undulating to hilly with gneissic rock outcrops.
On slopes: various sands and loams, some gravel, some duplex soils (Dy and Dr).
On flats: neutral red earth (Gn 2.12) with underlying red-brown hardpan.

My47 Undulating terrain.
Neutral red earth (Gn 2.12) and yellow earth (Gn 2.21) with some hardpan.
Associated red and yellow earthy sands (Uc 5.21, 5.22).

Mx12 Flat to gently undulating plain with some sandy rises.
Alkaline red earth (Gn 2.13) with red-brown hardpan in places, with veins of calcium carbonate.
On rises: sand (Uc 5.22) and some yellow duplex (Dy 5.84, 5.82).

My46 Plain with some dunes and narrow saline flats and creeks.
Neutral red earth (Gn 2.12) with some alkaline red earth (Gn 2.13).
On and near dunes: red earthy sand (Uc 5.21).

UPPER GREENOUGH RIVER VALLEY

My49 Plain with saline flats with underlying calcrete, and the flanking slopes.
Red earths, neutral (Gn 2.12) and alkaline (Gn 2.13) with low sandy rises (Uc 5.21) all underlain by red-brown hardpan. Saline flats: shallow powdery calcareous loam (Um 5.11) and highly calcareous grey-brown earth (Gc 1.12). On flanking slopes: shallow dense loams of unit F9.

UPPER HUTT RIVER VALLEY

Mx11 Gently sloping valley.
Alkaline red earth (Gn 2.13) often with calcrete (kunkar) at moderate depth or exposed.
PROBLEMS

* Flooding and potential salt encroachment.
* Soil structure has probably deteriorated since clearing.
* Sheet erosion by water: gullying is mostly minor but can be severe where water is concentrated by structures e.g. culverts and grade banks.
* Grassed waterways are lacking in most places though some are feasible on slopes draining to the Irwin River.

NOTE

* Reasonable legume pastures are possible: medics on soils with an alkaline reaction, sub.clovers on soils with an acid reaction.

TREATMENTS

* Minimum cultivation systems.
* Stubble management systems.
* Surface water control is needed. Large level bank systems have been installed on a project basis to overcome the problem of lack of disposal waterways but there is no consensus that this is the best overall approach, or on possible alternative treatments.
* Wider rotations including a pasture phase are indicated in relation to deterioration of soil structure.
GERALDTON ADVISORY DISTRICT

SANDPLAINS (GE 3)

Landscape/map units  Main soils

ERADU

AC9  Gently undulating lateritic sandplain underlain by sedimentary rocks, with some dunes*, areas of block lateritic and breakaways at margins.

Yellow earthy sand (Uc 5.22) with ironstone gravel.

On dunes, siliceous sand (Uc 1.22).

* (Narrow steep sand ridges on northern fringe).

ERADU-MINGENEW

AC3  Similar to unit AC9 which grades into this unit.

Yellow earthy sand (Uc 5.22) with some ironstone gravel but with slightly higher clay content than in unit AC9.

ALLANOOKA

Xd3  Irregular gullied slopes below breakaways.

Sandy neutral yellow duplex (Dy 5.82) with mottled subsoils and some ironstone gravel.

On more dissected areas: leached sand (Uc 2.2) and small areas of various duplex soils.

IRWIN

Xd9  Undulating ridges with some breakaways and mesas, with broad valleys, all with a lateritic mantle.

Gravelly sandy acidic yellow duplex with mottled subsoils (Dy 5.81, 5.84) in a complex pattern with gravel in a leached sandy matrix (KS-Uc 2.12).

Associated leached sand (Uc 2.12) underlain by gravel and mottled clay - sandy topsoils progressively deeper downslope.

AC2  Gently undulating plateau underlain by sedimentary rocks.

Yellow earthy sand (Uc 5.22) with siliceous sand (Uc 1.22).

Associated are patches of gravel (KS-Uc 2.12) and yellow duplex (Dy 5.84) with leached sand (Uc 2.21) in some shallow valley floors.
PROBLEMS

* Wind erosion from summer-autumn grazing and during crop establishment.
* Poor water-holding capacity of many soils: crops are often stressed for water in spring.
* On the Bradu sandplain very deep bores are the only source of stock water. Sites are difficult to find and very costly to equip. Many properties have only one bore, or a shared bore, with too few watering points for good grazing management.

NOTES

* Water erosion is generally minor even on the more dissected terrain.
* On the yellow earthy sands good stands of lupins and medics, especially Harbinger medic, are possible. On the gravelly and sandy duplex soils reasonable sub.clover pastures are possible. On the grey and pale-yellow sandy-surfaced soils sandplain lupins will grow except on the deepest phases.

TREATMENTS

* Minimum cultivation systems.
* Stubble management systems.
* The deep leached sands are suitable only for permanent lupin pastures where these will grow. Research is needed on establishing perennial vegetation on the deepest phases.
GERALDTON ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE (GE 4)

Landscape/map units

Main soils

HUTT RIVER VALLEY (Downstream)

Pb29 Rolling valley side-slopes over granite with some rock outcrops and some mesas and buttes.

Hard-setting acidic red duplex loams (Dr 2.21, 2.61).

My46 Plains with some dunes and narrow saline flats and creeks.

Neutral red earth (Gn 2.12) and some alkaline red earth (Gn 2.13).

On and near dunes, red earthy sand (Uc 5.21).

CHAPMAN VALLEY SYSTEM

Uc2 Dissected lateritic plateau.
(Note that Uc2 stands for a map unit, and is not a soil profile symbol.)

Hard-setting neutral yellow duplex with mottled subsoil (Dy 3.62) with ironstone gravel and boulders.

On dissection slopes: various yellow and red duplex (Dy and Dr).

Ub99 Hills with sandstone outcrops and small saline valleys.

Hard-setting neutral loamy yellow duplex with mottled subsoils (Dy 3.42, 3.22).

In saline valleys: sands (Uc 2.22, 5.22).

Ubl00 Similar to unit Ub99 but more dissected.

Similar to soils of unit Ub99.

Pb29 Rolling valley side-slopes over granite with some rock outcrops and some mesas and buttes.

Hard-setting acidic red duplex loams (Dr 2.21, 2.61).

Qc5 Terraced valley plain and some valley side-slopes.

On higher terraces: hard-setting red loamy duplex, either neutral (Dr 2.32) or alkaline (Dr 2.33) with mixed colluvial duplex soils on slopes and fills.

On lower terraces: deep red sand (Uc 1.43).

On poorly-drained flats: red duplex with bleached A2 horizon (Dr 3.42).
<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>GREENOUGH FLATS</td>
<td></td>
</tr>
<tr>
<td>BCl Riverine plain and terraces</td>
<td>Deep red-brown loamy sand and clayey sand (Uc 1.43) with small areas of gravel deposits and other soils and hard-setting red duplex (Dr 2.42).</td>
</tr>
</tbody>
</table>

GE 4

PROBLEMS

* Water erosion, both sheet erosion and gullying. The problem is increasing with increased cropping intensity including a tendency to crop unsuitable minor paddock units.

* Wind erosion from summer grazing: generally appears to be minor.

* Dissected landscapes create problems of cultivation and land management.

NOTE

* Good sub,clover pastures are possible: many have been established for over 50 years.

TREATMENTS

* Grade bank and waterway systems are appropriate in most situations but attention is needed to bank and waterway outlets and to the maintenance of waterways.

* A return to wider rotations is indicated and the retirement of hazardous small areas to pasture.

* More farm layout plans are needed.
GERALDTON ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE (GE 5)

IRWIN VALLEY SYSTEM

Landscape/map units  
Main soils

Oc38 Upper slopes topped by mesas and buttes of lateritic uplands of unit AC9 and their erosion products.  
Hard-setting alkaline red duplex (Dr 2.33). Associated are cracking clays (Ug 5.2, 5.3).

Oc39 Fairly narrow side slopes and terraces.  
Hard-setting alkaline red duplex (Dr 2.33). Associated are neutral duplex with dark clayey subsoil (Bd 1.32).

Qc6 Hilly ranges and their flanking slopes, some rock outcrops.  
Hard-setting red duplex, neutral (Dr 2.32, 3.32) and alkaline (Dr 2.33) with hard-setting neutral yellow duplex (Dy 3.42). On steeper slopes: associated shallow loams (Um) and sand (Uc). On flanking slopes: associated hard-setting alkaline duplex with dark clay subsoils (Bd 1.33), hard-setting alkaline yellow duplex (Dy 3.43) and cracking but well-structured clay (Ug 5.2).

Qc7 Broken hilly terrain with some rock outcrops and small valleys and plains.  
Hard-setting neutral duplex, red (Dr 2.32) and yellow with mottled subsoil (Dy 3.42).

Pb30 Hills with small terraced valleys.  
Hard-setting acidic red duplex (Dr 2.21). On upper slopes: associated sand (Uc 4.1) or shallow loam (Um 4.1) over weathered rock or carbonate pan. On valley terraces: associated hard-setting red duplex, neutral (Dr 2.22) or alkaline often with free lime (Dr 2.23).

Oc37 Valley plain with terraces and levees with some low gilgais.  
On the plain: hard-setting alkaline red duplex (Dr 2.33) with areas of cracking clay (Ug 5.2) showing badlands erosion. On levees: sands (Uc 1.43, 1.42) or red duplex (Dr 2.42) especially on backslopes. On terraces of tributary streams: yellow duplex (Dy 3.43).
Landscape/map units

Main soils

DONGARA FLATS

CC46 Riverine plain with small
     gilgais and some dunes.
     Grey cracking clays (Ug 5.25).
     On dunes : siliceous sand
     (Uc 1.22).

GE 5

PROBLEMS

* The hard-setting alkaline red duplex soils generate considerable run-off,
  are difficult to work, pasture establishment is difficult and crop yields
  are uncertain.

* Water erosion both sheet and gullying including, in part of the district,
  tunnelling and the worst erosion in the State's agricultural zone.

* Reliable waterways are lacking in many parts of the district.

* Wind erosion from late-summer grazing and during crop establishment.

* Some salinity, possibly primary.

TREATMENTS

* On the worst-affected land no treatment by works appears economic.

* Minimum tillage systems.

* Grade bank and waterway systems are indicated only for the most
  favourable sites and with special precautions in relation to discharge.
  Bank systems damaged by tunnel erosion need frequent maintenance or
  re-design.

* More pasture research is needed.
GERALDTON ADVISORY DISTRICT

COASTAL SANDPLAINS (GE 6)

Landscape/map units | Main soils
--- | ---
WEST BINNU

Ca28 Gently undulating sandplain with some low lateritic residuals. | Leached sand (Uc 2.21) and yellow siliceous sand (Uc 1.22).

DONGARA-ARROWSMITH

Ca27 Sandy plain with some pockets of dunes, small swamps and streams. | Leached sand (Uc 2.21) often with sandy-clay substrate at 1-2 m.
Leached sand (Uc 2.22) on dunes.

COASTAL DUNES (GE 7)

A13 Coastal dunes backed by deposits of inlets and estuaries. | Dunes: calcareous sand (Uc 1.11). In swales: various uniform profile soils from coarse sands to clays (Uc, m, f, g) and some acid peat.

B24 Undulating dunes with aeolianite under or exposed, and small swales. | On dunes: siliceous sand (Uc 1.22) with (in wetter sites) small areas of brown sand (Uc 4.22) and leached sand (Uc 2.21). In swales: various sands, loams, clays (Uc, m, f, g) and some acid peat.

B26 Undulating dunes with aeolianite under or exposed | Siliceous sand (Uc 1.22) with small patches of brown or leached sands.

JK9 Undulating dunes, some steep, with aeolianite at depth. | Brown sand (Uc 4.22) and siliceous sand (Uc 1.22).

D6 Undulating aeolianite dunes with small flats and valleys. | Grey-brown shallow coherent sand (Uc 6.11) with aeolianite at 0.3-1 m (exposed in places). Red duplex or gley soils in flats.
PROBLEMS

* The leached sands are basically unsuitable for agriculture.
* Wind erosion.
* Water erosion by run-off from the lateritic residuals.

TREATMENTS

* No further land releases on these land systems.
* Leave uncleared where this option is still available.
* Permanent lupin pastures on the cleared land.
THREE SPRINGS ADVISORY DISTRICT

Landscape/map units

EASTERN FRINGE (TS 1)

EAST PERENJORI-EAST BUNJIL

AC11 Undulating to hilly, based on gneissic rock.

Main soils

On crests: shallow yellow earthy sand (Uc 5.22).

On slopes: shallow loams (Um 5.41, 5.51, 1.43).

Small plains: shallow red earthy sand (Uc 5.21) and shallow red earth (Gn 2.12) with red-brown hardpan in places.

RED EARTHS ZONE (TS 2)

LAKE MONGER

My42 Flat to gently undulating with small samphire flats and areas of exposed calcrete.

Neutral and alkaline red earths (Gn 2.12, 2.13).

Mx10 Plains.

Alkaline red earth (Gn 2.13).

SV4 Saline valleys with salt lakes and channels with dunes and lunettes. (Baandee-type valley forms).

Adjacent soils vary, but mainly neutral earths (Gn 2.13, 2,12) often underlain by calcrete.

On fringes of lakes and channels: gypseous and saline loams (Um 1.1, 1.2).

On dunes and lunettes: sand (e.g. Uc 1.21) and some red duplex.
PROBLEMS

* Low average rainfall with high-intensity summer storms.

* The upland soils are mostly shallow and of low fertility. Those carrying wodjil vegetation are shallow and acidic.

* The more fertile earths are generally shallow, are often drought-stricken and their structure has probably deteriorated since clearing. Flooding, waterlogging and secondary salinity are becoming evident.

* Excessive run-off. Suitable disposal waterways are lacking due to the valleys being flat in cross-section with ill-defined watercourses.

* No confident recommendations about pasture legume establishment while financial constraints favour heavy cropping. Careful selection of legume varieties would be needed.

TREATMENTS

* Alternative cropping systems need to be developed, especially for the light upland soils.

* Minimum cultivation systems with early seeding of crops and stubble management.

* Surface water control is needed. Large level bank systems may overcome the problem of lack of disposal waterways but there is no consensus that this is the best approach, or on possible alternative treatments.
THREE SPRINGS ADVISORY DISTRICT

OLD PLATEAU

ZONE WITH RED DUPLEX SOILS (TS 3)

PERENJORI - THREE SPRINGS, LATHAM AND WADDI FOREST

Landscape/map units

Main soils

Oc36  Undulating to hilly with some lateritic mesas and breakaways.
On mesa crests: gravel (KS-Uc 2.12). On slopes:
hard-setting alkaline or neutral red duplex (Dr 2.33, 2.32, 2.22)
with yellow duplex (Dy 3.81) with
loam (Um 5.2) and sand (Uc 5.11).

Oc35  Undulating to rolling with some lateritic ridges, mesas and
buttes.
Some granite outcrops.
Hard-setting alkaline red loamy
duplex (Dr 2.33, 2.63, 2.73, 2.22)
with variable areas of yellow
duplex (Dy 3.43, 3.83, 3.42, 3.41).

Oc34  Broad flat valleys.
Hard-setting alkaline red loamy
duplex (Dr 2.33) and red earths
(Gn 2.13, 2.12).

SV4   Saline valleys with salt lakes and
channels with dunes and
lunettes.  
(Baandee-type valley forms).
Adjacent soils vary, but mainly
neutral earths (Gn 2.13, 2.12)
often underlain by calcrete.

On fringes of lakes and channels: gypseous and saline loams (Um 1.1, 1.2).

On dunes and lunettes: sand (e.g.
Uc 1.21) and some red duplex.
PROBLEMS

* Soil structure deterioration or inherent difficult soil properties including crusting, poor water infiltration and emergence problems for plant seedlings. Many of the duplex soils are shallow.

* Waterlogging and flooding.

* Lack of grassed waterways.

* Salt encroachment.

* Lack of stock water supplies due to saline groundwater at shallow depths.

* Decline of remaining native trees is a feature of long-established properties with a high proportion of clearing.

NOTE

* Legume pastures are possible though they degenerated in the dry years.

TREATMENTS

* Minimum cultivation systems.

* More research is needed to define appropriate treatments for various landscapes.

* More research is needed on siting and designing stock-water dams.
<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms8 Undulating sandplain with long gentle slopes and some abrupt erosional scarps.</td>
<td>On depositional slopes: sandy acid and neutral yellow earths (Gn 2.21, 2.22) with some gravel, and yellow earthy sand (Uc 5.22) often with ironstone gravel below 2m.</td>
</tr>
<tr>
<td></td>
<td>On erosional ridges and slopes: ironstone gravel (KS-Uc 4.11) and gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.</td>
</tr>
<tr>
<td>Ms9 Sandplain with fairly narrow valley side-slopes and some small flats.</td>
<td>On uplands: sandy yellow earths (Gn 2.21, 2.22) and yellow earthy sand (Uc 5.22).</td>
</tr>
<tr>
<td></td>
<td>On side-slopes: hard-setting yellow duplex (Dy 3.43).</td>
</tr>
<tr>
<td></td>
<td>On flats: red duplex (Dr 2.33).</td>
</tr>
<tr>
<td>Xd2 Smooth ridges and spurs (rare breakaways) separated by valleys with secondary salinity.</td>
<td>Sandy neutral duplex with some gravel and mottled subsoil (Dy 5.82).</td>
</tr>
<tr>
<td></td>
<td>Associated soils:-</td>
</tr>
<tr>
<td></td>
<td>on ridge crests: sandy and gravelly soils (Uc 5.22, KS-Uc 2.12) with hardened mottled-zone material at 30-50 cm.</td>
</tr>
<tr>
<td></td>
<td>on side-slopes and valleys: various yellow and red duplex.</td>
</tr>
<tr>
<td>Qb29 Rolling to hilly with some steep slopes and many gneissic rock outcrops. (On divide of Inering Brook and Petan Creek.) (Minor unit)</td>
<td>Hard-setting neutral red duplex (Dr 2.22, 2.62, 3.42).</td>
</tr>
<tr>
<td></td>
<td>With some yellow duplex (Dy 3.42) on erosional slopes and gradational soil (Gn 2.12) on colluvial slopes with a few gilgai.</td>
</tr>
<tr>
<td>JJ14 Steep granitic hills with some bare rock walls. (Minor unit).</td>
<td>Shallow sand (Uc 4.11) and leached sand (Uc 2.2) below rock outcrops.</td>
</tr>
</tbody>
</table>
TS 4

PROBLEMS

* Wind erosion from summer-autumn grazing and during crop establishment.
* Development of traffic pans in some of the longest developed situations.
* Subsoil acidity - areas need definition.
* Salinisation - areas and rate of increase need definition.
* Run-off and sheet erosion on hard-setting duplex soils: no grassed waterways: use of level bank systems could increase groundwater recharge.

NOTES

* Risk of drought and moisture-stress problems are significantly less in the western part of the region.
* Legume establishment is feasible: sweet lupins in the eastern parts of the region and sub.clovers in the western parts.

TREATMENTS

* Minimum cultivation systems.
* Stubble management systems.
* Treatment of several regional problems depend on further research.
THREE SPRINGS ADVISORY DISTRICT

OLD PLATEAU

VALLEY UNITS (TS 4 - cont.)

Landscape/map units                      Main soils

WEST MAYA

Va71 Valley plains and terraces with saline flats.                Hard-setting alkaline yellow duplex with mottled subsoil (Dy 3.43) and some red earth.

WEST LATHAM

Va69 Broad flat valleys.                          Hard-setting alkaline yellow duplex with mottled subsoil (Dy 3.43).

                                           Small areas of hard-setting alkaline red duplex (Dr 2.33) with lime often present.

Ta9 Valley side slopes where dissection has cut below the laterite level. (Minor unit). Various duplex soils, mostly hard-setting and acid or neutral.

SV1 Saline valleys with salt lakes and channels and their fringing areas, with remnants of old lateritic profile and some rock outcrops. (Baandee-type valley forms). Fringe areas : various re-salinized yellow duplex soils.

                                           On riverine wash : gypseous and saline loams (Um 1.1, 1.2) usually underlain by clay or sand strata at about 30 cm.

                                           On dunes and lunettes : various soils with slight development - Uc, Um, Uf.

                                           Deposits of common salt, gypsum, lime, alunite.
TS 4 (cont'd)

PROBLEMS

* Waterlogging and flooding.
* Salt encroachment.
* Sheet erosion by water on valley side-slopes.
* Lack of suitable grassed waterways – though possible waterway sites exist.

TREATMENTS

* On upper slopes: selection of sites for vegetation with high usage of soil moisture (perennial vegetation or crop system manipulation).
* Grade bank and waterway systems on selected favourable sites: level bank systems may be considered as alternatives.
* Drainage and establishment of halophytes on selected areas.
* More research is needed to define hydrologic properties of various landscapes and appropriate treatments. For example, to define whether stubble retention systems will increase non-wetting problems in soils; and which, if any, contour treatments are appropriate.
THREE SPRINGS ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE (TS 5)

UPPER ARROWSMITH RIVER (west of the Kadathinni Hills)

Landscape/map units

<table>
<thead>
<tr>
<th>Pb30</th>
<th>Hills with small terraced valleys.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oc36</td>
<td>Undulating to hilly with some lateritic mesas and breakaways.</td>
</tr>
<tr>
<td>Va69</td>
<td>Broad flat valley.</td>
</tr>
</tbody>
</table>

Main soils.

