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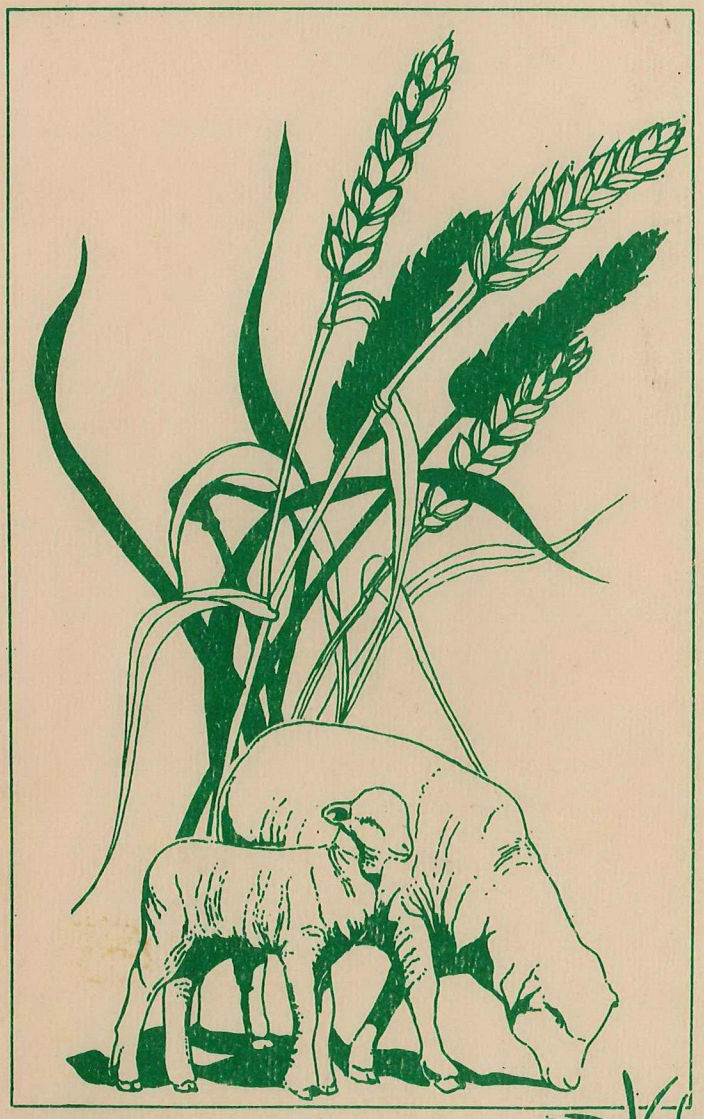

Western Australian
Department of Agriculture

THE AGRICULTURE AND LAND DESCRIPTION OF THE MIDLANDS, WONGAN HILLS AND DALWALLINU DISTRICTS OF WESTERN AUSTRALIA

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THE AGRICULTURE AND LAND DESCRIPTION OF THE MIDLANDS, WONGAN HILLS AND DALWALLINU DISTRICTS OF WESTERN AUSTRALIA

This report deals with the area of responsibility of the Moora District Office of the W.A. Department of Agriculture.

The Moora advisory district consists of seven shires which cover 2,811,400 hectares.

Agriculture in the advisory district varies according to climate and soil type. Sheep and cattle production are the main enterprises in the high rainfall (coastal) areas. Mixed cereal sheep production is the main system in the medium and low rainfall areas with cereals increasing in importance as annual rainfall diminishes.

Method

The Darling Fault runs north-south and splits the advisory district into two distinct geological zones, the West Midlands and the Great Plateau (see Fig. 1, 2, 3).

There is a summary of the climate of each zone.

Within these zones, units and sub-units are identified and described on the basis of soil, vegetation, hydrology, and land use.

In the case of the West Midlands (zone A), farming practices vary little between the units (1, 2, 3). Therefore, crops, pastures, fertiliser use, and animal enterprises for the whole of the West Midlands have been summarised before the component units and sub-units are described.

Throughout the report common farming practices are summarised. These are not necessarily recommendations of the W.A. Department of Agriculture.

THE WEST MIDLANDS (Zone A)

This zone contains the shires of Dandaragan and Gingin (see Appendix ii).

The West Midlands have mainly lateritic sandplain soils formed from sedimentary rocks to the west of the Darling Fault. Loamy and clay soils around Gingin and Dandaragan were cleared in the early part of this century. Most of the West Midlands is sandplain and was not released for agriculture until the 1950's or later. As a result, many farmers in this area are still bringing virgin land into production.

In this analysis, the West Midlands have been split into three broad geomorphic units (see Table 1).

Table 1
Soil units and land use - West Midlands (Region A)

	Total area (ha)	Area released for farming (ha)	
Unit 1 Coastal dunes and alluvium	483,000	219,000	(45%)
Sub-unit 1a Coastal sub-unit	220,000	77,000	(35%)
1b Bassendean sub-unit	240,000	120,000	(50%)
1c Pinjarra plain sub-unit	22,000	22,000	(100%)
Unit 2 Dissected area	353,500	314,500	(89%)
Sub-unit 2a Badgingarra sub-unit	166,000	136,000	(82%)
2b Herschel sub-unit	62,500	59,500	(94%)
2c West Mogumber sub-unit	125,000	119,000	(95%)
Unit 3 Dandaragan Plateau	324,500	278,500	(86%)
Sub-unit 3a Dandaragan sub-unit	93,500	93,500	(100%)
3b Plateau sub-unit	231,000	185,000	(80%)

CLIMATE

The West Midlands has a mediterranean type climate with hot dry summers and cool wet winters.