Hard-setting acidic red duplex (Dr 2.21).

On upper slopes: associated sand (Uc 4.1) or shallow loam (Um 4.1) over weathered rock or carbonate pan.

On valley terraces: associated hard-setting red duplex, neutral (Dr 2.22) or alkaline often with free lime (Dr 2.23).

On mesa crests: gravel (KS-Uc 2.12) on slopes: hard-setting alkaline or neutral red duplex (Dr 2.33, 2.32, 2.22) with yellow duplex (Dy 3.81) with loam (Um 5.22) and sand (Uc 5.11).

Hard-setting alkaline yellow and red duplex soils.
TS 5

PROBLEMS

* Water erosion, both sheet erosion and gulling.

* Lack of grassed waterways, though possible waterway sites exist.

* Pasture establishment and maintenance is difficult on the hard-setting soils.

* Salinisation of creek lines with some encroachment on valley floors of units Oc36 and Va69.

TREATMENTS

* Grade bank systems would be appropriate where adequate waterways are stabilised or developed.

* Development of management techniques of improved pastures is needed for the hard-setting soils.
THREE SPRINGS ADVISORY DISTRICT

COASTAL PLAIN

WEST THREE SPRINGS—WEST COOROW (TS 6)

Landscape/map units

AC3 Gently undulating plateau underlain by sedimentary rocks.

Main soils

Yellow earthy sand (Us 5.22) with significant clay content.

Associated patches of gravelly sand and gravelly duplex (KS–Us 2.12, Dy 5.84, 5.82).

Small areas of siliceous sand (Us 1.22).

AC4 Terrain similar to unit AC3.

Soils similar to those of unit AC3 but with more siliceous sand (Us 1.22) and more yellow duplex (Dy).

AC5 Gently undulating plain with sand dunes, some small lakes and outcrops of quartzite.

Soils similar to those of unit AC4.

AC6 Gently undulating plain with salt lakes and some sandy lunettes.

Yellow earthy sand (Us 5.22) and siliceous sand (Us 1.22).

Associated are neutral yellow duplex (Dy 2.42) in former lake beds.

AC7 Low hills with outcrops of quartzite.

Yellow earthy sand (Us 5.22).

Associated yellow duplex, acidic (Dy 3.81) and neutral (Dy 3.82) and red duplex (Dr 3.41, 3.42) with mottled subsoils.
TS 6

PROBLEMS

* The siliceous sands are of low inherent fertility, nutrients leach quickly and the soils have poor water-holding capacity and may be non-wetting.

* Wind erosion from summer grazing and during crop establishment can be severe under poor management.

* Minor salinity.

NOTES

* Water erosion is generally minor.

* On the yellow earthy sands good stands of crop and pasture lupins are possible.
  On the gravelly sands reasonable sub.clover pastures are possible.
  On the grey and pale-yellow sandy-surfaced soils sandplain lupins will grow except on the deepest phases.

TREATMENTS

* Minimum cultivation systems.

* Stubble management systems.

* The deep leached sands are suitable only for permanent lupin pastures where these will grow. Research is needed on establishing perennial vegetation on the deepest phases: or leave uncleared. (Production of Protaceae a viable option?)
THREE SPRINGS ADVISORY DISTRICT

COASTAL PLAIN

Landscape/map units

NORTH ENEABBA (TS 7)

Wd9 Undulating ridges with some breakaways and mesas, with broad valleys, all with a lateritic mantle.

Gravely sandy acidic yellow duplex with mottled subsoils (Dy 5.81, 5.84) in a complex pattern with gravel in a leached sandy matrix (KS-Uc 2.12).

Associated leached sand (Uc 2.12) underlain by gravel and mottled clay - sandy top soils progressively deeper downslope.

Wd10 Terrain similar to Wd9 with evenly sloping pediments with exposures of sandstone and shale.

Main soils similar to those of unit Wd9 but associated sands shallower.

ARROWSMITH-SOUTH ENEABBA (TS 8)

Ca27 Sandy plain with some pockets of dunes, small swamps and streams.

Leached sand (Uc 2.21) often with sandy-clay substrate at 1-2 m.

Leached sand (Uc 2.22) on dunes.

Ubo Gently undulating plain.

Neutral and alkaline yellow duplex with mottled subsoil (Dy 3.42, 3.43) with deep siliceous pan.

- 30 -
TS 7

PROBLEMS

* Wind erosion.
* Mosaics of soil types make land management difficult.
* Non-wetting properties of many of the soils.
* Slumping of saturated sands can lead to deep gullying.

TREATMENTS

* Minimum tillage systems.
* Good grazing management is most important.
* Discourage clover harvesting (except on favourable sites, if any).
* Retire slumped areas from cultivation.

TS 8

PROBLEMS

* The leached sands are basically unsuitable for agriculture.
* Sluggish natural drainage with increasing salinity in unit Ub97.
* Sheet erosion in unit Ub97.

TREATMENTS

* No further land releases on the leached sands, or leave uncleared, where these options are available.
* Permanent lupin pastures on the cleared leached sands where lupins will grow. Areas where lupins will not grow should be retired from agriculture.
* In unit Ub97 drainage with special agronomic and grazing management.
MOORA ADVISORY DISTRICT

OLD PLATEAU

Landscape/map units

Main soils

EASTERN FRINGE (MO 1)

Ms11 Dissected sandplain with ridges, scarps, granitic and gneissic outcrops.

Sandy yellow earths (Gn 2.21, 2.22) and yellow earthy sand (Uc 5.22).

In more dissected areas: various shallow sands (Uc) and shallow duplex (Dy and Dr).

Small flats: alkaline red earth (Gn 2.13).

RED DUXPLEX ZONE (MO 2)

Oc35 Undulating to rolling with some lateritic ridges, mesas and buttes.

Some granite outcrops.

Hard-setting alkaline red loamy duplex (Dr 2.33, 2.63, 2.73, 2.22) with variable areas of yellow duplex (Dy 3.43, 3.83, 3.42, 3.41).

Oc34 Broad flat valleys.

(Merredin-type valley form)

Hard-setting alkaline red loamy duplex (Dr 2.33) and red earths (Gn 2.13, 2.12).

RED EARTHS ZONE (MO 3)

My42 Flat to gently undulating with small samphire flats and areas of exposed calcrete.

Neutral and alkaline red earths (Gn 2.12, 2.13).

SV4 Saline valleys with salt lakes and channels with dunes and lunettes.

(Baandee-type valley forms).

Adjacent soils vary, but mainly neutral earths (Gn 2.13, 2.12) often underlain by calcrete.

On fringes of lakes and channels: gypseous and saline loams (Um 1.1, 1.2).

On dunes and lunettes: sand (e.g. Uc 1.21) and some red duplex.
MO 1, 2 & 3

PROBLEMS

* Low average rainfall with high-intensity summer storms.

* The upland soils may have acidity problems.

* The more fertile earths are often drought-stricken and their structure has probably deteriorated since clearing.

* Excessive run-off and lack of grassed waterways.

* Wind erosion hazard on most soil types (despite low sheep numbers in run of dry years).

* No confident recommendations for crops or for pasture legume species for the acid soils of the uplands.

* Identifying upland groundwater recharge-areas for possible special management.

NOTE

* Medic pastures are recommended for the alkaline red duplex soils and red earths with a fair degree of confidence, and halophytes for some situations in unit MO 3.

TREATMENTS

* Alternative cropping systems need to be developed, especially for the light upland soils.

* Minimum cultivation systems with early seeding of crops and stubble management. Weed control is a critical component of these systems.

* Surface water control is needed. Level bank systems may overcome the problem of lack of disposal waterways.

* Gypsum applications for structure deterioration of some of the red duplex soils and earths.
MOORA ADVISORY DISTRICT

OLD PLATEAU

CENTRAL: WUBIN - EAST WATHEROO - BURAKIN (MO 4)

Landscape/map units

Ms8 Undulating sandplain with long gentle slopes and some abrupt erosional scarps.

Main soils

On depositional slopes: sandy acid and neutral yellow earths (Gn 2.21, 2.22) with some gravel, and yellow earthy sand (Uc 5.22) often with ironstone gravel below 2m.

On erosional ridges and slopes: ironstone gravel (KS-Uc 4.11) and gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.

Ms9 Sandplain with fairly narrow valley side-slopes and some small flats.

On uplands: sandy yellow earths (Gn 2.21, 2.22) and yellow earthy sand (Uc 5.22).

On side-slopes: hard-setting yellow duplex (Dy 3.43).

On flats: red duplex (Dr 2.33).

Va66 Undulating with lateritic mesas and buttes and small granitic bosses.

Va66 Undulating with lateritic mesas and buttes and small granitic bosses.

Vand-setting alkaline yellow and red duplex (Dy 3.43 and Dr 2.33, 2.43, 3.33) with acid lateritic strata below 1.5 m.

DD17 Undulating with flats and some low gilgais.

Brown calcareous earths (Gc 1.12, 1.22) and red and yellow neutral earths (Gn 2.12, 2.2).

SV1 Saline valleys with salt lakes and channels and their fringing areas, with remnants of old lateritic profile and some rock outcrops. (Baandee-type valley forms).

Fringe areas: various re-salinized yellow duplex soils.

On riverine wash: gypseous and saline loams (Um 1.1, 1.2) usually underlain by clay or sand strata at about 30 cm.

On dunes and lunettes: various soils with slight development - Uc, Um, Uf.

Deposits of common salt, gypsum, lime, alunite.
PROBLEMS

* Wind erosion on sandy-surfaced soils unless they are carefully managed.

* Selecting suitable pastures for the acidic sandplain soils and the soils of the erosional ridges and slopes of unit Ms8.

* Run-off, sheet erosion and some gully erosion especially on the hard-setting duplex soils.

* Waterlogging, flooding and salt encroachment in valleys not separately mapped and in unit SV1.

* Identifying upland groundwater recharge-areas for possible special management.

* The brown calcareous earths of unit DD17 carried morrel vegetation. They are powdery when dry and prone to wind erosion. Surface salting may occur due to high inherent salt content.

The neutral earths carried gimlet vegetation. They have few problems but are difficult to work when wet.

TREATMENTS

* Minimum cultivation and stubble management systems.

* Grade bank and waterway systems on selected favourable sites. Level bank systems may be considered as alternatives.

* Establishment of halophytes and drainage on selected saline sites.
MOORA ADVISORY DISTRICT

OLD PLATEAU

SOUTH: LAKE HINDS - WONGAN (MO 5)

UPLANDS

Landscape/map units  | Main soils
--- | ---
Ms8  | Undulating sandplain with long gentle slopes and some abrupt erosional scarps.
     | On depositional slopes: sandy acid and neutral yellow earths (Gn 2.21, 2.22) with some gravel, and yellow earthy sand (Uc 5.22) often with ironstone gravel below 2m.
     | On erosional ridges and slopes: ironstone gravel (KS-Uc 4.11) and gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.
Ms10 | Terrain similar to unit Ms8.
     | More varied sandy yellow earths than in unit Ms8, acidic (Gn 2.21) and neutral (Gn 2.22, 2.25, 2.35).
Xd2  | Smooth ridges and spurs (rare breakaways) separated by valleys with secondary salinity.
     | Sandy neutral duplex with some gravel and mottled subsoil (Dy 5.82).
     | Associated soils:
     | on ridge crests: sandy and gravelly soils (Uc 5.22, KS-Uc 2.12) with hardened mottled-zone material at 30-50 cm.
     | on side-slopes and valleys: various yellow and red duplex.
M21  | Ranges of granites, gneisses etc and associated slopes.
     | Ironstone gravel with earthy matrix yellow (KS-Gn2.21) or red (KS-Gn 2.1) or with leached sandy matrix (KS-Uc2.12).
MO 5

PROBLEMS

* Wind erosion unless carefully managed.

* Sheet erosion by water and minor gullying.

NOTE

* Good clover pastures are possible but medic pastures may be more suitable for some soils.

TREATMENTS

* Minimum cultivation and related conservation practices.

* Establishment of vegetation with high water usage to mitigate salinity in the lower parts of the landscape may be indicated depending on further research.

* Some supplementary contouring.
MOORA ADVISORY DISTRICT

OLD PLATEAU

SOUTH: LAKE HINDS - WONGAN (MO 5 - Cont.)

LOWER SLOPES AND VALLEYS

Landscape/map units | Main soils
--- | ---
My41 Gentle lower slopes. | Neutral red earth (Gn 2.12) with some patches of gravel (KS-Gn 2.21).
DD16 Plains with some small lakes and lunettes. | Brown calcareous earth (Gcl.22) with associated alkaline red earth (Gn 2.13) and hard-setting yellow duplex (Dy 3.4).
Oc31 Broad flat valleys with some gilgais along drainage lines. (Merredin type valley form) | Hard-setting red loamy duplex (Dr 2.33) with acid clay strata below 1.8 m.
Va63 Valley plains and terraces. | Hard-setting alkaline yellow duplex (Dy 3.43) with small areas of gravelly duplex, yellow (Dy 3.42, 5.8) and red (Dr 5.6).
Va70 Valley plains and terraces. | Hard-setting alkaline yellow duplex (Dy 3.43) with small areas of brown calcareous earths (Gc 1.22, 1.12).
SI28 Broad flat valleys with some small clay pans and salt lake remnants, with some gypseous lunettes and areas of low gilgais. (Belka-type valley form) | Hard-setting yellow alkaline loamy duplex (Dy 2.43, 2.33) with acid lateritic clays at 60-120 cm.
SVl Saline valleys with salt lakes and channels and their fringing areas, with remnants of old lateritic profile and some rock outcrops. (Baandee-type valley forms). | Fringe areas: various re-salinized yellow duplex soils.
| On riverine wash: gypseous and saline loams (Um 1.1, 1.2) usually underlain by clay or sand strata at about 30 cm.
| On dunes and lunettes: various soils with slight development – Uc, Um, Uf.
| Deposits of common salt, gypsum, lime, alunite.
PROBLEMS

* Water erosion and waterlogging in years with early winter rains.
* Occasional flooding from summer rains.
* Salinity extensive in unit SI28.

NOTE

* Good clover and medic pastures according to soil type are possible.

TREATMENTS

* Grade bank or seepage interceptor systems, with waterways, on favourable sites.
* Drainage and establishment of halophytes on selected sites.
* More research is needed to define hydraulic properties of various landscapes and appropriate treatments.
MOORA ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE ZONE (MO 6)

Landscape/map units

Ufl Lateritic buttes, ridges and spurs.

Main soils

On ridge tops: gravelly yellow duplex (Dy 3.82, 3.81, 5.82, 5.81).

On lower slopes: variety of duplex soils and ironstone boulders from upslope.

Ub98 Hilly with granitic and gneissic rock outcrops.

Hard-setting neutral yellow duplex (Dy 3.42).

Qb29 Rolling to hilly with some steep slopes and many gneissic rock outcrops.

Hard-setting neutral red duplex (Dr 2.22, 2.62, 3.42).

With some yellow duplex (Dy 3.42) on erosional slopes and gradational soil (Gn 2.12) on colluvial slopes with a few gilgai.

Vd6 Flat valley floors.

(North branches of Moore River)

Hard-setting alkaline loamy duplex (Dy 3.33, 3.43) with areas of gilgai and cracking clay (Ug 5.37) and some red duplex.
PROBLEMS

* Water erosion both sheet and gullying.
* Poor maintenance of old contour systems.
* Patchy hillside waterlogging associated with duplex soils and seepages.
* Salinity in valleys and from many hillside seepages.
* Dissected landscapes create problems of cultivation and land management.

NOTE

* Good sub.clover pastures are possible: many are long established. Clovers have not done well on the valley floors of unit Vd6; medics are probably more suitable.

TREATMENTS

* Grade bank and waterway systems are appropriate in most situations but attention is needed to seepage control and accommodation to larger machinery.
* More farm layout plans are needed.
* Establish halophytes on selected saline sites.
* A response to gypsum applications is likely on some soils of the valley floors of unit Vd6.
MOORA ADVISORY DISTRICT

DARLING RANGE GRAVEL ZONE (MO 7)

Landscape/map units

JZ2 Dissected lateritic plateau of the Darling Range, with broad swampy drainage ways.

Main soils

On ridges and slopes: ironstone gravels with sandy or earthy matrixes (KS-Uc 4.2, 4.11, 2.12 and KS-Gn 2.24) overlying re-cemented ironstone gravel or block laterite or mottled-zone or pallid-zone material.

Some gravelly duplex soils also on slopes.

In drainage ways, leached sands (Uc 2.2, 2.3).

Tf3 Dissected terrain flanking unit JZ2, with breakaways, some granite tors and narrow valleys.

Hard-setting acidic gravelly yellow duplex (Dy 3.81, 5.41, 5.81).

Leached sand (Uc 2.21) in valleys.

JJ14 Steep granitic hills with some bare rock walls. (Minor unit).

Shallow sand (Uc 4.11) and leached sand (Uc 2.2) below rock outcrops.

Qb32 Valley side slopes on basic igneous and associated rocks, moderate to steep slopes with some rock outcrops; gentle colluvial slopes and limited valley floor.

Valley side slopes: hard-setting neutral red duplex (Dr 2.22) and neutral friable red earth (Gn 3.12) with some shallow sands (Uc) and loams (Um).

On colluvial slopes: various duplex, yellow (Dy) and red (Dr).

On valley floor: loam (Um 5.5) with some clay flats (Uf or Ug 5.2).

(Brockman River Valley)
PROBLEMS

* Salinity in valleys.

* Water erosion generally minor to moderate on the plateau (unit JZ2) but severe in places on the flanking slopes (units Tf3 and Qb32).

* Some minor wind erosion in particularly dry seasons.

* Subdivision into small properties is likely to increase erosion hazards.

NOTE

* Good sub.clover pastures are possible but many soils need high rates of fertiliser due to phosphorus fixation.

TREATMENTS

* Drainage possibilities should be investigated for saline and near-saline valleys.

* Strategic diversion banks and attention to firebreaks and tracks are generally sufficient. Where stable disposal waterways are lacking large absorption banks are needed.
**MOORA ADVISORY DISTRICT**

**COASTAL PLAIN**

**BETWEEN DANDARAGAN AND DARLING SCARPS (MO 8)**

<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC2 Gently undulating plateau underlain by sedimentary rocks.</td>
<td>Yellow earthy sand (Uc 5.22) with siliceous sand (Uc 1.22). Associated are patches of gravel (KS-Uc 2.12) and yellow duplex (Dy 5.84) with leached sand (Uc 2.21) in some shallow valley floors.</td>
</tr>
<tr>
<td>AC4 Terrain similar to unit AC2.</td>
<td>Soil similar to those of unit AC2 but with more siliceous sand (Uc 1.22) and more yellow duplex (Dy).</td>
</tr>
<tr>
<td>AC5 Gently undulating plain with sand dunes, some small lakes and outcrops of quartzite.</td>
<td>Soils similar to unit AC2.</td>
</tr>
<tr>
<td>AC6 Gently undulating plain with salt lakes and some sandy lunettes.</td>
<td>Yellow earthy sand (Uc 5.22) and siliceous sand (Uc 1.22). Associated are neutral yellow duplex (Dy 2.42) in former lake beds.</td>
</tr>
<tr>
<td>AC7 Low hills with outcrops of quartzite.</td>
<td>Yellow earthy sand (Uc 5.22). Associated yellow duplex, acidic (Dy 3.81) and neutral (Dy 3.82) and red duplex (Dr 3.41, 3.42) with mottled subsoils.</td>
</tr>
</tbody>
</table>

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PROBLEMS

* The siliceous sands are of low inherent fertility, nutrients leach quickly and the soils have poor water-holding capacity. There are problems of non-wetting especially on the siliceous and leached sands (Uc 1.22, 2.21).

* Wind erosion from summer grazing and during crop establishment, which can be severe under poor management.

* Minor salinity.

NOTES

* Water erosion is generally minor.

* On the yellow earthy sands good stands of crop and pasture lupins are possible. On the gravelly sands reasonable sub.clover pastures are possible. On the grey and pale-yellow sandy-surfaced soils sandplain lupins will grow except on the deepest phases.

TREATMENTS

* Minimum cultivation systems.

* Stubble management systems.

* The deep leached sands are suitable only for permanent lupin pastures where these will grow. Research is needed on establishing perennial vegetation on the deepest phases: or leave uncleared. (Production of Protaeaceae a viable option?)

* Need to investigate further the needs of pastures for phosphorus, potassium and sulphur on soils other than the poorest, and whether there is a role for perennial forage plants.

* The potential of the yellow earthy sands (Uc 5.22) needs more investigation.
<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB3 Dissected plateau slopes often flanking unit AC2, with valleys with small swamps.</td>
<td>On slopes, red earthy sand (Uc 5.21). In valley lines, leached sand with organic staining (Uc 2.21). Diatomaceous earth in swamps.</td>
</tr>
<tr>
<td>AB4 Slopes of main trunk valleys, with many breakaways and including the chalk formation at Gingen.</td>
<td>Red earthy sand (Uc 5.21) on main slopes. Various red, brown or yellow duplex on more dissected lower slopes. On valley floors red or brown duplex with some areas of sand (Uc 5.21) or diatomaceous earth. On chalk, shallow dark loam (Um 6.21).</td>
</tr>
<tr>
<td>AB5 Sandy outwash from granitic areas.</td>
<td>Shallow red earthy sand (Uc 5.21), red loam (Um 5.3) and shallow red earth (Gn 2.12).</td>
</tr>
<tr>
<td>Sp2 Ridge Hill Shelf adjoining Darling Scarp.</td>
<td>Hard-setting yellow duplex (Dy 2.61) with ironstone gravel, with brown sand (Uc 4.2) overlying gravel.</td>
</tr>
</tbody>
</table>
PROBLEMS

* Water erosion is generally minor but is more pronounced on the Ridge Hill Shelf (unit Sp2). Severe gullying occurs on the slopes of the main valleys (unit AB4) where soaks and springs overflow.