Annual rainfall and length of growing season decreases inland in a south-west to north-east direction from the coast.

The range is 770mm annual rainfall with a six month growing season at Gingin to 420mm with a four and a half month growing season at Watheroo (see Appendix i). The average break of the season varies from late April at Gingin to early May at Watheroo.

Frosts can be expected from May to September, being most common in July and August. They seldom occur near the coast, but become more common inland. The incidence of frost is greatly affected by topography - frosts are more common in valley floors.

Crops

Twenty to twenty five per cent of cleared area on farms is cropped annually (see Appendix ii). There is a trend towards more cropping.

Wheat is the most popular cereal for grain production, but yields are restricted by Septoria diseases, nitrogen deficiency and to a lesser extent, take-all disease. Take-all is more severe on the loams and sands over clay.

On the Department of Agriculture's Badgingarra Research Station (BRS), situated in sub-unit 2a, wheat is only sown on the best soils, and on average, yields 1.6 t/ha. Barley has been a more profitable crop, with BRS average yields being 1.95 t/ha. However, West Midland farmers claim that head loss is a problem with barley.

Yields on farms are much lower (see Dandaragan Shire Statistics Appendix ii).

Oats are also an important crop being grown for grain, hay, or standing feed.

White lupins have an excellent potential in the West Midlands, but it has seldom been realised on farms. Reasons for this include: sowing too late, poor harvesting technique (reducing seed quality), split seed, disease, weed competition and potassium deficiency (on poor soils).

Lupin grain has a good protein level (30%) and sells for a reasonably high price. The stubble can be used for fattening weaners, or adult sheep for sale. Lupinosis from lupin stubble is a problem that requires careful management.

There is considerable potential in a lupin, wheat rotation, (continuous cropping using the direct drill technique) on sandy surfaced soils where pasture stocking rate is restricted by wind erosion.

Good yields have been achieved from small plantings of linseed on gravel soils at BRS (average yield 1.29 t/ha for the six years 1975 to 1980). The market for linseed is restricted, but it can be a profitable sideline.

Fertilisers

All soils in the West Midlands require trace elements when initially cleared. Copper remains available in the soil for many years, but further applications of zinc and molybdenum may be required after several years.

Leaching of phosphorus, nitrogen, sulphur and potassium occurs particularly on sandy soils. Soil tests give the best guide for pasture requirements and phosphate history the best guide for phosphate requirements of crops.

Potassium deficiency is becoming more common in the West Midlands as the soil levels are depleted. Soil testing gives a good indication of requirements.

Manganese is essential on white lupins to prevent split seed and must be added to most soils.

Pastures

Yellow sands, gravels and shallow sand over gravel soils, support good subclover pastures. Seaton Park is well suited to loamy and gravelly soils.

Serradella can be grown on pale yellow sands and deeper sand (30-60cm) over gravel, but its persistence under grazing and following cutworm and looper attack is often disappointing.

W.A. sandplain lupins are grown on white sand over pale yellow sand, and grey sands which are too poor for clovers or serradella. As a guide, optimum stocking rates on established pastures are:-

Gravel 7.5 DSE/ha (DSE - Dry Sheep Equivalents)

Sandy surfaced clover paddock 5 DSE/ha

Unimproved poor sand (grass) 1 DSE /ha

Good W.A. sandplain lupin pastures 2.5 - 5 DSE/ha over winter, 15 DSE/ha over summer. (If lupinosis has not occurred)

Loams 7.5 to 10 DSE/ha

Animal enterprises

Sheep and cattle production are equally important in the West Midlands. Sheep enterprises are mainly wool and fat lambs, and adult sheep for live export. Most farms shear in August-October and lamb in April-May-June.

Cattle enterprises are mainly baby beef and steer beef production from annual pasture. A few farmers produce feedlot steers.

Pig production is relatively insignificant.

Main management problems are:-

- Due to the short growing season and low quality of most dry pastures, farmers have difficulty in finishing baby beef and having lambs large enough to survive the dry season. Weaner sheep being kept over summer usually require supplementary feed.

- Internal parasites. Two summer broad-spectrum drenches are recommended for worm control in sheep. Additional drenching is required after heavy summer rain or in summer-wet padocks. For cattle, a benzimidazole drench is recommended once or twice in autumn and once just after the break of the season.

- Lupinosis in sheep and breeding cattle grazing lupin stubbles.

- Selenium deficiency (white muscle disease) in weaner sheep particularly when grazing lupins.

- Cobalt deficiency in sheep and occasionally cattle is prevalent in grassy pastures on pale sandy soils, particularly in wet years.

- Grass seed contamination can greatly reduce the value of lamb carcasses unless the lambs are shorn before grass seed set.

- Lice on sheep. Most sheep are dipped annually to control lice.

COASTAL DUNES AND ALLUVIUM - Unit 1 (483,000 ha approx. 55% Crown Land)

This unit is also known as the Swan Coastal Plain. It consists of recent sediments deposited on a flat plain which is bounded by the Indian Ocean to the west and the Gingin Scarp on the east. It includes the Coastal, Bassendean and Pinjarra Plain sub-unit.

The sediments consist of three ages of sand dunes and of riverine loams and clays which were deposited by rivers coming from the Dandaragan Plateau.

Coastal - Sub-unit 1a (220,000 ha approx. 65% Crown Land)

It is made up of the Spearwood (Northcote JK9, B24) and Quindalup (Northcote A15, A16) dune system.*

Soils

The Quindalup dunes occur as a series of long dunes with ridges running parallel to the coastline. The dunes contain sand which is high in lime, but low in soluble salts and which shows no profile differentiation. Between the dunes there are plains of sand of varying depth over limestone. These plains are often waterlogged in winter and some contain semi-permanent lakes.

Spearwood dunes occur to the east of the Quindalup dunes and form the bulk of the sub-unit. The dune landscape in the Spearwood dunes is less distinct. Soils are yellow or brown sands or have 3 to 10 centimetres of white sand over yellow sand. The sands are underlain by limestone at increasing depth towards the east. On the western part of the system, limestone outcrops on hill tops are common.

Vegetation

Quindalup dunes support low coastal scrub of perennial shrubs which range in habit from prostrate mat plants (on the exposed areas) to erect shrubs up to 1.6 m high.

Vegetation on the Spearwood dunes ranges from low coastal scrub where the limestone is close to the surface, to a mixture of banksia, Christmas tree (Nuytsia florabunda), blackboy (Xanthorrhea) and Acacia spp. on the deeper sands. Occasionally pockets of tuart trees (E. gomphocephala) occur in interdunal valleys where moisture is close to the surface.

*Northcote et al "A Description of Australian Soils" CSIRO Publication 1975.

Hydrology

The soils do not generate runoff and a fresh to brackish watertable occurs between 4 and 40 metres below the surface. The watertable fluctuates during the year and ephemeral interdunal lakes occur in wet winters, usually where water has percolated through the limestone from the Bassendean sub-unit.

Land use

About 35 per cent of this sub-unit has been released for agriculture. The Quindalup dunes are not suited to agriculture, because of infertility and wind erosion problems.

Properties on the coast have mostly been purchased by developers for subdivision into small holiday farms. The majority of properties are used for agriculture, although many are unoccupied.

Subterranean clover and Harbinger medic grow well on the yellow sands, but legume content on land cleared for over 10 years has declined due to potassium deficiency. Regular potassium dressings may be required to maintain clover. W.A. sandplain lupins are grown as permanent pasture on poorer grey and white sands.

The main enterprises are sheep and cattle grazing. Stocking rates are generally between 2.5 and 6 DSE's (Dry Sheep Equivalent) per hectare.

This sub-unit contains the Nambung (11,930 ha) and Drover's Cave (2,680 ha) National Parks.

Bassendean Sub-unit 1(b) (240,000 ha approx. 50% Crown Land)

This sub-unit consists of gently sloping white sand dunes with frequent interdune sandy swamps (Northcote Cb39).

Where the Nambung River and Mullering Brook enter this sub-unit, they change into ill-defined drainage lines of almost flat shallow depressions flowing between low dunes (Northcote Ca27).

Soils (Northcote Ca27 Cb39)

Cn39 soils are undifferentiated deep grey white sands with black acid peaty sands in the swamps.

Ca27 soils have a gravelly clay basement overlain by varying depths of grey white sand. In the drainage lines the soil consists of fine grey silty sands over a gravelly clay at 20 to 60 centimetres. Between the drainage lines the gravelly clay is overlain by grey white sand dunes.

Vegetation

The sub-unit has attractive wildflowers.

Deep sandy soils support mainly banksias (Banksia spp.), woolly bush (Adenanthos sericea) with some blackbutt trees (E. todtiana), paperbark trees (Melaleuca and Leptospermum spp.), dense scrub, rushes (Juncus spp.) are found in the swamps with acid peaty sands.

Low scrub with occasional blackboys is found on the gravelly clay, and shallow sand over clay soils. Where these soils are saline, samphire (Halosarcia spp.) is dominant.

Hydrology

This sub-unit does not generate runoff because of the sandy soils. It receives runoff and seepage from the Dandaragan Plateau and the Dissected Area. Consequently there is a watertable which varies in depth from the surface to about 20 m below the surface. Most farms have good soaks and shallow bores. A small area of damp gravelly clay soil in the lower reaches of the Numbung river is saline.

Land use

The Moore River National Park (17,540 ha) is in the sub-unit. About 50 per cent of the sub-unit has been alienated for agriculture. There are two main areas, one generally west of Badgingarra and another generally west of Gingin.

The area west of Badgingarra is mainly in the catchment of the Nambung River. The farms have been released since 1955 and many farmers are still bringing land into production. Enterprises are almost exclusively cattle and sheep grazing.

Soils with shallow sand over clay support excellent subterranean clover, but the bulk of the soils are deep white sand.

Salt buildup in the summer-damp areas and extremely infertile white sands on the drier areas are posing problems for some farmers in this area.

The area west of Gingin was originally surveyed into units of 40 to 80 hectares. There are few bona fide farmers in this area, the bulk of the units being owned by investors or hobby farmers.

None of these small units would be viable on their own.

The low lying damp areas are often the most productive areas, which can support high stocking rates when sown to improved pastures (up to 35 DSE/ha over summer on strawberry clover/kikuyu pasture).

The high land between the damp areas is deep white sand which supports banksia forest. Less than 50 per cent of this unit is damp country. The deep white sand can generally support less than 2 DSE's/ha of grazing.

As this area has abundant water and is relatively close to Perth, it could be suitable for vegetable growing.

Although expensive to develop, the small farms in this area are attractive to hobby farmers as they contain some lakes and attractive wildflowers. Pastures may be grown, although uneconomic fertiliser dressings are required.

Pinjarra Plain Sub-unit 1c (Approx. 22,000 ha virtually all alienated for agriculture)

This sub-unit consists of alluvial plains containing a network of shallow lakes and often ill defined waterways.

Soils (Northcote Ub97)

Soils are predominently brown or grey clays or sands over clay, with some peaty deposits occurring in the lakes. In places, dunes from the

Bassendean sub-unit have blown onto the alluvial plains to form isolated hills of infertile white sand. Around Beermullah, some clays occur over limestone. The limestone outcrops on some low ridges produce yellow-orange sands when well drained or shallow, dark grey peaty clays when waterlogged.