* Most soils fix phosphorus readily.

NOTE

* This district has big old-established farms with many trees retained. There are few problems under the generally conservative management.

TREATMENTS

* Gullies formed in sands from the overflow of springs need to be fenced off and stabilised with couch, kikuyu or other suitable perennials. Where water flow is perennial, gully heads need to be specially sealed until vegetation is well established.

* Investigate role of perennial forage plants for the leached sands (Uc 2.21).
MOORA ADVISORY DISTRICT

COASTAL PLAIN

BADGINGARRA AND WEST MOGUMBER (MO 10)

Landscape/map units

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wd9</td>
<td>Undulating ridges with some breakaways and mesas, with broad valleys, all with a lateritic mantle.</td>
</tr>
<tr>
<td>Wd10</td>
<td>Terrain similar to Wd9 with evenly sloping pediments with exposures of sandstone and shale.</td>
</tr>
<tr>
<td>Tf7</td>
<td>Swampy flat valley.</td>
</tr>
</tbody>
</table>

Main soils

- Gravelly sandy acidic yellow duplex with mottled subsoils (Dy 5.81, 5.84) in a complex pattern with gravel in a leached sandy matrix (KS-Uc 2.12).
- Associated leached sand (Uc 2.12) underlain by gravel and mottled clay - sandy topsoils progressively deeper downslope.
- Main soils similar to those of unit Wd9 but associated sands shallower.
- Yellow duplex with mottled subsoils, hard-setting acid (Dy 3.81) or neutral (Dy 3.82) with friable acid duplex (Dy 5.81) and leached sand (Uc 2.21).
MO 10

PROBLEMS

* Wind erosion.

* Mosaics of soil types make land management difficult.
  (Gravelly ridges support reasonable crops and sub.clover pastures.
  Sandy hollows give poor growth with hazard of wind erosion and of water
  erosion by run-off from the gravelly ridges.)

* Non-wetting properties of many of the soils.

* Salinity in some drainage lines, especially below the Dandaragan Scarp.

TREATMENTS

* Minimum tillage systems.

* Good grazing management is most important.

* Discourage clover harvesting (except on favourable sites, if any).

* Grade bank systems where stable disposal waterways are available.
  Elsewhere large absorption banks are needed to control run-off.

* Investigate the role of perennial forage plants for the leached sands (Uc
  2.21).

* Gypsum applications on some of the valley duplex soils (unit Tf7).
MOORA ADVISORY DISTRICT

COASTAL PLAIN

WEST OF GINGIN SCARP (MO 11)

Landscape/map units  Main soils

Cb39  Subdued dune-swale terrain.  Leached sands (Uc 2.33, 2.22, 2.21).

Ca27  Sandy plain with some pockets of dunes, small swamps and streams.  Leached sand (Uc 2.21) often with sandy-clay substrate at 1-2 m.  Leached sand (Uc 2.22) on dunes.

Ub97  Gently undulating plain.  Neutral and alkaline yellow duplex with mottled subsoil (Dy 3.42, 3.43) with deep siliceous pan.

COASTAL DUNES (MO 12)

Landscape/map units  Main soils

A13  Coastal dunes backed by deposits of inlets and estuaries.  Dunes : calcareous sand (Uc 1.11).  In swales : various uniform profile soils from coarse sands to clays (Uc, m, f, g) and some acid peat.

A16  Broad swales with salt lakes between units A13 and B24.  Shallow calcareous sand (Uc 1.11) with continuous aeolianite at about 30 cm depth.

B24  Undulating dunes with aeolianite under or exposed, and small swales.  On dunes : siliceous sand (Uc 1.22) with (in wetter sites) small areas of brown sand (Uc 4.22) and leached sand (Uc 2.21).  In swales : various sands, loams, clays (Uc, m, f, g) and some acid peat.

JK9  Undulating dunes, some steep, with aeolianite at depth.  Brown sand (Uc 4.22) and siliceous sand (Uc 1.22).
MO 11

PROBLEMS

* The leached sands are basically unsuitable for agriculture.

* Sluggish natural drainage with increasing salinity in unit Ub97.

* Sheet erosion in unit Ub97.

TREATMENTS

* No further land releases on the leached sands, or leave uncleared, where these options are available.

* Permanent lupin pastures on the cleared leached sands where lupins will grow. Areas where lupins will not grow should be retired from agriculture.

* Investigate the role of perennial forage plants for the leached sands.

* In unit Ub97 drainage with special agronomic and grazing management.
MERREDIN ADVISORY DISTRICT

OLD PLATEAU

NORTHERN FRINGE (ME 1)

Landscape/map units

<table>
<thead>
<tr>
<th>AC10</th>
<th>Dissected sandplain ridges with long slopes.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main soils</td>
</tr>
<tr>
<td></td>
<td>On ridges: yellow earthy sand (Uc 5.22) with gravel (KS-Uc 4.11) and some sandy yellow earth (Gn 2.21).</td>
</tr>
<tr>
<td></td>
<td>On slopes: various shallow duplex (Dy and Dr).</td>
</tr>
<tr>
<td>Ms11</td>
<td>Dissected sandplain with ridges, scarps, granitic and gneissic outcrops.</td>
</tr>
<tr>
<td></td>
<td>Sandy yellow earths (Gn 2.21, 2.22) and yellow earthy sand (Uc 5.22).</td>
</tr>
<tr>
<td></td>
<td>In more dissected areas: various shallow sands (Uc) and shallow duplex (Dy and Dr).</td>
</tr>
<tr>
<td></td>
<td>Small flats: alkaline red earth (Gn 2.13).</td>
</tr>
</tbody>
</table>
ME 2

PROBLEMS

* Low average rainfall with high-intensity summer storms.

* The upland soils are mostly shallow, and may have acidity problems.

* Wind erosion a hazard on most soil types (despite low sheep numbers in a run of dry years).

* Sheet erosion by water.

* No confident recommendations for pasture legume species.

NOTES

* Gullying is usually minor and related to structures e.g. culverts.

* Salinity appears a minor problem.

TREATMENTS

* Alternative cropping systems need to be developed.

* Minimum cultivation systems with early seeding of crops.

* Stubble management systems (early burning is hazardous).
MERREDIN ADVISORY DISTRICT

OLD PLATEAU

EASTERN FRINGE (ME 2)

Landscape/map units

AC1 Undulating sandplain uplands with long gentle slopes with some abrupt erosional scarps, granite bosses, and narrow shallow valleys and flats.
(This unit is very similar to unit Ms8).

BB8 Undulating or low hilly ranges of greenstone (basic igneous rocks).

BB5 Similar to unit BB8 but more hilly and rocky.

JJ16 Broken terrain with granitic bosses and tors which may cover large areas in the unit. (Minor unit).

My44 Undulating ridges and low hills with some mesas and buttes and small valley plains.

DD15 Undulating plains with some low dunes, seasonal lakes and clay pans.

Ya28 Sandy valleys with some clay pans and small salt lakes, dunes and lunettes. (Belka-type valley forms)

Main soils

Uplands: yellow earthy sand (Uc 5.22) and sandy yellow earths (Gn 2.21, 2.22).

Erosional sites: ironstone gravel (KS-Uc 4.11) and gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material.

Shallow valleys: various yellow duplex soils (Dy).

Shallow calcareous loam (Um 5.11) and shallow brown and grey-brown calcareous earths (Gc 1.12, 1.22) with weathered rock underlying.

Some gilgais on low sites.

Around rocks: shallow often stony or gritty sands (Uc 4.11, 4.33, 4.22).

Associated small areas of various soils such as red duplex (Dr 2.62) and calcareous earths (Gc 2.22).

Neutral red earth (Gn 2.12) with variable gravel content.

Associated on slopes, shallow loams (Um) and red duplex (Dr 2.32); in valleys red duplex (Dr 2.33).

Brown or grey-brown calcareous earths (Gc 1.12, 1.22) with rises of ironstone gravel and flats of alkaline red earth (Gn 2.13).

Sandy alkaline duplex with mottled subsoil (Dy 5.43, 5.83) with various other yellow and red duplexes, some salinized, and some calcareous earths.
PROBLEMS

* Low average rainfall with high-intensity summer storms.
* The upland soils are mostly shallow and may have acidity problems.
* The more fertile soils of the slopes and valleys are often drought-stricken and their structure may deteriorate under frequent cropping.
* Sheet erosion by water.
* Wind erosion on many soil types (despite low sheep numbers in a run of dry years).
* No confident recommendations for pasture legume species.

TREATMENTS

* Alternative cropping systems need to be developed, especially for the light upland soils.
* Minimum cultivation systems with early seeding of crops and stubble management.
* Conservation practices (vegetation control) may provide sufficient control of surface water, though large level banks and drainage may be warranted in some situations.
MERREDIN ADVISORY DISTRICT
OLD PLATEAU
ZONE WITH RED DUPLEX SOILS (ME 3)

Landscape/map units

Ms8 Undulating sandplain with long gentle slopes and some abrupt erosional scarps.

Main soils
On depositional slopes: sandy acid and neutral yellow earths (Gn 2.21, 2.22) with some gravel, and yellow earthy sand (Uc 5.22) often with ironstone gravel below 2m.

On erosional ridges and slopes: ironstone gravel (KS-Uc 4.11) and gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.

JJ16 Broken terrain with granitic bosses and tors which may cover large areas in the unit.
(Minor Unit)

Around rocks: shallow often stony or gritty sands (Uc 4.11, 4.33, 4.22).

Oc35 Undulating to rolling with some lateritic ridges, mesas and buttes.
Some granite outcrops.

Hard-setting alkaline red loamy duplex (Dr 2.33, 2.63, 2.73, 2.22) with variable areas of yellow duplex (Dy 3.43, 3.83, 3.42, 3.41).

Oc33 Undulating plains with some low gilgais.

Hard-setting alkaline red loamy duplex (Dr 2.33) in complex association with calcareous earths (Gc 1.22, 1.12).

Mx9 Broad gently undulating plains.

Hard-setting alkaline red loamy duplex (Dr 2.33) in complex association with alkaline red earth (Gn 2.13) and some brown calcareous earths (Gc 1.12, 1.22).

Oc34 Broad flat valleys.
(Merredin type valley forms)

Hard-setting alkaline red loamy duplex (Dr 2.33) and red earths (Gn 2.13, 2.12).

Oc31 Broad flat valleys with some gilgais along drainage lines.
(Merredin-type valley forms)

Hard-setting alkaline red loamy duplex (Dr 2.33) with acid clay strata below 1.8 m.

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ME 3

PROBLEMS

* Soil structure deterioration or inherent difficult soil properties including crusting, poor water infiltration and emergence problems for plant seedings.

* Waterlogging and flooding. Lack of grassed waterways.

* Salt encroachment except usually in the Merredin-type valleys.

TREATMENTS

* Minimum cultivation systems.

* Surface water control is needed. Large level bank systems may overcome the problem of lack of disposal waterways but there is no consensus that this is the best approach, or on possible alternative treatments.
MERREDIN ADVISORY DISTRICT

OLD PLATEAU

CENTRAL AND SOUTHERN ZONE (ME 4)

Landscape/map units

Main soils

UPLAND UNITS

**Ms8** Undulating sandplain with long gentle slopes and some abrupt erosional scarps.

On depositional slopes: sandy acid and neutral yellow earths (Gn 2.21, 2.22) with some gravel, and yellow earthy sand (Uc 5.22) often with ironstone gravel below 2m.

On erosional ridges and slopes: ironstone gravel (KS-Uc 4.11) and gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.

**Va66** Undulating with lateritic mesas and buttes and small granitic bosses.

Hard-setting alkaline yellow and red duplex (Dy 3.43 and Dr 2.33, 2.43, 3.33) with acid lateritic strata below 1.5 m.

Around rocks: shallow often stony or gritty sands (Uc 4.11, 4.33, 4.22).

Associated small areas of various soils such as red duplex (Dr 2.62) and calcareous earths (Gc 2.22).

**JJ16** Broken terrain with granitic bosses and tors which may cover large areas in the unit.

(Minor unit).

**VALLEY UNITS**

**DD9** Gently undulating slopes with some low gilgais.

Brown and grey-brown calcareous earths (Gc 1.12, 1.22). Acid clays may occur at depth.

**Vb2** Upper reaches of broad flat valleys.

(Merredin-type valley forms)

Hard-setting loamy duplex with mottled subsoil (Dy 3.43) and leached yellow earths with variable ironstone gravel and siliceous hardpan.

**SI28** Broad flat valleys with some small clay pans and salt lake remnants, with some gypseous lunettes and areas of low gilgais.

(Belka-type valley forms)

Hard-setting yellow alkaline loamy duplex (Dy 2.43, 2.33) with acid lateritic clays at 60-120 cm.
PROBLEMS

* Wind erosion of sandy-surfaced soils unless they are carefully managed.

* Run-off, sheet erosion and some gullying, especially on the hard-setting duplex soils.

* Grassed waterways are generally lacking though possible waterway sites exist in the higher-rainfall parts of the region.

* Occasional flooding with salt encroachment in the Belka-type valleys of unit SI28 and trunk valleys but not usually in the Merredin-type valleys.

* The calcareous earths of unit DD9 carried morrel vegetation and are fertile by W.A. standards. They are powdery when dry and prone to wind erosion. Surface salting may occur.

* Soil structure deterioration on the hard-setting duplex soils, especially those of unit SI28.

TREATMENTS

* Minimum cultivation and stubble management systems.

* Grade bank and waterway systems on selected favourable sites. Level bank systems may be considered as alternatives.

* Drainage and establishment of halophytes on selected saline sites.

* Treatment of soils with structural problems needs further definition and research.
MERREDIN ADVISORY DISTRICT

OLD PLATEAU

SALINE TRUNK VALLEYS - BAANDEE TYPE

<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV2 Saline valleys with salt lake channels with lunettes and some dunes including barchan forms. (In eastern fringe zone.)</td>
<td>Gypseous and saline loams (Um 1.1, 1.2) and grey-brown highly calcareous earths (Gc 1.12).</td>
</tr>
<tr>
<td>SV4 Saline valleys with salt lakes and channels with dunes and lunettes. (In zone with red duplex soils)</td>
<td>Adjacent soils vary, but mainly neutral earths (Gn 2.13, 2.12) often underlain by calcrete. On fringes of lakes and channels: gypseous and saline loams (Um 1.1, 1.2). On dunes and lunettes: sand (e.g. Uc 1.21) and some red duplex.</td>
</tr>
<tr>
<td>SV1 Saline valleys with salt lakes and channels and their fringing areas, with remnants of old lateritic profile and some rock outcrops. (In zone with red duplex soils and central and southern zone).</td>
<td>Fringe areas: various re-salinized yellow duplex soils. On riverine wash: gypseous and saline loams (Um 1.1, 1.2) usually underlain by clay or sand strata at about 30 cm. On dunes and lunettes: various soils with slight development - Uc, Um, Uf. Deposits of common salt, gypsum, lime, alunite.</td>
</tr>
</tbody>
</table>
SALINE TRUNK VALLEYS

(see Appendix 1 pages 113, 114 and Appendix 2 pages 119, 120).
NORTHAM ADVISORY DISTRICT
OLD PLATEAU (NO 1)

UPLAND UNITS

Landscape/map units

Ms8  Undulating sandplain with long gentle slopes and some abrupt erosional scarps.
Main soils
On depositional slopes: sandy acid and neutral yellow earths (Gn 2.21, 2.22) with some gravel, and yellow earthy sand (Uc 5.22) often with ironstone gravel below 2m.

On erosional ridges and slopes: ironstone gravel (KS-Uc 4.11) and gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.

Va66  Undulating with lateritic mesas and buttes and small granitic bosses.
Hard-setting alkaline yellow and red duplex (Dy 3.43 and Dr 2.33, 2.43, 3.33) with acid lateritic strata below 1.5 m.

JJI6  Broken terrain with granitic bosses and tors which may cover large areas in the unit.  (Minor Unit)
Around rocks: shallow often stony or gritty sands (Uc 4.11, 4.33, 4.22).

Associated small areas of various soils such as red duplex (Dr 2.62) and calcareous earths (Gc 2.22).

VALLEY UNITS

SI28  Broad flat valleys with some small clay pans and salt lake remnants, with some gypseous lunettes and areas of low gilgais.  (Belka-type valley form)
Hard-setting yellow alkaline loamy duplex (Dy 2.43, 2.33) with acid lateritic clays at 60-120 cm.

SVI  Saline valleys with salt lakes and channels and their fringing areas, with remnants of old lateritic profile and some rock outcrops.  (Baandee-type valley form)
Fringe areas: various re-salinized yellow duplex soils.

On riverine wash: gypseous and saline loams (Um 1.1, 1.2) usually underlain by clay or sand strata at about 30 cm.

On dunes and lunettes: various soils with slight development - Uc, Um, Uf. Deposits of common salt, gypsum, lime, alunite.
PROBLEMS

* Wind erosion on sandy-surfaced soils unless carefully managed.

* Run-off, sheet erosion and some gullying especially on hard-setting duplex soils.

* Occasional flooding with salt encroachment in the lower landscape especially Belka-type valleys of unit SI28 and in trunk valleys.

NOTE

* Waterways are often available with careful selection and proper treatment.

TREATMENTS

* Minimum cultivation and stubble management systems.

* Grade bank and waterway systems on selected favourable sites. Level bank systems may be considered as alternatives.

* Establishment of halophytes and drainage on selected saline sites.
NORTHAM ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE ZONE (NO 2)

Landscape/map units

Ms7 Gently undulating sandplain with long gentle slopes with some abrupt erosional scarps.

Main soils

On convex uplands: sandy yellow earth (Gn 2.21) with irontone gravel and clay D horizon.

On depositional slopes flanking erosional sites: yellow earthy sand (Uc 5.22) with irontone gravel at depth in places.

On erosional sites leached sands overlying mottled or pallid-zone material.

Uf1 Lateritic buttes, ridges and spurs.

On ridge tops: gravelly yellow duplex (Dy 3.82, 3.81, 5.82, 5.81).

On lower slopes: variety of duplex soils and irontone boulders from upslope.

Ub98 Hilly with granitic and gneissic outcrops.

Hard-setting neutral duplex with mottled subsoils (Dy 3.42).

Qb29 Rolling to hilly with some steep slopes and many gneissic rock outcrops.

Hard-setting neutral red duplex (Dr 2.22, 2.62, 3.42).

With some yellow duplex (Dy 3.42) on erosional slopes and gradational soil (Gn 2.12) on colluvial slopes with a few gilgai.

Va63 Valley plains and terraces. (Mature valley forms – Mortlock.)

Hard-setting alkaline duplex with mottled subsoil (Dy 3.43).

Associated are small areas of gravelly yellow or red duplex soils (Dy and Dr).

Oc30 River flats and terraces. (Mature valley form – Avon.)

Hard-setting alkaline red duplex (Dr 2.33).

Associated are some yellow duplex (Dy 3.43).
Landscape/map units                          Main soils

DALE RIVER

Ub91  Undulating to hilly with some lateritic mesas and buttes on drainage divides, steep slopes and many granitic tors. Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43) with mottled subsoils. Associated yellow duplex with ironstone gravel and small areas of red duplex.

Ub96  Valley plains in which some salinity is usually present. (Mature valley forms) Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43). Also small areas of sand and gravel.

NO 2

PROBLEMS

* Water erosion both sheet and gullying.

* Many early grade bank systems are poorly maintained and some have too close bank spacing for modern machinery.

* Dissected landscapes create problems of cultivation and land management.

* Patchy hillside waterlogging associated with duplex soils and seepages.

* Salinity by hillside seepages and valley salting, often severe, in the Mortlock and similar valleys.

NOTES

* The Avon trunk valley, unit Oc30, has little salt-affected land.

* Good sub-clover pastures are possible: many are long-established.

TREATMENTS

* Grade bank and waterway systems are appropriate in most situations but attention is needed to seepage control and accommodation to larger machinery.

* Need to up-grade early contour systems and to establish new systems.

* More farm layout plans are needed.

* Establish halophytes on selected saline sites, especially Puccinellia for the main areas and Paspalum vaginatum for summer-moist sites.
NORTHAM ADVISORY DISTRICT

DARLING RANGE GRAVEL ZONE (NO 3)

Landscape/map units

J22 Dissected lateritic plateau of the Darling Range, with broad swampy drainage ways.

Main soils

On ridges and slopes: ironstone gravels with sandy or earthy matrixes (KS-Uc 4.2, 4.11, 2.12 and KS-Gn 2.24) overlying re-cemented ironstone gravel or block laterite or mottled-zone or pallid-zone material.

Some gravelly duplex soils also on slopes.

In drainage ways, leached sands (Uc 2.2, 2.3).

Tf3 Dissected terrain flanking unit J22, with breakaways, some granite tors and narrow valleys.

Hard-setting acidic gravelly yellow duplex (Dy 3.81, 5.41, 5.81).