Vegetation

Paperbark trees, flooded gums (E. rudis), sheoaks (Casuarina spp.) and low scrub are dominant on the clay or sand over clay soils around the lakes and main waterway.

Red gums (E. calophylla), Christmas trees, blackbutts and banksias occur on the orange and yellow sands, with banksias and Christmas trees forming the main vegetation on the white sand hills.

Hydrology

Being low lying and of low permeability, the clay soils are generally waterlogged in winter. Water supplies are plentiful. Small areas of salinity occur adjacent to the Gingin scarp.

Land use

The sub-unit is used for agriculture, mainly cattle production on sub-clover pastures. The farms vary in size from 200 to 1,600 hectares.

Much of this sub-unit was originally surveyed into small units with areas between 40 to 120 hectares.

Stocking rates are between 7 and 12 DSE/ha. Reduced clover content in pastures in recent years has forced farmers to reduce stocking rates and conserve more fodder.

DISSECTED AREA - Unit 2 (353,500 ha approx. 11% Crown Land)

This unit, including the Badgingarra, Herschel and West Mogumber sub-units, contains the remains of a laterite covered plateau which has been deeply eroded to form gravelly hills with breakaways and sandy valleys.

Badgingarra - sub-unit 2a (166,000 ha - estimated 18% Crown Land)

The sub-unit occurs in two adjoining areas which are separated by the Dandaragan scarp (and a strip of Herschel sub-unit soils).

West of the Dandaragan Scarp the sub-unit consists of undulating country dominated by lateritic plateau remnants and gravel hills with well defined, concave, sand-filled valleys. The plateau remnants are often terminated by breakaways. Valley sides vary in length - up to 1 km - with grades of 2 to 3 per cent and up to 5 per cent on short slopes and 60 per cent on breakaways.

East of the Dandaragan Scarp, the sub-unit forms a gently sloping plain which falls from a main north-south trending ridge (the Plateau sub-unit) to the Dandaragan Scarp. The plain is dissected by U-shaped valleys which drain into a few trunk valleys that pass through the Dandaragan Scarp. The valleys are generally flat bottomed (filled with deep sand) and up to 500 m in width, with side slopes generally 400 to 500 metres long with slopes of 3° or less. The depth of dissection

dissection increases towards the Dandaragan Scarp, causing increased width of valley floors, with longer and steeper valley sides. Breakaways are uncommon but small areas of clay-gravel occur on the valley sides.

Soils (Northcote Wd9)

West of the Dandaragan Scarp, gravel hills represent the old plateau surface and are characterised by blocky lateritic or gravelly soils overlying pale yellow sandy clay. Flanking the upland sandy gravelly soils are colluvial deposits released by weathering of the old lateritic mantle. These materials have moved downslope and have blanketed the valley sides so that in some cases, breakaways are not present. The hilltops and breakaways are frequently stony and non-arable.

Close to the upland gravel soils these deposits are sandy gravels or grey yellow sands over loose gravel, ranging in depth from 0.2 to 2 metres. Further downslope, grey-yellow sands predominate with very little gravel. The soils in the valley floors are generally grey-white sands or grey sand over pale yellow sand.

East of the Dandaragan Scarp, soils are similar to those west of the scarp, except that the plateau has been less dissected, leaving higher proportions of better class soils (generally less than 30 cm of sand over gravel).

Vegetation

Vegetation is largely dependent on soil type and tends to change gradually with increasing depth of sand over gravel. Gravelly crests are characterised by a low heath up to 1 metre high with dominant vegetation being blackboys, Hakea and Grevillea spp. The blocky non-arable gravels have low heath (70 to 100 centimetres) with numerous blackboys.

Soils with yellow sand or up to 50 cm of white sand over gravel support a heath which includes blackboys, black gins (Kingia australis) and occasional blackbutts and woolly-bush.

The deep sands are characterised by blackbutt, woollybush, and banksia forest.

East of Dandaragan scarp, blackboys are less common on the gravel soils. White gum (E. Wandoo) and mallees (Eucalyptus spp.) are common in clay areas.

This unit is notable for the diversity and beauty of its wildflowers.

Hydrology

As most of the soils readily absorb water there are few permanent waterways and little runoff. Creeks in large trunk valleys which pass through this sub-unit from the Dandaragan Plateau, usually only flow for short periods once or twice a year.

Underground water occurs in the underlying sedimentary rock and is generally very deep, with supplies of good quality and quantity. The water bearing aquifers are thought to be lens-shaped in cross section and to follow the bedding lines of the underlying sedimentary rocks.

The underground water table bears no relation to the overlying topography, so bores sited in depressions generally strike water at shallower depths than those on hills. Water supplies are at about 200 m at Badgingarra, gradually decreasing in depth to about 100 m at the west of the sub-unit.

East of the Dandaragan Scarp, underground water can generally be found within 130 m of the surface.

Some shallow bores (less than 50 m) have been located in well defined drainage lines, but the quantity and quality of water from these sources may be affected by seasonal conditions because the intake areas are relatively local. Soaks are occasionally found.

Land use

About 82 per cent of this sub-unit has been alienated for agriculture. Most of the farms are between 1,200 and 1,600 hectares and have been occupied after 1955.

The main enterprises are grazing on improved pasture and some cropping (less than 25 per cent of pastured area) for wheat, barley, oats and lupins.

The potential of individual properties varies greatly, depending on the proportion of gravel-based soil to deep grey sand. Deep sand makes up 30 per cent of some properties. It is uneconomic to develop because although high rates of phosphorus and potash are required to maintain pasture growth, other factors, such as water holding capacity, limit production. When developed, these soils are generally sown to W.A. sandplain lupins.

The Badgingarra National Park (14,000 ha) is included in this sub-unit.

Herschel - sub-unit 1b (62,500 ha approx. 6% Crown Land)

In the West Midlands this sub-unit is found in two main areas:

- a strip 85 km long and between 1 and 8 kilometres wide on and below the Dandaragan Scarp
- a strip about 45 km long and 6 km wide running north and south of Cockleshell Gully.

Erosion on the Dandaragan Scarp has cut down to fresh sedimentary rock. Soils are formed on the weathering products of this rock. Broad U-shaped valleys coming from the Dandaragan Plateau are rejuvenated at the Dandaragan Scarp to sharply incised V-shaped valleys. Soakage areas are often found in the valleys at this point.

The Dandaragan Scarp is quite distinct and is marked by a steep NW-SW trending breakaway at its northern end.

Side slopes of the dissected valleys range from about 200 to 500 metres in length with grades of 2 to 5 per cent. After passing through this clay sub-unit, the dissected valleys re-enter the Badgingarra sub-unit where they resume their U-shaped sandy nature.

The Cockleshell Gully section was formed by erosion of a broad divide, through the lateritic layer, to expose the underlying sedimentary rocks. The area is considerably dissected by V-shaped valleys with short side slopes. Often at the top of major ridges, breakaways and sandy-gravelly soils occur as residuals of the old landscape. Downslope the grades become steeper and the soil changes to colluvial clay or sand over clay.

Valleys originating in this sub-unit form main trunk valleys which pass through the Badgingarra sub-unit.

Soils (Northcote Wd 10)

The Herschel sub-unit has mainly loamy and clay soils which are colluvial deposits formed by weathering of sedimentary rocks and the overlying lateritic profile (pallid zone, mottled zone and lateritic gravel). These soils range from clay gravels with increasing yellow-brown clay at depth to yellow and brown mottled clays which are overlain by up to 30 cm of grey yellow sand. Residuals of the Badgingarra sub-unit may occur as uplands which have not yet been eroded away.

Vegetation

The vegetation on the clay soils is predominantly white gum and mallee forests with some York gums (E. loxophleba) and flooded gums. Vegetation on the residual lateritic soils is characteristic of the Badgingarra sub-unit.

Hydrology

Depth to underground water is variable. It appears to range from 30 to 100 metres, but can be deeper. The clay soils are well drained with distinct drainage lines and undulating country. Some drainage lines are in clay and others contain up to two metres of sand. Seepages often occur and range in salinity from fresh to highly saline. Soaks are often found at the edge of sandy areas; the saline seepages tend to orginate in the sedimentary rocks and the lower horizons of the laterite.

Good dam sites are fairly common.

Land use

Over 90 per cent of this sub-unit has been alienated for agriculture, and many farms are fully developed. They are between 1,000 and 1,600 hectares in size.

The main enterprise is grazing on sub-clover pasture. Limited cropping for wheat, oats, barley and lupins is also practised. (Less than 20 per cent of cleared area). Cereal cropping has become more popular in the recent dry years, but take-all and septoria diseases are a problem.

Unless care is taken, water erosion of tracks, firebreaks and paddocks can be severe.

West Mogumber - Sub-unit 2c (125,000 ha. - less than 5% Crown Land)

This sub-unit has formed by dissection of the eastern side of the Dandaragan Plateau to yield a landscape and soils that are similar to the Badgingarra sub-unit. Most valleys drain generally to the Moore River which passes east-west through the centre of the sub-unit.

Soils (Northcote Wd9)

Soils are similar to the Badgingarra sub-unit except that there is a greater proportion of deep sand. In many places the laterite (or the sedimentary rocks under the laterite) has been deeply eroded, forming rounded hills and a well developed valley system. Sand has accumulated in the valleys resulting in flat bottomed, deep sand valleys and bare laterite hills on which any scours have been filled with sand. This mixture of gravel and sand over much of the area often makes it difficult to manage each soil type effectively. Occasionally the lower trunk valleys contain better class yellow sand. Many gravel hills are too stony for cropping.

Hydrology

Almost all rainfall is absorbed by the sandy soils.

There are occasional lakes containing diatomaceous earth in the main trunk valleys, but these rarely fill. There are no dam sites, but soaks are occasionally found. Most water supplies come from bores. The bores are usually 30 to 100 metres deep and supply good quantities of good quality water.

Vegetation

Similar to Badgingarra sub-unit.

Land use

Similar to Badgingarra sub-unit.

DANDARAGAN PLATEAU - Unit 3 (324,500 ha approx. 14% Crown Land)

This unit is a high, undulating plateau. The plateau has mainly sandy soils with occasional gravel hills. It includes the Dandaragan and Plateau sub-units.

Geological erosion on the west of the plateau down to the underlying cretaceous rocks has led to the formation of loamy soils (Dandaragan sub-unit).

Dandaragan - sub-unit 3a (Total area 93,500 ha. less than 1% Crown Land)

This sub-unit consists of three main areas located around Dandaragan, Red Gully and Gingin. The areas are generally bounded by the Swan Coastal Plain on the west and the uplands of the Dandaragan Plateau (Plateau sub-unit) on the east.

The underlying geology of the Dandaragan Plateau consists of almost level-bedded cretaceous sediments (ferruginous sandstone overlying sandstones, glauconitic shales and chalk).