Leached sand (Uc 2.21) in valleys.

N22 Shallow valleys high in landscape unit with swampy flats.

Sandy acidic duplex gley soil (Dg 3.81) and similar hard-setting soils (Dg 2.81, 1.81).

Mw31 Deeply incised valleys with massive rock outcrops. (Young valley forms.)

On ridge tops and spurs: gravelly sand (Uc 4.11).

Steep upper slopes: duplex soils, red (Dr 2.21) and yellow (Dy 3.21).

On colluvial slope deposits: acid red earth (Gn 2.14).
PROBLEMS

* Salinity as seepages and in some valleys. As many farms in this region are small, some are proportionately badly affected.

* Minor water erosion, mostly confined to tracks and firebreaks.

NOTE

* Good sub.clover pastures are possible.

* Wind erosion generally minor.

TREATMENTS

* Drainage possibilities should be investigated for saline and near-saline valleys. Puccinellia pastures are viable.

* Strategic diversion banks and attention to firebreaks and tracks are about the only erosion control works needed.
NARROGIN ADVISORY DISTRICT

OLD PLATEAU (NA 1)

Landscape/map units

Ms8 Undulating sandplain with long gentle slopes and some abrupt erosional scarps. On depositional slopes: sandy acid and neutral yellow earths (Gn 2.21, 2.22) with some gravel, and yellow earthy sand (Uc 5.22) often with ironstone gravel below 2 m.

On erosional ridges and slopes: ironstone gravel (KS-Uc 4.11) and gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.

Va66 Undulating with lateritic mesas and buttes and small granitic bosses. Hard-setting alkaline yellow and red duplex (Dy 3.43 and Dr 2.33, 2.43, 3.33) with acid lateritic strata below 1.5 m.

Around rocks: shallow often stony or gritty sands (Uc 4.11, 4.33, 4.22).

Associated small areas of various soils such as red duplex (Dr 2.62) and calcareous earths (Gc 2.22).

JJ16 Broken terrain with granitic bosses and tors which may cover large areas in the unit. (Minor Unit)

SI28 Broad flat valleys with some small clay pans and salt lake remnants, with some gypseous lunettes and areas of low gilgais. (Belka-type valley form)

Hard-setting yellow alkaline loamy duplex (Dy 2.43, 2.33) with acid lateritic clays at 60-120 cm.

SVI Saline valleys with salt lakes and channels and their fringing areas, with remnants of old lateritic profile and some rock outcrops. (Baandee-type valley form)

Fringe areas: various re-salinized yellow duplex soils.

On riverine wash: gypseous and saline loams (Um 1.1, 1.2) usually underlain by clay or sand strata at about 30 cm.

On dunes and lunettes: various soils with slight development - Uc, Um, Uf.

Deposits of common salt, gypsum, lime, alunite.
NA 1

PROBLEMS

* Wind erosion on sandy-surfaced soils unless carefully managed.

* Run-off, sheet erosion and some gullying especially on hard-setting duplex soils.

* Occasional flooding with salt encroachment in the lower landscape especially Belka-type valleys of unit SI28 and in trunk valleys.

NOTE

* Waterways are often available with careful selection and proper treatment.

TREATMENTS

* Minimum cultivation and stubble management systems.

* Grade bank and waterway systems on selected favourable sites. Level bank systems may be considered as alternatives.

* Establishment of halophytes and drainage on selected saline sites.
<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ufl Lateritic buttes, ridges and spurs.</td>
<td>On ridge tops: gravelly yellow duplex (Dy 3.82, 3.81, 5.82, 5.81).</td>
</tr>
<tr>
<td></td>
<td>On lower slopes: variety of duplex soils and ironstone boulders from upslope.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DALE RIVER</strong></td>
<td></td>
</tr>
<tr>
<td>Ub91 Undulating to hilly with some lateritic mesas and buttes on drainage divides, steep slopes and many granitic tors.</td>
<td>Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43) with mottled subsoils. Associated yellow duplex with ironstone gravel and small areas of red duplex.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Ub96 Valley plains in which some salinity is usually present. (Mature valley forms)</td>
<td>Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43). Also small areas of sand and gravel.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AVON RIVER - SOUTH BRANCH</strong></td>
<td></td>
</tr>
<tr>
<td>Qb29 Rolling to hilly with some steep slopes and many gneissic rock outcrops.</td>
<td>Hard-setting neutral red duplex (Dr 2.22, 2.62, 3.42). With some yellow duplex (Dy 3.42) on erosional slopes and gradational soil (Gn 2.12) on colluvial slopes with a few gilgai.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Va63 Valley plains and terraces. (Mature valley forms - Mortlock type)</td>
<td>Hard-setting alkaline duplex with mottled subsoil (Dy 3.43). Associated are small areas of gravelly yellow or red duplex soils (Dy and Dr).</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>
NARROGIN ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE ZONE (NA 2 - Cont.2)

HOTHAM RIVER SYSTEM

Landscape/map units

Uf1 Lateritic buttes, ridges and spurs.
(With more extensive outliers of Darling Range gravels shown as JZ2).

Ub91 Undulating to hilly with some lateritic mesas and buttes on drainage divides, steep slopes and many granitic tors.

Qb30 Rolling to hilly with some lateritic mesas and buttes on drainage divides, steep slopes and many gneissic rock outcrops.

Main soils

On ridge tops: gravelly yellow duplex (Dy 3.82, 3.81, 5.82, 5.81).

On lower slopes: variety of duplex soils and ironstone boulders from upslope.

Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43) with mottled subsoils. Associated yellow duplex with ironstone gravel and small areas of red duplex.

Hard-setting red duplex, neutral (Dr 2.22, 3.42) and acid (Dr 3.41).

Associated yellow duplex including gravelly duplex below the ironstone ridges.

Hard-setting neutral yellow duplex (Dy 3.42) and sandy neutral duplex (Dy 5.42).

On sandhills and dunes: leached sand (Uc 2.21) and siliceous sand (Uc 1.21).

On residual ridges and knolls: gravel (KS-Uc).

Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43).

Also small areas of other soils as in unit Ub95.

Mature valley forms - Beraking type

Ub95 Valley plains with some sandhills, dunes, lateritic gravel and swamps.

Ub96 Valley plains in which some salinity is usually present.
NARROGIN ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE ZONE (NA 2 - Cont. 3)

ARTHUR RIVER SYSTEM

<table>
<thead>
<tr>
<th>Landscape/unit</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms7 Undulating sandplain: a remnant of the upper part of the landscape.</td>
<td>Sandy yellow earth (Gn2.21) and yellow earthy sand (Uc5.22) on upper slopes, leached sands on erosional surfaces.</td>
</tr>
<tr>
<td>Ufl Lateritic buttes, ridges and spurs.</td>
<td>On ridge tops: gravelly yellow duplex (Dy 3.82, 3.81, 5.82, 5.81).</td>
</tr>
<tr>
<td></td>
<td>On lower slopes: variety of duplex soils and ironstone boulders from upslope.</td>
</tr>
<tr>
<td>Ub90 Rolling to hilly with lateritic mesas and buttes on some drainage divides, and granite tors.</td>
<td>On crests and upper slopes: hard-setting gravelly yellow duplex, acid (Dy 3.81) and neutral (Dy 3.82).</td>
</tr>
<tr>
<td></td>
<td>On slopes: various hard-setting acid and neutral red duplex (Dr) some with ironstone gravel.</td>
</tr>
<tr>
<td></td>
<td>Mature valley forms - Mortlock type</td>
</tr>
<tr>
<td>Va64 Shallow flat valleys in which some salinity is usually present.</td>
<td>Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43).</td>
</tr>
<tr>
<td>Va65 Plains with lakes and lunettes and other aeolian deposits covering ironstone gravel ridges.</td>
<td>Complex pattern of various yellow and red duplex soils with sand on younger lunettes.</td>
</tr>
<tr>
<td>Ub95 Valley plains with some sandhills, dunes, lateritic gravel and swamps.</td>
<td>Hard-setting neutral yellow duplex (Dy 3.42) and sandy neutral duplex (Dy 5.42).</td>
</tr>
<tr>
<td></td>
<td>On sandhills and dunes: leached sand (Uc 2.21) and siliceous sand (Uc 1.21).</td>
</tr>
<tr>
<td></td>
<td>On residual ridges and knolls: gravel (KS-Uc).</td>
</tr>
<tr>
<td>Ub96 Valley plains in which some salinity is usually present.</td>
<td>Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43).</td>
</tr>
<tr>
<td></td>
<td>Also small areas of other soils as in unit Ub95.</td>
</tr>
</tbody>
</table>
PROBLEMS

* Water erosion both sheet and gullying.

* Many early grade bank systems are poorly maintained and some have too close bank spacing for modern machinery.

* Dissected landscapes create problems of cultivation and land management.

* Patchy hillside waterlogging associated with duplex soils and seepages.

* Salinity by hillside seepages and valley salting is often severe.

NOTE

* Good sub.clover pastures are possible; many are long-established.

TREATMENTS

* Grade bank and waterway systems are appropriate in most situations but attention is needed to seepage control and accommodation to larger machinery.

* Need to up-grade early contour systems and to establish new systems.

* More farm layout plans are needed.

* Establish halophytes on selected saline sites, especially Puccinellia for the main areas and Paspalum vaginatum for summer-moist sites.
NARROGIN ADVISORY DISTRICT

DARLING RANGE GRAVEL ZONE (NA 3)

Landscape/map units

Jz2 Dissected lateritic plateau of the Darling Range, with broad swampy drainage ways.

Main soils

On ridges and slopes : ironstone gravels with sandy or earthy matrixes (KS-Uc 4.2, 4.11, 2.12 and KS-Gn 2.24) overlying re-cemented ironstone gravel or block laterite or mottled-zone or pallid-zone material.

Some gravelly duplex soils also on slopes.

In drainage ways, leached sands (Uc 2.2, 2.3).

Jz1 Similar to unit Jz2 but more deeply dissected valleys of westward flowing rivers.

Similar to unit Jz2.

Tf3 Dissected terrain flanking unit Jz2, with breakaways, some granite tors and narrow valleys.

Hard-setting acidic gravelly yellow duplex (Dy 3.81, 5.41, 5.81).

Leached sand (Uc 2.21) in valleys.

Mw31 Deeply incised valleys with massive rock outcrops. (Young valley form)

On ridge tops and spurs : gravelly sand (Uc 4.11).

Steep upper slopes : duplex soils, red (Dr 2.21) and yellow (Dy 3.21).

On colluvial slope deposits : acid red earth (Gn 2.14).
PROBLEMS

* Salinity as seepages and in some valleys.

* Minor water erosion, mostly confined to tracks and firebreaks.

* Wind erosion generally minor but can be severe on heavily stocked properties from late-summer grazing.

NOTE

* Good sub. clover pastures are possible.

TREATMENTS

* Drainage possibilities should be investigated for saline and near-saline valleys. Puccinellia pastures are viable.

* Strategic diversion banks and attention to firebreaks and tracks are about the only erosion control works needed.
KATANNING ADVISORY DISTRICT

OLD PLATEAU

INLAND HEADWATERS ZONES (KA 1)

Landscape/map units                           Main soils

Va66   Undulating with lateritic mesas and buttes and small granitic bosses. Hard-setting alkaline yellow and red duplex (Dy 3.43 and Dr 2.33, 2.43, 3.33) with acid lateritic strata below 1.5 m.

Uf3    Undulating lateritic ridges and slopes with some granite tors on slopes On ridge crests: hard-setting gravelly yellow duplex (Dy 3.82) and leached sand over boulder laterite in places. On side slopes: hard-setting neutral duplex, yellow (Dy 3.42, 2.42) and red (Dr 2.32, 3.42), with small areas of sand near tors.

SI28   Broad flat valleys with some small clay pans and salt lake remnants, with some gypseous lunettes and areas of low gilgais. (Belka-type valley form) Hard-setting yellow alkaline loamy duplex (Dy 2.43, 2.33) with acid lateritic clays at 60-120 cm.

SVI    Saline valleys with salt lakes and channels and their fringing areas, with remnants of old lateritic profile and some rock outcrops. (Baandee-type valley form) Fringe areas: various re-salinized yellow duplex soils. On riverine wash: gypseous and saline loams (Um 1.1, 1.2) usually underlain by clay or sand strata at about 30 cm. On dunes and lunettes: various soils with slight development - Uc, Um, Uf. Deposits of common salt, gypsum, lime, alunite.
PROBLEMS

* Wind erosion on sandy-surfaced soils unless carefully managed.
* Run-off, sheet erosion and some gullying especially on hard-setting duplex soils.
* Occasional flooding with salt encroachment in the lower landscape especially Belka-type valleys of unit SI28 and in trunk valleys.

NOTE

* Waterways are often available with careful selection and proper treatment.

TREATMENTS

* Minimum cultivation and stubble management systems.
* Grade bank and waterway systems on selected favourable sites. Level bank systems may be considered as alternatives.
* Establishment of halophytes and drainage on selected saline sites.
KATANNING ADVISORY DISTRICT

OLD PLATEAU

PALLINUP RIVER SYSTEM (KA 2)

Landscape/map units

Uf3 Undulating lateritic ridges and slopes with some granite tors on slopes. Main soils

On ridge crests: hard-setting gravelly yellow duplex (Dy 3.82) and leached sand over boulder laterite in places.

On side slopes: hard-setting neutral duplex, yellow (Dy 3.42, 2.42) and red (Dr 2.32, 3.42), with small areas of sand near tors.

Ya31 Low-level lateritic plateau with gently undulating plains and some swamps and lakes. (Includes Gordon/Pallinup divide) Gravelly rises: hard-setting gravelly yellow duplex (Dy 3.82).

On plains: various yellow duplex (Dy) with lesser areas of various red duplex (Dr). Acid clay common at c. 1 m depth.

Small areas of hard-setting duplex where acidic rocks close to surface.

Ya27 Sandy flats with swamps, salt lakes and their lunettes. On flats: sandy alkaline yellow duplex (Dy 5.43).

On lunettes: alkaline red duplex (Dr 4.43, 5.43, 2.43).

Oc32 Rolling terrain with some low gilgais. Hard-setting alkaline duplex, red (Dr 2.33), yellow (Dy 2.43) and dark (Dd 1.33) in complex association with grey and brown cracking clays (Ug 5.2, 5.3, 5.38).

Od7 Undulating with many streams, mostly saline, sandy deposits in larger valleys. Some gneissic rock outcrops. Ridge slopes: neutral red duplex (Dr 2.32).

Main slopes: various hard-setting alkaline and neutral red duplex (Dr) with some yellow duplex (Dy).

Some bigger valleys: organic siliceous sand (Uc 1.2).

Wd7 Gently undulating plain with some depressions, flats, swamps, lakes and dunes (part of coastal plain). Sandy acid yellow duplex with ironstone (Dy 5.81, 5.84) and leached sand.

On poorly drained areas: duplex with gley subsoils or clay.
KA 2

PROBLEMS

* Water erosion, both sheet and gullying.
* Patchy hillside waterlogging and saline seepages with some valley salting.
* Wind erosion on sandy-surfaced soils unless carefully managed.

TREATMENTS

* Grade bank and waterway systems are appropriate in most situations but attention is needed to seepage control and accommodation to larger machinery.
* Establish halophytes on selected sites.
* In sites with poor natural drainage, research into hydrologic mechanisms and treatment options (drainage/aquifer pumping/tree planting etc.).
* More farm layout plans are needed.

COASTAL PLAIN

PROBLEMS

* Severe wind erosion on sandy-surfaced soils unless carefully managed.
* Waterlogging, some erosion and possible salinity on poorly-drained areas.

TREATMENTS

* Suitable land management systems need to be developed.
KATANNING ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE ZONE

GORDON RIVER SYSTEM (KA 3)

Landscape/map units

Ya31 Low-level lateritic plateau with gently undulating plains and some swamps and lakes. (Includes Gordon/Pallinup divide)

Main soils
Gravelly rises: hard-setting gravelly yellow duplex (Dy 3.82).

On plains: various yellow duplex (Dy) with lesser areas of various red duplex (Dr). Acid clay common at c. 1 m depth.

Small areas of hard-setting duplex where acidic rocks close to surface.

Ya27 Sandy flats with swamps, salt lakes and their lunettes.

On flats: sandy alkaline yellow duplex (Dy 5.43).

On lunettes: alkaline red duplex (Dr 4.43, 5.43, 2.43).

Ub90 Rolling to hilly with lateritic mesas and buttes on some drainage divides and granite tors.

On crests and upper slopes: hard-setting gravelly yellow duplex, acid (Dy 3.81) and neutral (Dy 3.82).

On slopes: various hard-setting acid and neutral red duplex, some with ironstone gravel.

Va64 Shallow flat valleys in which some salinity is usually present.

Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43).

Ca22 Dune and swale formations along Gordon Valley with some fringing lateritic mesas and saline flats.

On dunes: leached sand (Uc 2.21).

On flats and swales: varied yellow duplex (Dy).

On lateritic fringes: yellow duplex (Dy 3.8).

GRAVEL UPLANDS

Tf6 Undulating to hilly dissected lateritic plateau.

Hard-setting gravelly acidic and neutral yellow duplex (Dy 3.81, 3.82, 3.61, 3.62) with some leached sand (Uc 2.33) in valleys.

(Note: rejuvenation of river valleys is less pronounced than in regions further North due to lesser uplift of the land.)
PROBLEMS

* Considerable wind erosion in the North Stirlings district.
* Water erosion, both sheet and gullying.
* Patchy hillside waterlogging associated with duplex soils and seepages.
* Salinity by hillside seepages and valley salting, often severe, in the flat valleys.
* Impeded natural drainage in the flats of unit Ya27 with rising saline groundwater over some 36,000 ha and spread of salinity.
* Flood erosion damage along the trunk stream of the Gordon River (in 1982, possibly exceptional).

NOTE

* Good sub.clover pastures are possible: many are long established.

TREATMENTS

* Careful grazing and cropping management on sandy-surfac ed soils.
* Grade bank and waterway systems are appropriate in most situations but attention is needed to seepage control and accommodation to larger machinery.
* Establish halophytes on selected saline sites, especially Puccinellia for the main areas and Paspalum vaginatum for summer-moist sites.
* In sites with poor natural drainage, research into hydrologic mechanisms and treatment options (drainage/aquifer pumping/tree planting etc.).
* More farm layout plans are needed.
KATANNING ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE ZONE

BEAUFORT RIVER SYSTEM (KA 4)

Landscape/map units  Main soils

Ub90  Rolling to hilly with lateritic mesas and buttes on some drainage divides and granite tors.  On crests and upper slopes: hard-setting gravelly yellow duplex, acid (Dy 3.81) and neutral (Dy 3.82).

On slopes: various hard-setting acid and neutral red duplex, some with ironstone gravel.

X15  Gently undulating sandplain with some lateritic spurs and buttes and low sand ridges.  On spurs and ridges: gravel (KS-Uc 2.12) and gravelly yellow duplex (Dy 5.8).

Main slopes: yellow sandy duplex, neutral (Dy 5.42) or alkaline (Dy 5.43) with leached sand (Uc 2.2) on sand ridges and deeper sandy areas.

Under most of the unit, acid kaolinitic clay at 1-1.5 m.

Va64  Shallow flat valleys in which some salinity is usually present.  Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43).

Va65  Plains with lakes and lunettes and other aeolian deposits covering ironstone gravel ridges.  Complex pattern of various yellow and red duplex soils with sand on younger lunettes.

Ub95  Valley plains with some sandhills, dunes, lateritic gravel and swamps. (Beaufort River Flats)  Hard-setting neutral yellow duplex (Dy 3.42) and sandy neutral duplex (Dy 5.42).

On sandhills and dunes: leached sand (Uc 2.2l) and siliceous sand (Uc 1.2l).

On residual ridges and knolls: gravel (KS-Uc).
Landscape/map units  

**GRAVEL UPLANDS**

**Tf4** Dissected lateritic plateau with gently undulating ridges and narrow incised valleys.

Main soils

On ridge crests: gravel (KS-Uc 4.2) and gravelly yellow duplex (Dy 5.8).

On slopes: hard-setting gravelly yellow duplex (Dy 3.61, 3.61) with some red duplex and sand in places with ironstone gravel and boulders from upslope.

**KA 4**

**PROBLEMS**

* Wind erosion on sandy-surfaced soils unless carefully managed.
* Water erosion both sheet and gullying.
* Many early grade bank systems are poorly maintained and some have too close bank spacing for modern machinery.
* Dissected landscapes create problems of cultivation and land management.
* Patchy hillside waterlogging associated with duplex soils and seepages.
* Salinity by hillside seepages and valley salting is often severe.

**NOTES**

* Good sub.clover pastures are possible: many are long-established.

**TREATMENTS**

* Careful grazing and cropping management on sandy-surfaced soils.
* Grade bank and waterway systems are appropriate in most situations but attention is needed to seepage control and accommodation to larger machinery.
* Need to up-grade early contour systems and to establish new systems.
* More farm layout plans are needed.
* Establish halophytes on selected saline sites, especially Puccinellia for the main areas and Paspalum vaginatum for summer-moist sites.
LAKE GRACE ADVISORY DISTRICT

OLD PLATEAU (LG 1)

UPLANDS

Landscape/map units

SI30 Narrow ironstone gravel ridges with gently undulating pediments and some swamps and lakes. (Unit includes the divide between the Swan-Avon system and South-draining rivers.)