Soils (Northcote AB3 AB4)

The Dandaragan sub-unit was formed by dissection of the Dandaragan Plateau in post-cretaceous times to form deep broad mature valleys with elevated tributary valleys leading from a gently undulating upland. Laterite subsequently developed on this landscape.

Erosion of this mantle with increasing depth of stripping downslope, progressively exposed the laterite, lateritic mottled zone, ferruginous sandstone, glauconitic clays and chalk. Colluvial sediments from these exposed layers provided the parent materials of the present day soils. Orange-yellow sands formed from the lower levels of the laterite, red-brown sands from the ferruginous sandstone, brown sands over reddish clays from the glauconitic clays and black clays with lime fragments from the chalk. The upper valleys occasionally contain colluvial deposits of white infertile sand.

Colluvial movement of the soil materials has caused a smoothing of the landscape and a gradual change between soil types. These soils have a high copper and zinc requirement when first cleared.

Vegetation

Much of the natural vegetation has been cleared for agriculture. Original vegetation on the slopes was mainly red gum, grevilleas and hakeas, acacias and Macrozamia. In the winter waterlogged valleys, flooded gum and Melaleuca and Leptospermum species (including paperbark trees) are common.

Hydrology

The soils of the slopes generally have good drainage and the main valleys often contain semi-permanent creeks. Soaks are very common at the base of the white sand deposits in the valleys.

Some saline patches occur in the upper-middle valleys where the valley grade is reduced.

Land use

Virtually all of this sub-unit has been alienated for agriculture, and many farms are fully developed. The size of farms in this sub-unit is variable, ranging from 400 to 10,000 ha. Farms around Dandaragan are generally large. The holdings around Gingin are much smaller in size. Enterprises in this sub-unit are mainly sheep and cattle grazing on improved pasture, with limited cropping (less than 20 per cent of cleared area).

As this land sub-unit was developed early in this century, many of the original farms were surveyed as small units of between 20 and 40 hectares. The landscape in this sub-unit is very picturesque and there is a demand for small farmlets.

Plateau - sub-unit 3b (231,000 ha - approx. 20% Crown Land)

This sub-unit comprises the remnant lateritic plateau which forms the main divide between east and westward flowing valleys.

From the divide, the plateau slopes gently to the east (except where it is dissected by the West Mogumber sub-unit) to the Darling Fault where it merges into a strip of flat lake and sandhill country (the northern branch of the Moore River, north of Moora). (Northcote AC5 AC6).

The lateritic plateau has only been slightly eroded, and the colluvial sands formed by the erosion have accumulated in the valleys, which has further smoothed the landscape.

Soils (Northcote AC2 AC4 AC5 AC6)

In the undulating uplands, the soils are mainly yellow sands (Northcote AC2 AC4) formed on colluvial deposits which are derived from weathering of the underlying laterite. On hill crests, the lateritic gravel occasionally approaches the soil surface, forming sandy gravel soils. Infertile white sand is often found in the valleys.

Lake country (Northcote AC5 AC6) forms a narrower strip on the east side of the Darling Fault and a larger area to the north west of the sub-unit (which, for the most part, has been included in the Watheroo National Park). This is an undulating plain with yellow sand dunes interspersed by waterlogged areas and small lakes which are reasonably fresh on the western edge, but become more saline towards the east.

Vegetation

The sub-unit has attractive wildflowers.

AC2 soils are characterised by blackbutts, acacias, banksias and Christmas trees on the sands. Gravelly soils are characterised by hakea, grevillea and acacia scrub.

AC4 and AC6 soils contain native pear (Xylomelum augustifolium) and native pine (Actinostrobus spp.), acacias and banksias on the sands.

Casuarina trees and samphire occur in the saline channels which form the northern most branch of the Moore River.

Hydrology

Nearly all rainfall is absorbed by the sandy soils. Ground water can be down to 130 m on the western edge of the sub-unit, and it is thought that the water table becomes gradually shallower to the east.

Land use

About 80 per cent of this sub-unit has been allocated for agriculture since 1955. Much of the remaining area has been incorporated into the Watheroo National Park. Many farms are still in the developmental phase. The main enterprises are sheep and cattle grazing on improved pastures and cropping for wheat, barley oats and lupin (generally less than 25 per cent of the cleared areas).

Potassium deficiency and poor water holding capacity of the pale yellow sands often limit subterranean clover production.

Poor clover growth and wind erosion limit sheep and cattle stocking rates.

High costs of fertilisers, variable crop yields and variable returns from sheep and cattle enterprises have greatly reduced the development of new land on farms. Stocking rates are between 2.5 and 4 DSE's/ha.

THE GREAT PLATEAU (Zone B)

This zone contains the shires of Chittering, Moora, Victoria Plains, Dalwallinu and Wongan-Ballidu (see Appendix v, vi, vii).

It is a laterite covered plateau of igneous rock, (mainly granites and gneisses) extending eastwards from the Darling Fault to include most of the south of Western Australia. Erosion of the plateau has exposed varying layers of the laterite, and in places, the underlying rock.

CLIMATE

The Great Plateau has a mediterranean-type climate with hot dry summers and cool wet winters.

Annual rainfall and length of growing season decrease inland in a south-west to north-east direction from the coast.

The range is 750mm annual rainfall with a six month growing season at Bindoon to 300mm annual rainfall with a three month growing season east of Wubin (see Appendix iv). The average break of the season varied form mid-April at Bindoon to mid-May east of Wubin. However, the break of the season can occur up to six weeks before or after the average date.

Isolated thunderstorms with heavy rainfall occur about one year in three in the eastern part of the zone. The intense rainfall often causes paddock and road erosion. Summer rain is welcome in these areas, because it enables farmers to prepare land for cropping, and the stored moisture on heavy land often improves crop yields.