Main soils

On ridges: ironstone gravel (KS-Uc 4.11) with gravelly sand (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.

Main slopes: alkaline yellow duplex, hard-setting (Dy 2.43) or sandy (Dy 4.43, 5.43) with smaller areas of other duplex including those with gley subsoils (dull or grey coloured, frequently waterlogged). Acid clay common at c. 1 m depth.

UF3 Undulating lateritic ridges and slopes. (Minor unit in south-west of district).

Mainly hard-setting yellow duplex soils.

Ms8 Undulating sandplain with long gentle slopes and some abrupt erosional scarps.

On depositional slopes: sandy acid and neutral yellow earths (Gn 2.21, 2.22) with some gravel, and yellow earthy sand (Uc 5.22) often with ironstone gravel below 2m.

On erosional ridges and slopes: ironstone gravel (KS-Uc 4.11) and gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.

Va66 Undulating with lateritic mesas and buttes and small granitic bosses.

Hard-setting alkaline yellow and red duplex (Dy 3.43 and Dr 2.33, 2.43, 3.33) with acid lateritic strata below 1.5 m.

XL7 Slopes and upper valleys. (Similarities with unit Va66).

Sandy neutral and alkaline yellow duplex (Dy 5.42, 5.43).

Associated are various other yellow and red duplex and some leached sand (Uc 2.31).

JJ16 Broken terrain with granitic bosses and tors. (Minor Unit)

Around rocks: shallow often stony or gritty sands (Uc 4.11, 4.33, 4.22).
LG 1

PROBLEMS

* Wind erosion on sandy-surfaced soils unless they are carefully managed, especially those of unit SI30.

* Run-off, sheet erosion and some gullying, especially on the hard-setting duplex soils.

* Grassed waterways are generally lacking though possible waterway sites exist in the higher rainfall parts of the district.

TREATMENTS

* Alternative land management systems need to be developed for sandy-surfaced soils, especially those of unit SI30 still being cleared, probably incorporating the use of windbreaks and plants with high water usage.

* Minimum cultivation systems, including stubble management systems (early burning is hazardous).

* Grade banks and waterway systems on selected favourable sites. Level bank systems may be considered as alternatives.

* More farm layout planning is needed to accommodate the agronomic and contour treatments.
<table>
<thead>
<tr>
<th>Landscape/map units</th>
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<tbody>
<tr>
<td>DD9 Gentle slopes east of Kondinin lakes, with some low gilgais.</td>
<td>Brown and grey-brown calcareous earths (Gc 1.12, 1.22) some with acid clay at depth.</td>
</tr>
<tr>
<td>Oc31 Broad flat Kondinin valley, with some low gilgais.</td>
<td>Hard-setting alkaline loamy red duplex (Dr 2.33) with acid clay strata below 1.8m.</td>
</tr>
<tr>
<td>DD11 Gentle slopes on eastern sides of saline valleys.</td>
<td>Brown or grey-brown calcareous earths (Gc 1.12, 1.22, 2.12). Associated various yellow duplex and some red duplex.</td>
</tr>
<tr>
<td>SI28 Broad flat valleys with some small clay pans and salt lake remnants, with some gypseous lunettes and areas of low gilgais. (Belka-type valley forms)</td>
<td>Hard-setting yellow alkaline loamy duplex (Dy 2.43, 2.33) with acid lateritic clays at 60-120 cm.</td>
</tr>
<tr>
<td>SI29 Plains flanking saline valleys, with some small clay pans and lakes with dunes and lunettes.</td>
<td>Hard-setting alkaline yellow duplex (Dy 2.43) with low rises of sandy alkaline duplex (Dy 5.43). Associated are other duplex soils including some with gley subsoils.</td>
</tr>
<tr>
<td>SVI Saline valleys with salt lakes and channels and their fringing areas, with remnants of old lateritic profile and some rock outcrops. (Baandee-type valley forms)</td>
<td>Fringe areas: various re-salinized yellow duplex soils. On riverine wash: gypseous and saline loams (Um 1.1, 1.2) usually underlain by clay or sand strata at about 30 cm. On dunes and lunettes: various soils with slight development - Uc, Um, Uf. Deposits of common salt, gypsum, lime, alunite.</td>
</tr>
</tbody>
</table>
LG 1 (cont'd)

PROBLEMS

* Occasional flooding with salt encroachment in the Belka-type valleys of unit SI28 and the trunk valleys.

* The calcareous earths of unit DD9 are powdery when dry and prone to wind erosion. Surface salting may occur.

* Soil structure deterioration on the hard-setting duplex soils, especially those of unit SI28.

TREATMENTS

* Drainage and establishment of halophytes on selected saline sites.

* Minimum cultivation and stubble management systems.

* Treatment of soils with structural problems needs further definition and research.
JERRAMUNGUP ADVISORY DISTRICT

OLD PLATEAU (JE 1)

Landscape/map units

Ms8 Undulating sandplain.
(Minor unit in north-east of Jerramungup district)

Sandy yellow earths, earthy sand and gravel

SI30 Narrow ironstone gravel ridges with gently undulating pediments and some swamps and lakes.
(Unit includes the divide between the Swan-Avon system and south-draining rivers.)

On ridges: ironstone gravel (KS-Uc 4.11) with gravelly sand (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.

Main slopes: alkaline yellow duplex, hard-setting (Dy 2.43) or sandy (Dy 4.43, 5.43) with smaller areas of other duplex including those with gley subsoils (dull or grey coloured, frequently waterlogged). Acid clay common at c. 1 m depth.

SI29 Plains flanking saline valleys, with some small clay pans and lakes with dunes and lunettes.

Hard-setting alkaline yellow duplex (Dy 2.43) with low rises of sandy alkaline duplex (Dy 5.43).

Associated are other duplex soils including some with gley subsoils.

On dunes and lunettes: silt (Um) and clay (Uf).

UF3 Undulating lateritic ridges and slopes with some granite tors on slopes.

On ridge crests: hard-setting gravelly yellow duplex (Dy 3.82) and leached sand over boulder laterite in places.

On side slopes: hard-setting neutral duplex, yellow (Dy 3.42, 2.42) and red (Dr 2.32, 3.42), with small areas of sand near tors.

Od7 Undulating with many streams, mostly saline, sandy deposits in larger valleys. Some gneissic rock outcrops.

(Rallinup River system)

Ridge slopes: neutral red duplex (Dr 2.32).

Main slopes: various hard-setting alkaline and neutral red duplex (Dr) with some yellow duplex (Dy).

Some bigger valleys: organic siliceous sand (Uc 1.2).

Od8 Undulating to rolling valley slopes with gneissic rock outcrops and some salt drainage ways.

Hard-setting alkaline red duplex (Dr 2.43). Associated various duplex red (Dr) and yellow (Dy).
PROBLEMS

* Severe wind erosion especially on the sandy-surfaced soils of unit SI30 and of unit Uf3 to a lesser degree.

* Rising saline groundwater causing concern that salinisation may become a major problem in the upper catchment (unit Uf3) and drainage lines of units Od8. Unit SI30 includes the 'Mallee Road Sump' which is the subject of continuing research.

* Water erosion on the more-dissected country and in the incised river valleys.

TREATMENTS

* Alternative land management systems need to be developed for the sandy-surfaced soils, probably incorporating the use of windbreaks and plants with high water usage, possibly including perennial plant species.

* Minimum cultivation systems, including stubble management systems (early burning is hazardous).

* Grade bank systems are generally appropriate for the non-sandplain situations with care given to the selection and management of waterways.

* More farm layout planning is needed to accommodate the agronomic and contour treatments.
JERRAMUNGUP ADVISORY DISTRICT

REJUVENATED NATURAL DRAINAGE ZONE

RAVENSTHORPE DISTRICT (JE 2)

<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM15 Rolling to undulating terrain. (Also a minor unit near Jerramungup)</td>
<td>Cracking clays, brown (Ug 5.37) and grey (Ug 5.27) with country rock at c. 1.5 m in complex association with hard-setting alkaline red duplex (Dr 3.43, 2.43, 2.63) many with some ironstone gravel. On gentler slopes, various hard-setting alkaline yellow duplex (Dy) and grey-brown calcareous earths (Uc).</td>
</tr>
<tr>
<td>BB4 Ranges of greenstone (basic igneous rocks) with some rock outcrops.</td>
<td>On steeper slopes: shallow calcareous loam (Um 5.11). On gentler slopes: cracking clays (Ug 5.37, 5.2).</td>
</tr>
<tr>
<td>Va67 Laterite ridges and dissected slopes with many rock outcrops.</td>
<td>On flat ridge crests: sandy gravelly alkaline yellow duplex (Dy 5.82). Upper hill slopes: various sandy neutral duplex with kaolinized granite at 50-60 cm depth. Main slopes: hard-setting alkaline duplex (Dy 3.43, Dr 3.43).</td>
</tr>
<tr>
<td>Od9 Valley terraces and flats. Some re-salinisation of flats.</td>
<td>Hard-setting alkaline red duplex (Dr 2.43) with deep cracking clays (Ug 5.29, 5.3) on some terraces and some recent alluvium.</td>
</tr>
<tr>
<td>JJ15 Ranges with gentle hilly ridges and some steep slopes and some bare rock walls of quartzites. (Minor unit).</td>
<td>Various shallow yellow duplex (Dy) on the ridges and shallow sand (Uc 4.11), with rock outcrops.</td>
</tr>
</tbody>
</table>
PROBLEM

* Water erosion, both sheet erosion and some gullying.

TREATMENTS

* Grade bank systems are generally appropriate with care given to the selection and management of waterways.
JERRAMUNGUP ADVISORY DISTRICT

COASTAL PLAIN (JE 3)

Landscape/map units

Wd7 Gently undulating plain with some depressions, flats, swamps, lakes and dunes.

Main soils

Sandy acidic yellow duplex containing ironstone gravel (Dy 5.81) or with laterite between the A and B horizons (Dy 5.84), some leached sand and gravel.

On poorly-drained areas: duplex with gley subsoils (Dg 4.42, 4.43) or clay (Ug 5.25).

X16 Plains with many flats, swamps, lakes and some dunes.

(Similar to unit Wd7 but more wet areas).

Sandy neutral yellow duplex (Dy 5.42) and leached sands (Uc 2.2, 2.3).

On poorly drained areas, duplex with gley subsoils or clay.

JERDACUTTUP DISTRICT

Cz1 Gently undulating plain with some lakes, swamps and salt flats.

Ironstone gravel (KS-Uc 2.2) with shallow leached sands (Uc 2.21, 2.22) with underlying ironstone gravel or boulders.

Associated sandy gravelly neutral yellow duplex (Dy 5.82).

COASTAL (JE 4)

A15 Coastal dunes and swales with saline flats, swamps and lakes with some aeolianite.

Calcareous sand (Uc 1.11) on recent fore dunes and siliceous sand (Uc 1.21) on older dunes.

JK11 Granitic outcrops and headlands with some bare rock walls.

Shallow sand (Uc 4.2) and leached sand (Uc 2.3) with some gravelly yellow duplex (Dy) and some calcareous dune sand banked up against the granite.
JE 3

PROBLEMS

* Severe wind erosion on sandy-surfaced soils unless carefully managed, particularly the leached sands.

* Waterlogging, some erosion and some salinity in poorly-drained areas.

* The upper parts of unit Cz1 have rising groundwater and show signs of salinity. Unit Cz1 includes the 'Middle Road Sump' which has some salt-affected drainage lines.

* Leached sands are highly infertile though this feature is somewhat offset by the medium to high rainfall.

TREATMENTS

* Suitable land management systems need to be developed, possibly including the use of perennial plant species.
<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lb10 Gently undulating plain with some granitic bosses and tors.</td>
<td>Grey-brown highly calcareous earth (Gc 1.12) in complex association with hard-setting alkaline duplex, yellow (Dy 2.83, 3.83, 3.73) and red (Dr 3.83, 3.43, 2.33) and other duplex. Acid clay common below 2 m depth.</td>
</tr>
<tr>
<td>DD12 Gently undulating plain with raised gilgais.</td>
<td>Brown and grey-brown calcareous earths (Gc 1.22, 2.22) with highly calcareous earth (Gc 1.12) in gilgai areas. Associated are various yellow duplex. Calcrete (kunkar) underlies soils in places and acid clay common at 1-2 m depths.</td>
</tr>
<tr>
<td>JY1 Undulating with low lateritic rises and small flats and valleys. (Minor Unit)</td>
<td>Low flat-topped rises: ironstone gravel (KS-Uc 4.11) with gravelly sands (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm. Small flats and valleys: various yellow and red duplex, earthy and siliceous sands and calcareous earths.</td>
</tr>
</tbody>
</table>
PROBLEMS

* The calcareous earths are powdery when dry and prone to wind erosion. Surface salting may occur. These soils are slippery when wet and liable to surface sealing.

TREATMENT

* The calcareous earths respond favourably to fallowing. Surface sealing can be alleviated by gypsum applications. A research programme on cultivation techniques is continuing.

* Minimum cultivation and stubble management systems is appropriate for the duplex soils if they are in areas large enough for separate treatment.

* Establishment of halophytes on selected saline sites.
ESPERANCE ADVISORY DISTRICT

OLD PLATEAU

MALLEE DISTRICT (ES 2)

Landscape/map units

SI30  Narrow ironstone gravel ridges with gently undulating pediments and some swamps and lakes.

Main soils

On ridges: ironstone gravel (KS-Uc 4.11) with gravelly sand (Uc 4.11, 2.12) underlain by hardened mottled-zone material at 30-60 cm.

Main slopes: alkaline yellow duplex, hard-setting (Dy 2.43) or sandy (Dy 4.43, 5.43) with smaller areas of other duplex including those with gley subsoils (dull or grey coloured, frequently waterlogged). Acid clay common at c. 1 m depth.

Ya29  Gently undulating plain with many seasonal lakes, clay pans, lunettes and dunes.

Various alkaline sandy and hard-setting yellow duplex soils.

Associated are grey-brown highly calcareous earth (Gc 1.12) with small areas of grey cracking clays (Ug 5.2, 5.5) on flood-liable sites.

Calcrite under soils in places and acid clay common at 1.5-2 m depths.

Leached sands on dunes and lunettes.

Ya30  Landform similar to unit Ya29 but with fewer lakes

Soils similar to unit Ya29 but underlying acid clay deeper, 2-3.4 m.

DD14  Flat to undulating with some low rocky narrow ridges or tors and bosses, shallow valleys, some clay pans and salt lakes with dunes and lunettes.

Brown and grey-brown calcareous earths (Gc 1.12, 1.22, 2.22) most with loamy surfaces, associated with shallow neutral red earth (Gn 2.12) often with rock at lm. In valleys: loamy alkaline red duplex (Dr 1.73, 1.83).

On dunes and lunettes: siliceous sand (Uc 1.2).

In places underlain at 1-1.5m by rock or non-calcareous clays.
ES 2

PROBLEMS

* Wind erosion on sandy-surfaced soils.

* Moderate to severe water erosion, with waterway problems due to deterioration of ground cover in autumn especially in the western mallee.

* Rising saline groundwater causing concern that salinisation may become a major problem.

NOTE

* Further land alienation beyond the present limits appears hazardous in view of uncertainty about rainfall and soil problems, particularly saline groundwater at shallow depths under uncleared land.

TREATMENTS

* Development of stable farming systems aiming to retain ground cover and increase soil water usage. Possible treatments include minimum tillage, careful grazing management and multiple cropping. Windbreaks may be a supplementary measure.

* Research into hydrologic mechanisms and treatment options.

* More farm layout planning is needed to accommodate drainage patterns and agronomic treatments.
ESPERANCE ADVISORY DISTRICT

COASTAL PLAIN (ES 3)

Landscape/map units

MUNGLINUP DISTRICT

Cz1 Gently undulating plain with some lakes, swamps and salt flats.

Ironstone gravel (KS-Uc 2.2) with shallow leached sands (Uc 2.21, 2.22) with underlying ironstone gravel or boulders.

Associated sandy gravelly neutral yellow duplex (Dy 5.82).

ESPERANCE DOWNS

Xd1 Gently undulating plain with some flats, seasonal swamps and lakes and some more strongly undulating land where dissection has begun.

Sandy neutral yellow leached duplex with variable amounts of surface gravel (Dy 5.82) grading into leached sands (Uc 2.21, 2.22) with surface gravel in places and clay at 1-1.5 m.

Associated are various yellow duplex :-

- on plain : sandy, acid with laterite between the A and B horizons (Dy 5.84);
- in shallow valleys : sandy neutral (Dy 5.42);
- in depressions : hard-setting neutral or alkaline (Dy 2.42, 2.43);
- in seasonal swamps : sandy alkaline (Dy 5.43) with some cracking clays (Ug 5.2, 5.3);
- in places regular ridges and flats with sandy leached duplex (Dy 5.8 and 5.4). Most of this unit has clay at depth.

Va68 Incised valleys with some steep and often rocky slopes topped by mesas and buttes of units Cz1 and Xd1.

Hard-setting yellow duplex some with ironstone gravel, alkaline (Dy 3.43) or neutral (Dy 3.82) associated with other yellow duplex and red duplex (Dr 3.43).

Ca26 Granitic bosses and tors as "islands" in units Xd1 and Ya29, Ya30.

(Minor Unit)

Shallow leached sand (Uc 2.22).
ES 3

PROBLEMS

* Waterlogging and rising saline groundwater causing concern that salinisation may become a major problem.

* Wind erosion on land where surface cover is removed by grazing or by fallowing for cropping.

* Water erosion on the sloping sides of the incised river valleys.

TREATMENTS

* Development of stable farming systems aiming to retain ground cover and increase soil water usage. Possible treatments include minimum tillage, careful grazing management and surface drainage. Windbreaks and perennial forage plants may be supplementary measures.

* Research into hydrologic mechanisms and treatment options.

* Grade bank systems are appropriate on the sloping lands if waterway surface cover can be maintained.
<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>A15 Coastal dunes and swales with saline flats, swamps</td>
<td>Calcareous sand (Uc 1.11) on recent</td>
</tr>
<tr>
<td>and lakes with some aeolianite.</td>
<td>fore dunes and siliceous sand</td>
</tr>
<tr>
<td>Ca26 Granitic headlands and off-shore islands.</td>
<td>(Uc 1.21) on older dunes.</td>
</tr>
<tr>
<td></td>
<td>Shallow leached sand Uc 2.22.</td>
</tr>
<tr>
<td></td>
<td>Coastal dunes may be piled up against the rocks.</td>
</tr>
</tbody>
</table>
PROBLEMS

* Fragile sandy slopes with some steep limestone/sand ridges.
* Wind erosion on frontal dunes.
* Low fertility soils.
* Water erosion from tracks and public facilities.

TREATMENTS

* Strategic fencing to exclude stock and people from fragile areas.
* Use of appropriate species for stabilisation.
* Selective and careful burning to avoid erosion.
* Careful planning of access and public facilities.
ALBANY ADVISORY DISTRICT

GORDON RIVER SYSTEM (AL 1)

Landscape/map units

Ya31 Low-level lateritic plateau with gently undulating plains and some swamps and lakes. (Includes Gordon/Pallinup divide) Main soils

Gravelly rises : hard-setting gravelly yellow duplex (Dy 3.82).

On plains : various yellow duplex (Dy) with lesser areas of various red duplex (Dr). Acid clay common at c. 1 m depth.

Small areas of hard-setting duplex where acidic rocks close to surface.

Ya27 Sandy flats with swamps, salt lakes and their lunettes. On flats : sandy alkaline yellow duplex (Dy 5.43).

On lunettes : alkaline red duplex (Dr 4.43, 5.43, 2.43).

Uf3 Undulating lateritic country. (Minor unit in Albany district) Hard-setting yellow duplex soils.

Ub90 Rolling to hilly with lateritic mesas and buttes on some drainage divides and granite tors. On crests and upper slopes : hard-setting gravelly yellow duplex, acid (Dy 3.81) and neutral (Dy 3.82).

On slopes : various hard-setting acid and neutral red duplex, some with ironstone gravel.

Va64 Shallow flat valleys in which some salinity is usually present. Hard-setting yellow duplex, neutral (Dy 3.42) and alkaline (Dy 3.43).

Ca22 Dune and swale formations along Gordon Valley with some fringing lateritic mesas and saline flats. On dunes : leached sand (Uc 2.21).

On flats and swales : varied yellow duplex (Dy).

On lateritic fringes : yellow duplex (Dy 3.8).
AL 1

PROBLEMS

* Some wind erosion on sandy-surfaced soils, especially of unit Ya27.
* Water erosion, both sheet and gullying.
* Patchy hillside waterlogging associated with duplex soils and seepages.
* Salinity by hillside seepages and valley salting, often severe, in the flat valleys.
* Impeded natural drainage in the flats of unit Ya27 with rising saline groundwater over some 36 000 ha and spread of salinity.
* Saline groundwater at shallow depths restrict sites for obtaining stock water supplies.
* Flood erosion damage along the trunk stream of the Gordon River (in 1982, possibly exceptional).

NOTE

* Good sub.clover pastures are possible: many are long established.

TREATMENTS

* Careful grazing and cropping management on sandy-surfaced soils.
* Grade bank and waterway systems are appropriate in most situations but attention is needed to seepage control and accommodation to larger machinery.
* Establish halophytes on selected saline sites, especially Puccinellia for the main areas and Paspalum vaginatum for summer-moist sites.
* For sites with poor natural drainage, research into hydrologic mechanisms and treatment options (drainage/aquifer pumping/tree planting/increasing water use by intensifying rotations).
* More farm layout plans are needed, incorporating reticulation where there are only limited stock water sources.
<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca24 Gently undulating plain with some small swampy areas. (Merges into unit Wd7).</td>
<td>Complex association of: shallow leached sands (Uc 2.21, 2.32) on boulder laterite layers; gravel (Ks-Uc 2.12) on hardened mottled-zone material; gravelly yellow acid duplex (Dy 5.81) and sandy duplex with laterite between the A and B horizons (Dy 5.84).</td>
</tr>
<tr>
<td>Wd7 Gently undulating plain with some depressions, flats, swamps, lakes and dunes.</td>
<td>Sandy acidic yellow duplex containing ironstone gravel (Dy 5.81) or with laterite between the A and B horizons (Dy 5.84), some leached sand and gravel. On poorly-drained areas: duplex with gley subsoils (Dg 4.42, 4.43) or clay (Ug 5.25).</td>
</tr>
<tr>
<td>X16 Plains with many flats, swamps, lakes and some dunes. (Similar to unit Wd7 but more wet areas).</td>
<td>Sandy neutral yellow duplex (Dy 5.42) and leached sands (Uc 2.2, 2.3). On poorly drained areas, duplex with gley subsoils or clay.</td>
</tr>
<tr>
<td>XCl Low hills and ridges.</td>
<td>Gravelly sandy yellow duplex, neutral (Dy 5.62), and acid (Dy 5.81) with some shallow sands (Uc 4.1, 4.2) and dark loam (Um 4).</td>
</tr>
</tbody>
</table>

**MIDDLE KALGAN RIVER VALLEY**

<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ub94 Valley slopes topped by mesas and buttes of unit Ca24, with gently undulating plain and some saline flats.</td>
<td>On slopes: alkaline red duplex (Dr 3.43) and hard-setting yellow duplex, alkaline (Dy 3.43) and neutral (Dy 3.82). On valley plain: hard-setting neutral duplex, yellow (Dy 3.42) and red (Dr 2.42).</td>
</tr>
</tbody>
</table>

**LOWER KALGAN RIVER VALLEY**

<table>
<thead>
<tr>
<th>Landscape/map units</th>
<th>Main soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca21 Broken terrain with deep sand deposits and rock outcrops.</td>
<td>Leached sands (Uc 2.21, 2.3) and some hard-setting neutral duplex.</td>
</tr>
</tbody>
</table>
PROBLEMS

* Wind erosion, especially on the sandy-surfac ed soils of unit Wd7.

* Impeded natural drainage especially in unit Ca24 with concern that salinity will spread.

* Seasonal waterlogging of duplex soils.

* Moderate water erosion and spread of salinity along the middle Kalgan valley.

* Inherent infertility of leached sands somewhat offset by the medium to high rainfall.

TREATMENTS

* Research into hydrologic mechanisms and treatment options, including crop rotation strategies to increase water use.

* Establish halophytes on selected saline sites.

* Wider use of minimum tillage techniques.

* Grazing management guidelines are needed, especially to maintain adequate ground cover during the dry months.

* Alternative pastures and crops for the leached sands, including perennial species.

* Agronomic treatments and strategic diversion banks should be sufficient to control water erosion.

* More farm layout plans are needed to separate soil types suited to cropping from those which need to be permanently under pasture.
ALBANY ADVISORY DISTRICT

HIGH-RAINFALL REGION - NORTH (AL 3)

Landscape/map units

Uf2  Gently undulating lateritic plateau.

Main soils

Hard-setting gravelly yellow duplex (Dy 3.82) with sandy neutral duplex (Dy 5.42) at lower levels.

Ub93 Valley slopes below unit Uf2.

Hard-setting neutral yellow duplex (Dy 3.42, 5.62) with variable areas of red duplex (Dr 2.32, 5.62).

Tf6  Undulating to hilly dissected lateritic plateau.

Hard-setting gravelly acidic and neutral yellow duplex (Dy 3.81, 3.82, 3.61, 3.62) with some leached sand (Uc 2.33) in valleys.

Ta9  Valley slopes below unit Tf6.

Hard-setting yellow duplex (Dy 3.21, 3.22, 3.41) with variable areas of red duplex (Dr 2.21, 2.22, 2.41).

Cd22 Gently undulating lateritic plateau with some granitic tors.

Leached sands (Uc 2.12, 2.21) with ironstone gravel or boulders as shallow as 15 cm with mottled clay below 0.6-1.5 m.

(Merges along its southern boundaries with unit Cb42 in region AL 4).

Cb43 Plain with swampy flats, shallow swamps and lakes and some lunettes.

Associated gravelly bleached sandy acid duplex (Dy 5.81) and flats of leached sand (Uc 2.33).

Various leached sands some with thin surface peat and some duplex with yellow or gley subsoils.

Lunettes of siliceous sand with surface organic staining (Uc 1.2).

Lk21 PORONGURUP RANGE

On lower slopes: friable acid yellow duplex (Dy 5.41).
AL 3

PROBLEMS

* Water erosion on gravelly slopes.
* Waterlogging on duplex soils.
* Salinity of hillside seepages and valley salting.
* Identification of recharge areas.

TREATMENTS

* Contour working and better designed firebreaks and access systems.
* Shallow interceptor drainage into clay layers to reduce slope length.
* Establish halophytes on saline sites.
* Establish woodlot and tree areas to increase water usage, especially on recharge areas.
* Establish perennial pastures.
* Modify cropping practices to increase water usage.
* Farm planning to improve land use.
* Grade banks and waterway systems.

NOTE: The high-rainfall region is included to complete coverage of the Albany advisory district. (As noted on page 2, other high-rainfall districts, comprising the Metropolitan, Harvey, Bunbury, Busselton and Manjimup advisory districts, are not dealt with in this publication.)

The division into northern and southern sectors, given here, is not delineated on the district map. The northern sector, particularly, has a wide range of rainfall and of enterprises.
ALBANY ADVISORY DISTRICT

HIGH-RAINFALL REGION - SOUTH (AL 4)

Landscape/map units

Ca23  Undulating plain with prominent sequence of ridges, some swamps and lakes. Similar to unit Wd7 to East (in region AL 2) and unit Cb42 to West.

Main soils

On ridges: various gravelly yellow and some red duplex with areas of boulder laterite.

Main areas: leached sands (Uc 2.2, 2.3) and on dunes near lakes and swamps.

Swampy flats: small areas of sandy neutral yellow duplex (Dy 2.42).

Cb42  Plain with swampy flats broken by low sandy or gravelly knolls.

Leached sand (Uc 2.33) with in places thin surface peat.

On knolls, leached sands (Uc 2.2, 2.3) over ironstone gravel or gravel exposed.

Cb41  Low-lying wet plain with swamps, lakes, some estuarine areas, and some granitic tors on slopes.

Leached sands (Uc 2.33, 2.32) some with thin peaty surfaces, and some ironstone gravel from unit Ca23.

In swamps and depressions: a variety of peaty and other soils and diatomaceous earth.

Xl4   Swamps plain with some granitic tors.

Sandy neutral yellow duplex (Dy 5.42) and leached sand (Uc 2.33) with low ridges of gravelly yellow duplex.
PROBLEMS

* Low fertility soils.
* Non-wetting sands and staggered germination.
* Waterlogging of duplex soils.
* Hillside and valley salinity.
* Moderate firebreak erosion.
* Flooding of flats for 6-7 months of the year.

TREATMENTS

* Improved fertiliser use, including potash applications on deep-sand soil types.
* Use of alternative pasture species including perennial pastures.
* Interceptor drains on duplex soils.
* Chemical firebreaks for appropriate sites.

* Drainage of flats. Some connection into government drainage schemes is possible.
* Use summer fodder crops on swamps.
ALBANY ADVISORY DISTRICT

COASTAL (AL 5)

Landscape/map units  Main soils

(West)

Ca20  Coastal dunes with swampy inter-dune flats.  Frontal dunes of unconsolidated calcareous sand (Uc 1.11) with plains of similar sand with small freshwater swamps.

Inland dunes of leached sand with organic staining with bleached then coloured lower horizons (Uc 2.21) overlying calcareous sand at 1-2 m depth.

Swampy inter-dune flats with compact pan (Uc 2.34).

(East)

A15  Coastal dunes and swales with saline flats, swamps and lakes with some aeolianite.  Calcareous sand (Uc 1.11) on recent fore dunes and siliceous sand (Uc 1.21) on older dunes.

JK11  Granitic outcrops and headlands with some bare rock walls.  Shallow sand (Uc 4.2) and leached sand (Uc 2.3) with some gravelly yellow duplex (Dy) and some calcareous dune sand banked up against the granite.
PROBLEMS

* Extremely steep limestone/sand ridges.

* Fragile sandy slopes.

* Wind erosion on frontal dunes.

* Low fertility soils.

* Water erosion from carparks etc.

TREATMENTS

* Strategic fencing to exclude stock and people from fragile areas including dunes and to prevent grazing of steep ridges.

* Use of appropriate species for stabilisation.

* Selective and careful burning to avoid coastal erosion.

* Careful planning of public parking areas etc. to avoid erosion of tracks and access ways.
REFERENCES


Rural Land Use in Western Australia (map), W.A. Department of Lands and Surveys, 1981.

Sawkins, D.N. The agriculture and land descriptions of the Midlands, Wongan Hills and Dalwallinu districts of Western Australia. W.A. Department of Agriculture, 1981.
APPENDIX 1

MAJOR REGIONS

1. The Old Plateau (outer wheatbelt)

The Old Plateau or 'outer wheatbelt' lies inland of the coastal plains and of the limits of geological re-juvenation of the river systems. It extends to the present limits of dryland (non-irrigated) agriculture.

The region generally is a gently undulating plateau with wide mostly convex divides, long gentle slopes and broad valleys. The main valleys, up to 18 km wide, have chains of lakes and channel country, mostly very saline, the remains of ancient river systems which now rarely flow as connected systems. The gradients of these valleys are very low, generally about 1 in 1500 or less.

The main valleys constitute local base levels for the geological development of tributary valleys most of which have low gradients. In places some deeper tributary dissection has occurred resulting in localised landforms similar to those of the region of rejuvenated natural drainage.

The uplands are mostly covered with sand and gravel plains which originally carried heath vegetation. The lower slopes and valleys have extensive areas of hard-setting yellow duplex soils with, in the north-eastern districts, slightly alkaline red duplex soils and, in the northern districts, red earths underlain by extensive hardpans. Calcareous loams, many quite saline, occur near the lake systems. The natural vegetation of the slopes and valleys was mixed woodlands of York gum and salmon gum with morrel, ginlet and more localised species, with extensive areas of mallee vegetation in the south and south-east.

There are only small reserves in the northern and eastern sectors where land alienation was mostly completed by 1930 especially of the heavier soil types. There are some big reserves and more Crown land in the south-east where alienation, especially of the mallee and the "light lands", mostly occurred after 1950 and development is still continuing.

Average rainfall of the region ranges from 400 mm to about 275 mm with a distinct component of patchy summer rain which, over the long term, comprises a third or more of the annual total.

This large region, over 12 million hectares, is devoted to extensive cereal growing, mainly wheat, with stock raising, mainly sheep for wool.

The proportion of cleared land sown to crop each year is lower in the sectors with higher rainfall and grades to 60 per cent or over on the drier fringes. Wheat comprises over 85 per cent of the total crop and the proportions of both total crop and wheat were increasing up to the mid 1980's.

Some 60 per cent of the cleared land, overall, has been sown at some time to improved pasture species but the subterranean clovers have been much reduced in the dry years from 1969 onwards and by the increased intensity of cropping. Medics are better able to survive in the present conditions but available varieties are suited only to a limited range of soil types. The overall stocking rate is about 1.3 dry-sheep-equivalents per hectare, ranging from about 0.7 DSE/ha in the drier districts to over 2 DSE/ha in districts such as Bruce Rock and Corrigin.
Salt encroachment has affected a little under two per cent of the cleared land overall. It is generally more severe in the longest-settled and most-cleared parts of the zone and often affects what were originally the more productive soil types.

From the 1979 salt-land survey, in Shires which are entirely or largely within this zone, the following examples show the percentage of cleared land affected by salt encroachment with, in brackets, the percentage of cleared land in each Shire: Tammin Shire, 6.1% (90%); Dowerin, 4.0% (75%); Dumbleyung, 3.7% (85%); Corrigin, 3.0% (77%); Kulin Shire, 0.5% (72%).

Though salt encroachment undoubtedly results from land clearing in the environment of the agricultural zone, there are differences in vulnerability between land systems. Some tributary valleys in the outer wheatbelt, the "Merredin-type valleys" as described by Bettenay and Mulcahy (1972), are usually not affected by surface salinity.

The figures given for salt encroachment (secondary salinisation) do not represent all the salt land in the outer wheatbelt. There are considerable areas of saline flats and saline playas in the ancient river courses some of which were salt long before any agricultural development (primary salinity). Some areas were never included within farm boundaries and so are excluded from the farm land statistics. Valleys which were saline before land clearing are mostly those in map units SV2 and SV4. Valleys denoted by map unit SV1 have become more saline since development. Originally the lakes carried fresh water and the soils were mostly non-saline though seasonally waterlogged.

Wind erosion is a considerable hazard on most soil types in this zone. It was especially prevalent in the era of long fallows between the two World Wars and has become so again in the series of droughts and dry years from 1969 onwards.

Water erosion occurs as the result of scattered intense summer thunderstorms when ground cover is seasonally reduced and in early winter during the cultivation period before crop growth provides sufficient cover. Flooding in the low-gradient valleys is an occasional problem following prolonged winter rains.

2. Regions of rejuvenated natural drainage (inner wheatbelt)

The inland boundaries of the 'inner wheatbelt' regions are the limits of the geological rejuvenation of river systems. They are marked by the downstream ends of the salt lake systems of the outer wheatbelt - the 'Meckering Line'. The main region, from about Watheroo southwards, is bounded on the west by the gravel zone of the Darling Range or by the State Forests. Separate regions include the dissected country of the Chapman Valley, the middle Irwin basin, the Phillips River (Ravensthorpe) district and a small adjacent belt near Jerramungup.

Rejuvenation of the natural drainage incised deeper, narrower valleys into the Old Plateau forming steeper, shorter slopes and different associations of soils from those in the outer wheatbelt. The once-extensive lateritic cover of the plateau has been reduced mainly to breakaways and gravelly soils on the ridges with only limited sandplains. On many lower slopes shallow, relatively fertile soils have formed directly from basement rocks.

The floors of some of the tributary valleys, such as that of the Mackie River near York, are underlain by lateritic palloid-zone material and suffer from salt encroachment while the main trunk valley of the Avon River is mostly salt-free.
Land alienation was mostly completed by 1930 and Crown reserves are generally small, the main ones being the forestry reserves at Dryandra near Narrogin. In many instances, vegetation in the smaller Crown reserves is deteriorating because of the use of reserves as sources of gravel for road building.

The natural vegetation of the main zone was mainly wandoo woodland with associated species such as York gum. As with other cereal-growing districts, concern has been expressed in recent years that native trees remaining along road verges, fence lines and in unfenced situations on farms are not regenerating and are deteriorating through fires, grazing and injudicious handling of some herbicides. Preserving the remaining native vegetation will be difficult and costly.

Average rainfall of this zone ranges from 600 mm to about 375 mm.

Sheep for wool and meat are the main livestock carried at an overall stocking rate of over 3 dry-sheep-equivalents per hectare. About 30 per cent of the total cleared area is sown to crops each year and that proportion was increasing up to the mid 1980's. Wheat constitutes about two-thirds of the total crop.

Over 80 per cent of the cleared land has been sown at some time to improved pasture species, at first mainly Dwalganup subterranean clover which was later mostly replaced with less-oestrogenic sub.clovers. The main associated species sown was Wimmera rye-grass which in the last decade has also been recognised as having toxicity problems for sheep in some circumstances.

Salt encroachment has affected about 1,85 per cent overall of cleared land in the zone. Katanning Shire is the worst affected with 4.5 per cent of its cleared land affected by salt (1979 salt land survey). In years of above-average rainfall, waterlogging may reduce areas sown to crops and severely limit crop growth. Waterlogging may be treated by a modification of conventional contour banks by forming deeper bank channels to intercept seepage.

These regions have relatively steep slopes which are often topped by water-shedding features such as ironstone breakaways ("mallet hills") and granite outcrops, and have shallow loamy and duplex soils. Even with a moderate cropping regime, water erosion is a hazard. The increase in the proportion of land sown to crops has increased the risks of water erosion. There has also been a trend towards cropping steep hill slopes previously regarded as suitable only for grazing.

These regions have been a main focus of the now "traditional" control measures of contour banking associated with grassed waterways and changes to the original "on-the-square" internal fencing layouts to make contour farming more convenient and efficient. These established measures are still generally appropriate to this zone. Some modifications are needed to improve seepage control and to accommodate minimum-cultivation techniques and the trend to larger cropping machines.
3. The West Coastal Plain

The west coastal region comprises the "Midlands" and the sandy plains extending to the south boundary of the Kalbarri National Park.

The region is divided from the 'wheatbelt' zones on the ancient plateau to the east mainly by the continuation of the Darling fault-line, though this geological boundary is obscured where similar sandy soils adjoin in both zones.

This zone is a gently undulating plain almost entirely covered with sandy-surfaced soils underlain by sedimentary rocks. Small areas of ancient sedimentary rocks outcrop in the north. The river valleys are narrow and bounded by sandplains or laterite-covered slopes topped in places by breakaways.

There is an almost continuous wide belt of coastal dune systems with intervening swales, the inland dunes being ancient and extremely leached.

Inland of the coastal dune systems, there are extensive areas with gravelly lateritic ridges with deep sands in the valleys, the soils being extremely variable at farm scale, other major soils being deep yellow and grey sands.

The region has some moderate-sized national parks, areas of vacant Crown land and of State Forest, especially softwood plantations.

Annual rainfall of the region ranges from over 600 mm in the south-west to about 400 mm on the inland boundary in the north.

The farming system is extensive grazing, mostly of sheep, with about 20 per cent of the cleared land being cropped each year. Growing lupins for grain and grazing, though typically associated with the 'Midlands', accounts usually for less than 10 per cent of the total area cropped each year. About 80 per cent of the cleared land has been sown to improved pastures at some time and the overall stocking rate of this northern sector is a little under 4 dry-sheep equivalents per hectare.

Establishment of improved pastures is difficult on the many areas of deep sands. The complex patterns of poorly-stabilised sands in valleys flanked by lateritic ridges which readily shed water present acute problems of land protection and management and of farm layout.

Salt encroachment has affected about 0.6 per cent of the cleared land. Appropriate land conservation treatments are agronomic and improved management practices more than conservation earthworks.
4. **The South Coastal Plain**

The coastal plain extends 40 to 50 kilometres inland from the south coast between Albany and Cape Arid. It is bounded to the west by the high rainfall zone and to the east by the Cape Arid National Park. On the north it is bounded by the Stirling Range National Park, by the inner wheatbelt, including the Salmon Gums district, and by Crown land. It includes the coastal Cape Le Grand and Stokes National Parks, and the Fitzgerald River National Park which divides it into western and eastern (Esperance Downs) agricultural sectors.

The coastal plain, which is low and very gently undulating, is covered with the sandy upper horizons of the lateritic profile. Exposures of the underlying gneiss-granite occur mostly in the western sector. Shallow swales with swamps, and small lakes, mostly brackish, are common. The valleys of the short, south-flowing rivers are narrow and incised, especially in the eastern sector, with steep and often rocky side slopes topped by ironstone of the edge of the lateritic plain.

On the Esperance Downs the soils are mainly duplex with sandy surface, including varying amounts of gravel, over-lying clay which may be as deep as 1 to 1.5 metres. In the Albany district the sandy surfaces are underlain by gravel or cemented laterite.

Annual rainfall of the zone ranges from 875 mm average near Albany to 400 mm or less on the inland margin.

The area of south coastal zone is about 2 million hectares of which about half is cleared land. Unalienated land comprises about 20 per cent of the zone and uncleared land on farms 30 per cent.

Over 80 per cent of the cleared land has been sown at some time to improved pasture species but in the '70s the clovers have suffered from persistence problems in the series of dry years and, in places, from root-rotting diseases. Both sheep and cattle are grazed at an overall stocking rate of about 4 dry-sheep equivalents per hectare. Between 20 and 25 per cent of the cleared land is sown to field crops each year.

Salt encroachment has affected about 0.8 per cent of the cleared land in the zone. Its incidence is more severe in the western sector but appears to be increasing on the Esperance Downs.

In recent dry years, with late starts to the growing season and related pasture deterioration, sandy-surfaced soils in this zone and adjacent parts of the Jerramungup district suffered several severe wind erosion events. Wind erosion and fear of salt encroachment are the conservation problems of current concern, leading to widespread re-appraisals of grazing and cropping management, and investigations into the roles of windbreaks and of deep-rooted plants including trees and lucerne.
APPENDIX 2

VALLEY FORMS

Most river systems in the agricultural districts, especially the longer ones, have a sequence of valley forms along their courses, caused by geological erosion. The valley forms have typical physical features with soil conservation consequences in terms of slopes, soil associations, drainage and incidence of primary and secondary salinity.