Frosts may be expected from May to September, being most common in July and August. Frost frequency increases slowly in a south-east direction.

The Great Plateau is categorised into three main units (see Table 2).

Table 2 - Soil units and land use, The Great Plateau (Zone B)

		Total area (ha)	Area released for farming (ha)
Unit 4	Darling Range	184,000	172,000 (94%)
Unit 5	Zone of mature natural drainage	276,500	276,500(100%)
Unit 6	Zone of ancient natural drainage	1,233,400	1,061,000 (86%)

DARLING RANGE - Unit 4 (184,000 ha - approx. 6% Crown Land)

This unit occurs mainly in the Shire of Chittering. Annual rainfall ranges from 450 to 750 millimetres.

The unit comprises a high laterite covered range situated just east of the Darling Fault from Bindoon to Moora. The laterite has been

dissected by branches of the Moore and Brockman rivers to reveal underlying lateritic clays and parent rock.

Soils and vegetation

The laterite, lateritic clay and parent rock have weathered to form "buckshot" gravels (Northcote JZ2), lateritic sand loams (Tf3) and red brown loams (Qb29, Qb32).

Buckshot gravels

Buckshot gravels are associated with the highest parts of the range which has an undulating relief with stony non-arable ridges, and gravel soils containing small rounded ironstone pisoliths ("buckshot gravel"). These soils have a high phosphate requirement, particuarly in relatively young paddocks. Copper and zinc (A mix superphosphate) is required on new land. Depressions often contain grey sand. Natural vegetation on these soils is marri (E. calophylla), white gum woodland with an understory of prickly scrub.

Lateritic sand loams

Lateritic sand loams occur in hilly terrain downslope of the buckshot gravels. Chief soils are hard acidic yellow gravelly clay loams or gravelly sands over a clay subsoil.

Natural vegetation is white gum forest with accompanying flooded gums and sheoaks on valley floors. A copper and zinc dressing (A-mix superphosphate) is required on new land.

Red-brown loams

The red-brown loams have formed where the rivers have exposed the igneous parent rock. The parent rocks are mainly granites and gneisses with numerous dolerite dykes and schists formed in shear zones running parallel to the Darling Fault.

Soils on the valley sides are mainly fertile red brown earths associated with outcrops of igneous rock. Soils on the main valley floors are fertile alluvial silty loams and clays. These soils do not require trace elements.

Natural vegetation is a mixture of white gum, flooded gum, York gum and jam trees (Acacia acuminata). Sheoaks and paperbark trees are found along the river valleys and swamps and lakes.

Hydrology

The buckshot gravels absorb nearly all rainfall, but the lateritic and red brown loams provide good runoff for dams.

Water supplies are shallow, low yielding and often mildly saline bores, dams, and soaks. Main valley floors are often waterlogged in winter. Some valleys have become saline. The Brockman River is brackish and the Moore River is saline in summer.

Land use

The red-brown loams were settled as small blocks (10 to 80 hectares) in the early days of agricultural development in Western Australia. Farms are generally small multi-enterprise units (sheep and cattle

production, horses, cereal, hay, some cereal grain production, citrus and grape production). Farms in this area are being increasingly sought by hobby farmers as it is close to Perth, has fertile soils, good water supplies and pleasant scenery.

The lateritic loams and buckshot gravels have larger (800 to 2,000 ha) family farms carrying out sheep and cattle grazing and cropping for cereal hay and grain.

Crops

Up to 30 per cent of some farms is non-arable due to rock or winter waterlogging. Less than 30 per cent of arable land is cropped on most farms, but the area sown to cereals is increasing because of good grain prices.

Disease (take-all and septoria in wheat, net blotch and powdery mildew of barley) is the major factor limiting crop yield.

Waterlogging has been a problem in wet years, but this will be less limiting as more crops are sown by direct drilling methods.

Manganese deficiency is common in cereals grown on gravel soils. There is good potential for white lupin production on well drained soils.

Pastures

Most soils can grow excellent sub clover pastures. Most farmers graze approximately 5 DSE/ha on the existing pasture/crop rotation. Higher stocking rates can be achieved (7.5 to 10 DSE's maximum on gravel soils, 10 to 15 DSE/ha on red brown loams). The main varieties of sub clovers are Seaton Park, Daliak and Woogenellup. Many paddocks still contain the oestrogenic variety Dwalganup, but clover disease is no longer a significant problem. This is mainly due to the increased grass content in pastures.

Animal enterprises

Cattle raising for baby beef or steer beef production has become more important in the last five years.

Sheep enterprises are mainly fat lamb production, wool and merino sheep meat production.

AREA OF MATURE NATURAL DRAINAGE - Unit 5 (Area 276,500 ha - virtually all alienated for agriculture)

This unit occurs mainly in the shires of Victoria Plains and Moora. Annual rainfall ranges from 400 to 450mm.

In this unit the ancient plateau has been eroded by an active, westward flowing drainage system to expose lower levels of the laterite and the underlying parent rock. Remnants of the old plateau exist on the main divides where they form sandy and gravelly soils. The divides are all more or less truncated and many are reduced to narrow ridges with breakaways and flanking pediments.

The tributary and main valleys are U-shaped and are often salt affected.

Soils and vegetation

Lateritic soils (Ufl) on the uplands are mainly ironstone gravels, yellow mottled sandy gravels, and sands over gravel or yellow mottled clay. On new land, a dressing of copper and zinc (A-mix superphosphate) is required.

Vegetation is mainly white gums, mallees and heath on gravels and clays, and sandplain heath on sands, and sands over gravel subsoil.