Valley types, recognized in earlier studies, were named and characterised by Bettenay and Mulcan (1972).

Valley forms east of the Darling Scarp, apart from their minor headwaters, were characterised in three groups related to the major regions described in Appendix 1, as follows:

<table>
<thead>
<tr>
<th>Valley Forms</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old forms:</td>
<td>Old Plateau</td>
</tr>
<tr>
<td>- Merredin type</td>
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<tr>
<td>- Belka type</td>
<td></td>
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<tr>
<td>- Baandee type</td>
<td></td>
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<tr>
<td>Mature forms:</td>
<td>Rejuvenated drainage</td>
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<tr>
<td>- Mortlock</td>
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<td>- Beraking</td>
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<td>- Avon</td>
<td></td>
</tr>
<tr>
<td>Young forms:</td>
<td>Rejuvenated drainage</td>
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<tr>
<td>- Darkin</td>
<td></td>
</tr>
<tr>
<td>- Helena</td>
<td></td>
</tr>
</tbody>
</table>

**Merredin-type valleys of the Old Plateau**

Merredin-type valleys have the following features:

- They are tributary to Belka and Baandee-type valleys.
- Up to 3 km wide.
- Floors are 30 m to 60 m below adjacent uplands: flat or slightly concave in cross-section.
- Gradients 1 in 250 in headward sections decreasing to 1 in 500.
- Natural drainage lines are ill-defined: water moves in broad shallow sheets following heavy rain.
- Floors have thin sheets of colluvium usually overlying older more clayey deposits.
- Underlying the valley floors in most places are acid lateritic mottled-zone and pallid-zone material, the latter usually exceeding 30 m in thickness.
Groundwater, where present, is saline but generally it occurs at depth so that surface soils are mostly not affected by salinity.

Soils are mostly hard-setting red duplex. There are some sandy-surfaced alkaline yellow duplex soils with underlying siliceous pan. Some cracking clays occur near creek lines.

Map units representing these valleys are: 0c31, 0c34, Vb2.

**Belka-type valleys of the Old Plateau**

Belka-type valleys have the following features:

- They are major tributaries to Baandee-type valleys or in places are trunk valleys.
- Up to 6 km wide.
- Floors are 30 m to 60 m below adjacent uplands: flat in cross-section with slight rises to their depositing stream channels.
- Gradients of tributary valleys about 1 in 700 with slight concave longitudinal profile. Gradient of trunk valleys is about 1 in 1500.
- Natural drainage lines are ill-defined and braided: water moves in broad sheets following heavy rain.
- Floors have alluvial deposits 1 m to 3 m thick, sandy near the depositing drainage lines, more clayey on the broad flats between streams.
- Under the alluvium are extensive remnants of acid lateritic mottled-zone and pallid-zone material, the latter exceeding 30 m in thickness in most places.
- Saline groundwater occurs in the pallid-zone material at depths less than 6 m in many places: there has been some development of surface salinity.
- Soils are mostly hard-setting alkaline yellow duplex with some cracking clays on the floodplains.
- Map units SI28, SI29, Va70 (Moora advisory district), Ya28 (Merredin advisory district). Map unit Vd6 near Moora denotes an anomalous valley form due to an apparent capture by the Moore River of what was earlier part of the Avon River system.

**Baandee-type valleys of the Old Plateau**

Baandee-type valleys have the following features:

- They are major trunk valleys with extensive salt lake chains and flats.
- Commonly 10 km and up to 19 km wide.
- Floors are about 60 m below adjacent uplands, the lakes being cut by wind deflation 1.5 m to 6 m below the valley floors, usually to the highly saline watertable.
. Gradients about 1 in 1500.

. Following heavy rain, water flows to the lakes which may fill and spill over in broad sheets. The lake chains are blocked with soil debris and rarely flow as connected systems and then usually only in some sections of these very long valleys.

. Wind-formed dunes and lunettes may be 6 m to 9 m high. Aeolian and alluvial materials overlie acid lateritic and kaolinized materials which are mostly deep, though rock does outcrop on lake floors in places.

. Soils are mostly shallow gypseous and saline loams, calcareous earths and various saline alkaline yellow or red duplex soils developed on alluvium. The most extensive form of secondary salinisation in the agricultural districts has occurred by lateral and headward encroachment in these valleys. In places unaffected soils exist quite close to the deeper-cut lakes.

. Map units SV1, SV2, SV4.

Mortlock-type mature valleys

Mortlock-type valleys have the following features:

. They are trunk and tributary valleys downstream of Baandee-type valleys and of the 'Meckering line' limit of river rejuvenation.

. Up to 5 km wide.

. Floors are 30 m to 45 m below adjacent uplands in the Northam district. Valleys are somewhat shallower in the south.

. Gradients of about 1 in 650.

. They have defined drainage channels which dry to pools of salty water in summer.

. On the floors and terraces are laterized water-laid deposits with deeper sandy surfaces towards the heads and sides of the valleys, overlying deep lateritic pallid-zone material. Laterites extend as spurs down the valley sides.

. Groundwater in the pallid-zone material is saline and has caused considerable salt encroachment in some valleys following clearing.

. Soils are mostly hard-setting alkaline yellow duplex, many having a high gravel content.

. Map units Va63, Va64, Va65, Ub95, Ub96.
Beraking-type mature valleys

. Beraking-type valleys occur in the upper reaches of the Hotham river system.

. Features generally similar to Mortlock-type valleys in the districts covered by this publication.

. Map units Ub95, Ub96 (Hotham system).

The Avon Valley

. The trunk valley downstream of the Mortlock type valleys.

. Up to 5 km wide.

. Floor is 45 m to 75 m below the adjacent uplands.

. Gradient of about 1 in 250 with an incised main channel.

. The floor has recent alluvium overlying truncated Mortlock lateritic and weathered material of no great thickness. The valley sides are generally non-lateritic: there are some iron-cemented scree slopes on the lower sides.

. Groundwater is not extensive and the valley is generally unaffected by salinity.

. Soils are mainly hard-setting red duplex with minor patches of hard-setting alkaline yellow duplex soils.

. Map unit Oc30.

Young valley forms of the gravel zone

. Young valleys are steep-sided and narrow.

. The floors are 60 m or more below the adjacent lateritic uplands and are restricted in area.

. The streams are not at grade, having mostly rocky floors with waterfalls and rapids. Streams are fed by groundwater from deep pallid-zone material in the uplands and are nearly permanent (streams further west in the Darling Range are permanent).

. The valley sides are non-lateritic with many rock exposures.

. Soils are mainly hard-setting acid red duplex with restricted areas of acid red earth in the valley bottoms.

. Map unit Mw31.
APPENDIX 3

SOME LESS-FAMILIAR TERMS

Aeolianite: a deposit or layer of material, originally wind-borne (aeolian), now hardened or cemented into a rock-like formation. The cementing agent should be specified, but in this context it is usually lime (i.e. calcareous aeolianite).

Alluvium/alluvial: soil parent-material deposited by stream action. (See also 'Colluvium'.)

Alunite: or 'alumstone', a basic sulphate of aluminium and potassium formed as a breakdown product of rocks underlying some Baandee-type valleys.

Barchan: a wind-formed dune crescent-shaped in plan with the horns of the crescent projecting downwind. Several individual dunes may coalesce complicating or obscuring the crescent shape. Mentioned in the description of Baandee-type valleys SV2. (See also 'Lunette'.)

Boss: a massive exposure of granitic or gneissic rock, often shaped like an irregular flattened dome.

Butte: an isolated flat-topped hill, usually with breakaways and exposures of hardened laterite or hard rock on one or more of its upper margins. The cap rock may be reduced to a very small area. (See also 'Mesa'.)

Calcrete: a soil or soil horizon hardened and cemented by redistributed lime. The hardened material consists of quartz, sand, roots and other detrital material cemented by secondary lime. Calcrete is sometimes referred to as "kunker".

Colluvium/colluvial: deposited soil parent-material which has been transported by gravity or by sheet-wash.

Lunette: a wind-formed dune on the downwind sides of lakes in Baandee-type and other saline valleys. Generally similar in shape to barchans but with the crescent horns projecting up-wind (usually to the west or north-west). Usually formed of material with a high content of silt and clay blown from the lake floors.

Mesa: a flat-topped structure larger than a butte and from which buttes are usually derived by geological erosion. Often with breakaways and exposures of hardened laterite or hard rock on one or more of its upper margins.

Structured (of soil or subsoil): natural aggregation of soil particles into blocks (peds) with some geometrical shape such as cubes or prisms; as opposed to massive soil horizons. Soils which naturally form surface peds when dry are called 'self-mulching'.

Tor: natural heap of sub-angular or rounded large boulders associated with exposures of jointed rock.
APPENDIX 4

SOIL DESCRIPTIONS

Primary profile forms (summary)

U - Uniform texture throughout profile.

May have a surface crust.

Uc (coarse) sands, sandy loams.
Um (medium) loams, clay loams.
Uf (fine) clays: non-cracking.
Ug clays: cracking seasonally.

G - Gradational texture throughout profile.

Change of less than 1.5 texture classes throughout profile.

May have clear visual boundaries.

Gc calcareous throughout profile.
Gn non-calcareous in part or whole of profile.
Lime may be present in B, C or D horizons.

D - Duplex or texture contrast in profile.

More than 1.5 texture class difference between A and B horizons (eg. sand over sandy clay loam, or loam over clay).
Laterite layer may occur between A and B horizons.
B horizon may be whole-coloured or mottled.
Subdivided according to colour of upper 15 cm of B horizon, as follows:

Dr (red)
Dy (yellow)
Dg (gley) Dull greyish colours due to waterlogging.
Dd (dark) Dark other than dull colours.

KS- prefix.

Ironstone gravel comprises 60% or more of the mineral material. The code following KS- describes the other material (matrix).
The terms acid, neutral and alkaline refer to the trend or changes in pH values down soil profiles.

**Strongly Acid:**
- The A₁ horizon has a value higher than pH 7.0 while the deep subsoil (the lower part of the B horizon or the B-C horizon) has a value less than pH 6.5.
- A₁ values less than pH 7.0.
- Deep subsoil values less than pH 6.5.

**Neutral:**
- Deep subsoil between pH 6.5 and pH 8.0.

**Alkaline:**
- Deep subsoil values higher than pH 8.0.

**Bleached horizons:**
- The A₂ horizons of many soils are much paler than adjacent horizons, being near-white or white either irregularly or as a whole. This feature indicates leaching of mineral constituents into, usually, a lower layer, and reduction in fertility.

**Gley horizons:**
- Horizons with a dull greyish, blueish or greenish coloration indicating permanent or periodic wetness. Mottles in the gley horizon may have reddish hues if oxidising conditions occur periodically.

Bleaching and gleying may indicate historic conditions and the present soil environment needs to be determined.
SOIL PROFILE FORMS (FACTUAL KEY - NORTH COTE)

Uc (coarse). Sands/loamy sands of uniform texture throughout profile:

1.11 Calcareous.
1.2 Siliceous: 1.21 pale colour. 1.22 bright colour.
1.4 Siliceous, firm and coherent: 1.43 deep colour.

2 Leached, with bleached A₂ horizon underlain by:
   2.12 non-calcareous rock.
   2.21 coloured sand (podzol).
   2.22 mottled sand (iron organic podzol).
   2.3 various compact, cemented or pan-like horizons.
      (2.32, 2.33, 2.34)

4 Shallow or podzolic sands with unbleached A₂ horizon underlain by:
   4.1 weathered rock or carbonate pan.
   4.2 coloured B horizon.
   4.3 cemented pan.
      4.11 skeletal.
      4.22 podzol.
      4.33 groundwater podzol.

5 With earthy fabric below the surface:
   5.21 brighter colours. 5.22 darker colours.

6 Coherent sand with slight ped structure:
   6.11 grey-brown, shallow over weathered rock.

Um (medium). Loams/clay loams of uniform texture throughout profile:

1.1 Calcareous.
1.2 Siliceous.
1.4 Coherent and firm:
   1.43 bright colour below darkened surface.

4.1 Mostly shallow, underlain by weathered rock or carbonate pan.
4.2 Different coloured porous B horizon. Variable depth.

5 Weakly layered:
   5.11 Calcareous, powdery, less than 60 cm deep.
   5.2 Non-calcareous, powdery.
   5.3 Coherent with red-brown hardpan.
   5.41 Coherent, dense, shallow but no hardpan.
   5.51 Coherent, porous, shallow but no hardpan.

6 Friable, well-structured:
   6.21 Shallow, dark.

-125-
Uf (fine texture). Non-cracking clays.

Ug Seasonally cracking clays:

5.2 Grey, well-structured (self-mulching):

- 5.25 underlain by brown or mottled clay.
- 5.27 underlain by rock at less than 1.5 m.
- 5.29 underlain by rock at more than 1.5 m.

5.3 Brown, well-structured (self-mulching):

- 5.37 underlain by rock at less than 1.5 m.
- 5.38 underlain by rock at more than 1.5 m.

5.5 Grey, massive, poorly structured.

G Gradational texture throughout profile

(change less than 1.5 texture classes, but may have clear visual boundaries):

Gc Calcaceous throughout profile:

1 Brown calcareous earths:

- 1.12 Grey-brown sandy-loam or loam at surface. Highly calcareous: lime visible in surface layers but at maximum concentration below 30 cm. Moderate to high salinity.
- 1.22 Surface mostly sand or sandy loam. Surface lime detectable only by acid treatment.
  Maximum lime concentration below 38 cm, coincides with maximum clay content. Generally
  less saline than Gc 1.12.

2 Brown calcareous earths, more structured below surface than Gc 1:

- 2.12 Grey-brown, highly calcareous as for Gc 1.12.
- 2.22 Less surface lime as for Gc 1.22.

Gn Non-calcareous in part or whole of profile:

Upper soil ranges from sand to loam. May have surface organic staining. Porous subsoils.

<table>
<thead>
<tr>
<th>A2 horizon</th>
<th>Acid</th>
<th>Neutral</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Red earths</td>
<td>no A2</td>
<td>-</td>
<td>2.12</td>
</tr>
<tr>
<td>unbleached</td>
<td>2.14</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2.2 Yellow earths</td>
<td>no A2</td>
<td>2.21</td>
<td>2.22</td>
</tr>
<tr>
<td>unbleached</td>
<td>2.24</td>
<td>2.25</td>
<td>-</td>
</tr>
<tr>
<td>2.3 Leached yellow earths (may have D horizons of clay)</td>
<td>bleached</td>
<td>-</td>
<td>2.35</td>
</tr>
</tbody>
</table>
D Duplex or texture contrast profile:

(more than 1.5 texture class difference between A and B horizons). Subdivided according to colour of upper 15 cm of B horizon:

Dr Duplex with red or red mottled subsoils:

<table>
<thead>
<tr>
<th>A2 horizon</th>
<th>Acid</th>
<th>Neutral</th>
<th>Alkaline</th>
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<tbody>
<tr>
<td>2</td>
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<tr>
<td>Seasonally hard-setting; whole-coloured red subsoils (at least upper 15 cm):</td>
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<tr>
<td>Structured subsoil:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Unbleached</td>
<td>2.21</td>
<td>2.22</td>
<td>-</td>
</tr>
<tr>
<td>Part-bleached</td>
<td>-</td>
<td>2.32</td>
<td>2.33</td>
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<tr>
<td>Bleached</td>
<td>2.41</td>
<td>2.42</td>
<td>2.43</td>
</tr>
<tr>
<td>Unstructured subsoil:</td>
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<td></td>
</tr>
<tr>
<td>Unbleached</td>
<td>2.61</td>
<td>2.62</td>
<td>2.63</td>
</tr>
<tr>
<td>Part-bleached</td>
<td>-</td>
<td>-</td>
<td>2.73</td>
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<tr>
<td>3</td>
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<td>Seasonally hard-setting; red mottled subsoil:</td>
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<td></td>
</tr>
<tr>
<td>Structured subsoil:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part-bleached</td>
<td>-</td>
<td>-</td>
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<td>Bleached</td>
<td>3.41</td>
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<td>Unstructured subsoil:</td>
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<tr>
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<td>3.83</td>
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<tr>
<td>4</td>
<td></td>
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<tr>
<td>Friable; whole-coloured red subsoil:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Bleached</td>
<td>-</td>
<td>-</td>
<td>4.43</td>
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<tr>
<td>5</td>
<td></td>
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<tr>
<td>Friable; red mottled subsoil:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bleached</td>
<td>-</td>
<td>-</td>
<td>5.43</td>
</tr>
<tr>
<td>Unbleached</td>
<td>-</td>
<td>5.62</td>
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</tr>
</tbody>
</table>

Dy Duplex with yellow or yellow mottled subsoils:

<p>| |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>2 Seasonally hard-setting; whole-coloured yellow subsoils (at least upper 15 cm):</td>
</tr>
<tr>
<td>Structured subsoil:</td>
</tr>
<tr>
<td>Part-bleached</td>
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<tr>
<td>Bleached</td>
</tr>
<tr>
<td>Unstructured subsoil:</td>
</tr>
<tr>
<td>Bleached</td>
</tr>
<tr>
<td>3 Seasonally hard-setting; yellow mottled subsoil:</td>
</tr>
<tr>
<td>Structured subsoil:</td>
</tr>
<tr>
<td>Unbleached</td>
</tr>
<tr>
<td>Part-bleached</td>
</tr>
<tr>
<td>Bleached</td>
</tr>
<tr>
<td>Unstructured subsoil:</td>
</tr>
<tr>
<td>Unbleached</td>
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<tr>
<td>Part-bleached</td>
</tr>
<tr>
<td>Bleached</td>
</tr>
</tbody>
</table>

* (often contain gravel)
4 Friable; whole-coloured yellow subsoil:

bleached - - 4.43

5 Friable; yellow mottled subsoil:

structured subsoil: unbleached 5.41 5.42 5.43
unstructured subsoil: unbleached - 5.62* -
bleached 5.81* 5.82* 5.83
bleached 5.84

(laterite between A and B horizons)

* (often contain gravel)

Dg Duplex with subsoils of dull, greyish, blueish or greenish colour (gley) which may be whole-coloured or mottled:

<table>
<thead>
<tr>
<th>A2 horizon</th>
<th>Acid</th>
<th>Neutral</th>
<th>Alkaline</th>
</tr>
</thead>
</table>

1 Seasonally hard-setting; whole-coloured subsoil (at least upper 15 cm);
unstructured subsoil: bleached 1.81 - -

2 Seasonally hard-setting; mottled subsoil:
unstructured subsoil: bleached 2.81 - -

3 Friable; whole-coloured subsoil:
bleached 3.81 - -

4 Friable; mottled subsoil:
bleached - 4.42 4.43

Dd Duplex with subsoils of dark colours other than gley.

1 Seasonally hard-setting; whole-coloured subsoils:

part bleached - 1.32 1.33
MAP SUPPLEMENT
With DETACHABLE COLOUR KEY

to accompany the text of Research Report No 1/86.

A framework for regional soil conservation treatments in the medium and low rainfall agricultural districts

by John Carder and John Grasby
Division of Resource Management
Department of Agriculture,
Western Australia.
1986
MAP SUPPLEMENT

with

DETACHABLE COLOUR KEY

to accompany the text of

A FRAMEWORK FOR REGIONAL SOIL CONSERVATION TREATMENTS
in the medium and low rainfall agricultural districts

by John Carder and John Grasby
Division of Resource Management
W.A. Department of Agriculture

1986
CONTENTS

Detachable colour key

<table>
<thead>
<tr>
<th>Page</th>
<th>Total areas and percentage areas of map units</th>
</tr>
</thead>
</table>

SHIREs, LEGENDS AND MAPS
covering the following Department of Agriculture advisory districts

<table>
<thead>
<tr>
<th>Page</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Geraldton
Three Springs
Moora
Merredin
Northam
Narrogin
Katanning
Lake Grace
Jerramungup
Esperance
Albany
ACKNOWLEDGEMENTS

Map digitisation and compilations: ESRI-Australia, Perth.

Base map data: by courtesy of the Surveyor General.

Soils map and data: by courtesy of CSIRO, Division of Soils, and Melbourne University Press.
TOTAL AREAS & PERCENTAGE AREAS OF MAP UNITS

(NOTE: this table has the same format and relates to the same landscape/map units as the COLOUR KEY)

<table>
<thead>
<tr>
<th>UNALIENATED LAND: National Parks, State Forests, major reserves, 2,657,168 ha 12.3% of total mapped area (21,729,168 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OLD PLATEAU</strong></td>
</tr>
<tr>
<td>Inland fringe districts 757,791 ha 3.5%</td>
</tr>
<tr>
<td>Lateritic uplands 4,803,570 ha 22.0%</td>
</tr>
<tr>
<td>Undulating lateritic plateau 817,106 ha 3.8%</td>
</tr>
<tr>
<td>Sandplains with gravel ridges 845,046 ha 3.9%</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Red earths zone 611,467 ha 2.0%</td>
</tr>
<tr>
<td>Red duplex zone 1,140,903 ha 5.3%</td>
</tr>
<tr>
<td>Plains with lakes 441,173 ha 2.0%</td>
</tr>
<tr>
<td>Highly calcareous earths 110,662 ha 0.5%</td>
</tr>
<tr>
<td>Calcareous earths 196,894 ha 0.9%</td>
</tr>
</tbody>
</table>

| REJUVENATED NATURAL DRAINAGE ZONES                           |                                                       |
|-------------------------------------------------------------|                                                       |
| Gravel uplands, young valleys 1,310,983 ha 6.0%             | Dissected land, mature valleys 2,932,879 ha 13.5%      |
|                                                             | Ravensthorpe district 34,927 ha 0.2%                    |
|                                                             |                                                       |
| COASTAL PLAINS                                              |                                                       |
| Sandplains with gravel 1,181,092 ha 5.4%                    | Red earthy sands 87,018 ha 0.4%                        |
| Sandplains 1,808,965 ha 8.3%                                | High-rainfall districts (Albany) 907,231 ha 4.2%       |
|                                                             | Coastal dunes & headlands 752,380 ha 3.5%              |
# A Framework for Regional Soil Conservation Treatments

## Landscape / Map Unit Colour Key

### Unalientated Land: National Parks, State Forests, Major Reserves, Vacant Crown Land (as in 1980)

<table>
<thead>
<tr>
<th>Old Plateau</th>
<th>Valley Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inland fringe districts</td>
<td>Baandee-type</td>
</tr>
<tr>
<td>AZ1: AC1,11: Ms11,12 etc.</td>
<td>SV1,2,4</td>
</tr>
<tr>
<td>Lateritic Uplands</td>
<td>Belka-type</td>
</tr>
<tr>
<td>Ms7–10: Va66</td>
<td>S128,129</td>
</tr>
<tr>
<td>Undulating lateritic plateau</td>
<td>Sand-filled valleys</td>
</tr>
<tr>
<td>Uf3</td>
<td>Ca21,22</td>
</tr>
<tr>
<td>Sandplains with gravel ridges</td>
<td>Merredin and other Old Plateau types</td>
</tr>
<tr>
<td>S130</td>
<td>Vb2: Va69,71: Vd6</td>
</tr>
<tr>
<td></td>
<td>and</td>
</tr>
<tr>
<td></td>
<td>Part rejuvenated</td>
</tr>
<tr>
<td></td>
<td>Oc: Od: Ub: Va64,65,68</td>
</tr>
</tbody>
</table>

### Rejuvenated Natural Drainage Zones

<table>
<thead>
<tr>
<th>Rejuvenated Natural Drainage Zones</th>
<th>Coasts:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel uplands, young valleys</td>
<td>Ravensthorpe district</td>
</tr>
<tr>
<td>JZ2: Tt3,4,6: Cz1</td>
<td>BB4: MM15</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissected land, mature valleys</td>
<td></td>
</tr>
<tr>
<td>Oc: Pb: Qb: Qc: Ub: Uf1</td>
<td></td>
</tr>
</tbody>
</table>

### Coastal Plains

<table>
<thead>
<tr>
<th>Coastal Plains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandplains with gravel</td>
</tr>
<tr>
<td>Wd7,9,10: X6: Xc1</td>
</tr>
<tr>
<td>Sandplains</td>
</tr>
<tr>
<td>AC2–7,9: Xd1,3</td>
</tr>
</tbody>
</table>

- Red earthy sands: AB3–5
- Leached sands: Ca24,27,28: Cb39
- High-rainfall districts (Albany district)
- Coastal dunes and headlands

---

District centres — Main roads
GERALDTON ADVISORY DISTRICT

Shires included in the advisory district

Chapman Valley*
Greenough
Irwin
Mingenew
Morawa*
Mullewa*
Northampton*

*(part only in the agricultural zone)

Total mapped area: 2,198,717 hectares
<table>
<thead>
<tr>
<th></th>
<th>000 ha</th>
<th>%</th>
<th></th>
<th>000 ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GE 4 Hutt River valley (downstream)</strong></td>
<td>434</td>
<td>20.0</td>
<td><strong>GE 1 Eastern fringe</strong></td>
<td>100</td>
<td>4.5</td>
</tr>
<tr>
<td>Pb29</td>
<td></td>
<td></td>
<td><strong>GE 2 Red earths zone</strong></td>
<td>537</td>
<td>24.5</td>
</tr>
<tr>
<td>Chapman Valley system</td>
<td></td>
<td></td>
<td><strong>My46-49 etc.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb29; Qc5 etc.</td>
<td></td>
<td></td>
<td><strong>Lateritic uplands (minor unit)</strong></td>
<td>6</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>GE 5 Irwin River system</strong></td>
<td></td>
<td></td>
<td><strong>Me9</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qc6, 7; Oc37-39 etc.</td>
<td></td>
<td></td>
<td><strong>Baande-type valleys</strong></td>
<td>38</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>COASTAL SANDPLAINS</strong></td>
<td></td>
<td></td>
<td><strong>SV1,4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GE 6 West Binnu</strong></td>
<td>{101}</td>
<td>4.5</td>
<td><strong>GE 3 Sandplains</strong></td>
<td>801</td>
<td>36.5</td>
</tr>
<tr>
<td>Ca28</td>
<td></td>
<td></td>
<td><strong>AC9,3,2;Xd3;Wd9</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dongara-Arrowsmith</td>
<td>{</td>
<td>}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GE 7 Coastal dunes</strong></td>
<td>{183}</td>
<td>8.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A13; B26 etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL MAPPED AREA</strong></td>
<td>2,199</td>
<td>100.0</td>
<td><strong>(Note: there is no clear surface boundary between the Old Plateau and the coastal plain, unlike in districts further south. Here, units such as AC3 and AC9 cross over the sub-surface Darling fault-line.)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UNALIENATED LAND</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Parks, major reserves, vacant Crown land</td>
<td>126</td>
<td>5.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Geraldton

- --- Main roads
THREE SPRINGS ADVISORY DISTRICT

Shires included in the advisory district

Carnamah
Coorow
Perenjori*

Three Springs

*(part only in the agricultural zone)

Total mapped area: 1,359,724 hectares
## Three Springs Advisory District

<table>
<thead>
<tr>
<th></th>
<th>Rejuvenated Natural Drainage Zone</th>
<th></th>
<th>Old Plateau</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>000 ha</td>
<td>%</td>
<td>000 ha</td>
<td>%</td>
</tr>
<tr>
<td><strong>TS 5</strong> Upper Arrowsmith Pb30; Oc36; Va69</td>
<td>8</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COASTAL PLAIN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TS 6</strong> West Three Springs-West Coorow AC3-7</td>
<td>207</td>
<td>15.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TS 7</strong> North Eneabba Md9,10</td>
<td>331</td>
<td>24.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TS 8</strong> Arrowsmith-South Eneabba Ca27</td>
<td>53</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TS 9</strong> Coastal dunes</td>
<td>70</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                |            |            |            |            |
| **TOTAL MAPPED AREA** | 1,360 | 100.0    |            |            |

|                |            |            |            |            |
| **UNALIENATED LAND** | National Parks, major reserves, vacant Crown land | 199 | 14.6    |            |

- Three Springs

--- Main roads

---
MOORA ADVISORY DISTRICT

Shires included in the advisory district

Chittering (a)
Dalwallinu (b)
Dandaragan (a)
Gingin (a)
Moora
Victoria Plains
Wongan-Ballidu

(a) (part excluded as being in the high-rainfall zone)
(b) (part only in the agricultural zone)

Total mapped area: 2,607,926 hectares
<table>
<thead>
<tr>
<th>REJUVENATED NATURAL DRAINAGE ZONE</th>
<th>000 ha</th>
<th>%</th>
<th>OLD PLATEAU</th>
</tr>
</thead>
<tbody>
<tr>
<td>MO 6 Dissected land</td>
<td>256</td>
<td>10.0</td>
<td>MO 1 North-east fringe</td>
</tr>
<tr>
<td>Uf1; Ub98; Qb29</td>
<td></td>
<td></td>
<td>Ms11</td>
</tr>
<tr>
<td>Valleys</td>
<td>50</td>
<td>2.0</td>
<td>MO 2 Red duplex zone</td>
</tr>
<tr>
<td>Vd6</td>
<td></td>
<td></td>
<td>Oc34,35</td>
</tr>
<tr>
<td>MO 7 Gravel uplands, young valleys</td>
<td>108</td>
<td>4.0</td>
<td>MO 3 Red earth zone</td>
</tr>
<tr>
<td>Jz2; Tf3; Qb32</td>
<td></td>
<td></td>
<td>My42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COASTAL PLAIN</th>
<th>000 ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>MO 8 Dandaragan plateau</td>
<td>204</td>
<td>8.0</td>
</tr>
<tr>
<td>AC2-7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO 9 Red earthy sands</td>
<td>87</td>
<td>3.5</td>
</tr>
<tr>
<td>AB3-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO10 Badgingarra, West Mogumber</td>
<td>354</td>
<td>13.5</td>
</tr>
<tr>
<td>Wd9,10; Tf7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO11 Leached sands</td>
<td>245</td>
<td>9.5</td>
</tr>
<tr>
<td>Ca27; Cb39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO12 Coastal dunes</td>
<td>234</td>
<td>9.0</td>
</tr>
<tr>
<td>A13,16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL MAPPED AREA** 2,608 100.0

**UNALIENATED LAND**
State Forests, major reserves, vacant Crown land
**Moora**

--- Main roads
MERREDIN ADVISORY DISTRICT

Shires included in the advisory district

Bruce Rock
Kellerberrin
Koorda*
Merredin
Mt Marshall*
Mukinbudin
Narembeen
Nungarin
Trayning
Westonia
Yilgarn*

*(part only in the agricultural zone)

Total mapped area: 3,416,647 hectares
<table>
<thead>
<tr>
<th>OLD PLATEAU</th>
<th>000 ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 1 Northern fringe AC10; Ms11</td>
<td>567</td>
<td>16.5</td>
</tr>
<tr>
<td>ME 2 Eastern fringe AC1; BB5,8; Ya28 etc.</td>
<td>866</td>
<td>25.5</td>
</tr>
<tr>
<td>ME 3 Red duplex zone Oc33,35 etc.</td>
<td>1,550</td>
<td>45.5</td>
</tr>
<tr>
<td>ME 4 Central and southern zone Lateritic uplands Ms8; Va66</td>
<td>32</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Merredin-type valleys Vb2</td>
<td>222</td>
</tr>
<tr>
<td></td>
<td>Belka-type valleys</td>
<td>180</td>
</tr>
</tbody>
</table>

**TOTAL AREA** 3,417 100.0

**UNALIENATED LAND**

| Major reserves, vacant Crown land | 149 | 4.4 |

- Merredin -- Main roads

---
NORTHAM ADVISORY DISTRICT

Shires included in the advisory district

Beverley
Cunderdin
Dowerin
Goomalling
Northam
Quairading
Tammin
Toodyay
Wyalkatchem
York

Total area: 1,750,111 hectares
<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
<th>Area (ha)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NO 1 OLD PLATEAU</strong></td>
<td>Lateritic uplands</td>
<td>446</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td>Ms7,8; Va66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belka-type valleys</td>
<td>144</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>S128</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baandee-type valleys</td>
<td>73</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>SV1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NO 2 REJUVENATED NATURAL DRAINAGE ZONE</strong></td>
<td>Dissected land, mature valleys</td>
<td>801</td>
<td>46.0</td>
</tr>
<tr>
<td></td>
<td>Oc30; Qb29; Va63</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NO 3 DARLING RANGE GRAVEL ZONE</strong></td>
<td>Gravel uplands, young valleys</td>
<td>287</td>
<td>16.5</td>
</tr>
<tr>
<td></td>
<td>JZ2; Tf3 etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL AREA</strong></td>
<td></td>
<td>1,750</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**UNALIENATED LAND**
State Forests, major reserves, vacant Crown land: 168 ha (9.6%)

- Northam
- Main roads
NARROGIN ADVISORY DISTRICT

Shires included in the advisory district

Boddington
Brookton
Corargin
Cuballing
Narrogan
Pingelly
Wagin
Wandering
West Arthur
Wickepin
Williams

Total area: 2,150,701 hectares
### NA 1 OLD PLATEAU

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateritic uplands Ms8; Va66</td>
<td>334</td>
<td>15.5</td>
</tr>
<tr>
<td>Belka-type valleys S128</td>
<td>203</td>
<td>9.5</td>
</tr>
<tr>
<td>Baandeey-type valleys SV1</td>
<td>26</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### NA 2 REJUVENATED NATURAL DRAINAGE ZONE

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avon River system Uf1; Qb29; Va63 etc.</td>
<td>1,001</td>
<td>46.5</td>
</tr>
<tr>
<td>Hoitham River system Uf1; Qb30; Ub95,96 etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arthur River system Ub90,95,96; Va64 etc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NA 3 DARLING RANGE GRAVEL ZONE

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel uplands, young valleys J22; Tf3 etc.</td>
<td>587</td>
<td>27.0</td>
</tr>
</tbody>
</table>

### TOTAL AREA

<table>
<thead>
<tr>
<th></th>
<th>Area (ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL AREA</td>
<td>2,151</td>
<td>100.0</td>
</tr>
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</table>

### UNALIENATED LAND

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Forests, major reserves, vacant Crown land</td>
<td>258</td>
<td>12.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Narrogin</th>
<th></th>
<th></th>
</tr>
</thead>
</table>

---

**Main roads**
KATANNING ADVISORY DISTRICT

Shires included in the advisory district

Broomehill
Dumbleyung (a)
Gnowangerup (b)
Katanning
Kent (a)
Kojonup
Tambellup
Woodanilling

(a)(divided between Katanning and Lake Grace advisory districts for operational convenience)

(b)(includes a small area of Jerramungup Shire for operational convenience)

Total mapped area: 1,536,630 hectares
<table>
<thead>
<tr>
<th>REJUVENATED NATURAL DRAINAGE ZONE</th>
<th>OLD PLATEAU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KA 2 Pallinup River system</strong></td>
<td><strong>KA 1 Lateritic uplands</strong></td>
</tr>
<tr>
<td>Gravel uplands, young rivers</td>
<td>Undulating lateritic plateau</td>
</tr>
<tr>
<td>Tf4,6</td>
<td>Uf3</td>
</tr>
<tr>
<td><strong>KA 3 Gordon River system</strong></td>
<td>Plains with lakes (N.Stirling)</td>
</tr>
<tr>
<td>Dissected uplands</td>
<td>Ya27,31</td>
</tr>
<tr>
<td>Ub90; X15</td>
<td><strong>Belka-type valleys</strong></td>
</tr>
<tr>
<td>Part-rejuvenated valleys</td>
<td>S128</td>
</tr>
<tr>
<td>Oc32; Od7; Va64,65</td>
<td>Calcareous earths</td>
</tr>
<tr>
<td><strong>KA 4 Beaufort River system</strong></td>
<td>DD11</td>
</tr>
<tr>
<td>Sand-filled valley (Gordon)</td>
<td><strong>Baandee-type valleys</strong></td>
</tr>
<tr>
<td>Ca22</td>
<td>SV1</td>
</tr>
<tr>
<td><strong>COASTAL PLAIN (minor unit)</strong></td>
<td><strong>TOTAL MAPPED AREA</strong></td>
</tr>
<tr>
<td>Sandplains with gravel</td>
<td><strong>1,537</strong></td>
</tr>
<tr>
<td>Wd7</td>
<td><strong>UNALIENATED LAND</strong></td>
</tr>
</tbody>
</table>

(Note: rejuvenation of river valleys is less pronounced than in regions further north, due to lesser uplift of the land.)

- - - Main roads
LAKE GRACE ADVISORY DISTRICT

Shires included in the advisory district

Dumbleyung (a)
Kent (a)
Kondinin
Kulin
Lake Grace

(a) (divided between Lake Grace and Katanning advisory districts for operational convenience)

Total mapped area: 2,372,364 hectares
## LAKE GRACE ADVISORY DISTRICT

<table>
<thead>
<tr>
<th>Description</th>
<th>Area (ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LG 1 OLD PLATEAU</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandplains with gravel ridges S130</td>
<td>466</td>
<td>19.5</td>
</tr>
<tr>
<td>Lateritic uplands Ms8; Va66; X17</td>
<td>1,328</td>
<td>56.0</td>
</tr>
<tr>
<td>Undulating lateritic plateau UF3</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>Belka-type valleys S128,129</td>
<td>280</td>
<td>12.0</td>
</tr>
<tr>
<td>Calcareous earths DD11</td>
<td>55</td>
<td>2.5</td>
</tr>
<tr>
<td>Baandee-type valleys SV1</td>
<td>234</td>
<td>10.0</td>
</tr>
<tr>
<td><strong>TOTAL AREA</strong></td>
<td>2,372</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**UNALIENATED LAND**

<table>
<thead>
<tr>
<th>Description</th>
<th>Area (ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major reserves, vacant Crown land</td>
<td>378</td>
<td>16.0</td>
</tr>
</tbody>
</table>

- Lake Grace  
- - - Main roads
JERRAMUNGUP ADVISORY DISTRICT

Shires included in the advisory district

Jerramungup

Ravensthorpe (a)

(a) (divided between Jerramungup and Esperance advisory districts for operational convenience)

Total mapped area: 1,355,738 hectares
<table>
<thead>
<tr>
<th>JERRAMUNGUP ADVISORY DISTRICT</th>
<th>000 ha</th>
<th>%</th>
<th>000 ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JE 1 OLD PLATEAU</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandplains with gravel ridges</td>
<td>282</td>
<td>21.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S130</td>
<td></td>
<td></td>
<td>Ravensthorpe district</td>
<td>35</td>
</tr>
<tr>
<td>Undulating lateritic plateau</td>
<td>418</td>
<td>31.0</td>
<td>BB4; MM15 etc.</td>
<td></td>
</tr>
<tr>
<td>UF3</td>
<td></td>
<td></td>
<td>Jerdacuttup district</td>
<td>49</td>
</tr>
<tr>
<td>Lateritic uplands (minor unit)</td>
<td>2</td>
<td>0.2</td>
<td>Cz1</td>
<td></td>
</tr>
<tr>
<td>Ms8</td>
<td></td>
<td></td>
<td>Part-rejuvenated valleys</td>
<td>214</td>
</tr>
<tr>
<td>Belka-type valley</td>
<td>9</td>
<td>0.5</td>
<td>Od7,8</td>
<td></td>
</tr>
<tr>
<td>S129</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL MAPPED AREA</strong></td>
<td>1,356</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UNALIENATED LAND</strong></td>
<td></td>
<td></td>
<td>(Note: the general land surface dips gently southwards and valleys are only partly rejuvenated.)</td>
<td></td>
</tr>
<tr>
<td>National Parks, major reserves,</td>
<td>480</td>
<td>35.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vacant Crown land</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Jerramungup
- - - Main roads
ESPERANCE ADVISORY DISTRICT

Shires included in the advisory district

Dundas (Salmon Gums) (a)

Esperance (a)

Ravensthorpe (b)

(a) (part only in the agricultural zone)

(b) (divided between Esperance and Jerramungup advisory districts for operational convenience)

Total mapped area: 1,574,833 hectares
<table>
<thead>
<tr>
<th>District</th>
<th>000 ha</th>
<th>%</th>
<th>000 ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ES 1 Salmon Gums district</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly calcareous earths Lb10</td>
<td>111</td>
<td>7.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcareous earths DD12, (DD14)*</td>
<td>91</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baandee-type valley (minor unit)</td>
<td>7</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ES 2 Mallee district</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandplains with gravel ridges S130</td>
<td>96</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plains with lakes Ya29,30; (DD14)*</td>
<td>266</td>
<td>17.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL MAPPED AREA</strong></td>
<td>1,575</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UNALIENATED LAND</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Parks, major reserves, vacant Crown land</td>
<td>182</td>
<td>11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ES 3 Munglinup district</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cz1 Esperance Downs Xd1</td>
<td>627</td>
<td>40.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part-rejuvenated valleys Va68</td>
<td>116</td>
<td>7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ES 4 Coastal dunes &amp; headlands</strong></td>
<td>88</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Note: the general land surface dips gently southwards and valleys are only partly rejuvenated.)
ALBANY ADVISORY DISTRICT

Shires included in the advisory district

Albany
Cranbrook
Denmark
Plantagenet

Total area: 1,405,204 hectares
### ALBANY ADVISORY DISTRICT

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
<th>000 ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL 1</td>
<td>Gordon River system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plains with lakes</td>
<td>66</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>Ya27,31</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dissected uplands</td>
<td>24</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Ub90; Uf3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Part-rejuvenated valleys</td>
<td>41</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Va65; (Ub94 in AL 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sand-filled valleys</td>
<td>23</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Ca22; (Ca21 in AL 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>HIGH RAINFALL REGION</strong></td>
<td>907</td>
<td>64.5</td>
</tr>
<tr>
<td>AL 3</td>
<td>North</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uf2; Ub93; Tf6; Ta9; Cd22; Cb43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AL 4</td>
<td>South</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ca23; Cb41,42; X14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AL 2</td>
<td>COASTAL PLAIN - EAST</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leached sands</td>
<td>70</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>Ca24</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sandplains with gravel</td>
<td>240</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>Wd7; X16; Xc1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AL 5</td>
<td>Coastal dunes &amp; headlands (East) A15; JK11. (West) Ca20</td>
<td>33</td>
<td>2.5</td>
</tr>
</tbody>
</table>

(Note: the general land surface dips gently southwards and valleys are only partly rejuvenated.)

**TOTAL AREA** | 1,405 | 100.0

**UNALIENATED LAND**
National Parks, State Forests, major reserves, vacant Crown land | 359 | 25.6

- Albany
- Main roads