Depressions in the uplands are occasionally filled with infertile deep white sands carrying banksias or Christmas trees. Soaks are often found below these deposits. Soils formed off parent rock (mainly granite) are fertile loams (Qb29) with rock outcropping or being present at shallow depths. These soils do not require trace elements.

The natural vegetation is York gums, jam trees, white gum and sheoak.

Alluvial soils (Vd6) occur in the floor of the main trunk valleys. The soils are mainly hard, yellow mottled clay loams with some gilgai soils and cracking clays. Natural vegetation is mainly York gums, salmon gums (E. salmonophloea) and white gums. These soils do not need trace elements.

Hydrology

This unit is drained by the Moore River, which flows in winter but is reduced to saline pools in summer. Since clearing, three per cent of productive soil in this area has become salt affected. Salinity occurs mainly in the trunk or tributary valleys or as small seepages on valley sides.

Trunk valleys and heavy soils on the valley sides can become too waterlogged for cropping in winter.

Most farms have underground water sources (shallow bores, wells and soaks). These supplies are often unreliable in very dry seasons. Dams can be found in the clay soils, but suitable sites are limited by shallow soils and salinity. As a result, many dams are small and have poor natural catchments.

Land use

Up to 25 per cent of some farms are non-arable due to rock or gravel outcrops, shallow soils, waterlogging or salinity. Enterprises are cereal production with sheep and cattle production on annual clover pastures.

Crops grown are mainly wheat with some barley and oats. Cereal yields are relatively high and returns from wheat are better than from other enterprises, resulting in an increase in crop area. Between 30 and 50 per cent of arable area is cropped annually. Reduced tillage cropping is being more widely adopted and herbicide usage is rapidly increasing.

Subterranean clover is successfully grown in this unit. In recent dry years, clover content has decreased greatly in the eastern (low rainfall) region where up to 50 per cent of land is cropped annually. Stocking rates vary from 2.5 to 6 DSE's/pasture hectare varying with

rainfall and cropping intensity. Heavy clay soils often have poor legume growth, because clovers do not grow well and lucerne fleas attack medics which are adapted to these soils.

The main animal enterprise is merino sheep grazing annual pastures to produce wool and live sheep for export. A few farmers run pigs.

Cattle production (steer and baby beef enterprises) has greatly declined in the last five years, due to dry seasons.

AREA OF ANCIENT NATURAL DRAINAGE SYSTEMS - Unit 6 (1,233,400 ha approx. 14% Crown Land)

This unit contains the Shires of Dalwallinu and Wongan Ballidu and the north eastern half of Moora.

Rainfall decreases in a north easterly direction from 400 to 275 mm.

This unit is a zone of old valley floors of the Great Plateau which is ancient and well preserved.

The unit has a sparse open drainage network, consisting of shallow, wide and ill defined valleys containing extensive chains of salt lakes. The salt lakes are regarded as remnants of ancient rivers. These chains of salt lakes eventually join the headwaters of the Swan-Avon and Moore rivers. The valley systems only form a connected system in extremely wet years.

The landscape is broadly undulating with slopes of less than 10.50 per cent, commonly approaching 1.75 per cent. The graded valleys occupy broad depressions and are seldom more than 60 m below the smooth, gently rounded divides. The uplands are mostly convex in shape and have a sandy surface underlain by lateritic mottled and pallid zones. In places, lower strata are exposed, revealing clay on the crests surrounded by sandy slopes. There are limited areas of breakaway pediments with soils developed on lateritic mottled and pallid zones and some exposures of country rock as bosses of gneiss or granite. With the exception of small areas where erosion has revealed the country rock, the whole landscape is underlain by deep pallid zones of weathering. The depth of weathering is greater under the valleys (where it may be greater than 20 m) than in the uplands.

Valleys are broad and dish-shaped and of low gradient (generally 1 in 500 to 1 in 1,500). Drainage lines flow infrequently following heavy rains and rarely as a continuous system. Valley floors are partly blocked by debris, are often saline, and modified by wind action to give bare dry salt lakes with flanking sand or gypsum dunes.

The trunk valleys are 10 to 19 kilometres wide and the main tributary valleys up to three kilometres wide.

Soils and vegetation

Soils are mostly developed on various lateritic horizons (sand, gravel, mottled zone, pallid zone) in the uplands or on alluvial, colluvial and aeolian deposits in the valleys which are derived by erosion of the laterite. As a rough estimate, 70 per cent of the soils are sandplain or gravels on the uplands, and 30 per cent are loams or clay loams in the valleys. Sandplains and gravel soils need copper,

zinc and molybdenum when first cleared. Trace elements are not required on clays and loams in valleys. Dominant soil associations are:-

Yellow earths

Yellow earths (Northcote Ms7 to 11) occupy 45 per cent of the unit on gently sloping to undulating uplands with long gentle slopes and abrupt erosional scarps (breakaways). Chief soils are yellow earths and earthy sands ("sandplain soils"). To a lesser extent, loam and clay loam soils occur as deposits in the main valleys or around granite outcrops. West of Dalwallinu the sandplain vegetation is dominated by native pine and native pear scrub. East of this, the vegetation is mainly sandplain heath and tammar (Casuarina spp.) with scattered mallees. The sandplain and wodgil soils are naturally acid (often with more acid subsoils). The pH of the surface soil is often between 5.0 and 5.5, which could affect clover growth.

Hard setting loamy soils with clay subsoils

These soils (Northcote Oc35, Va66, S128, Ub98) form 21 per cent of this unit -mainly gently undulating to hilly and with some ridges and uneven slopes and with some lateritic mesas and breakaways. Some granitic rock outcrops. Chief soils are hard setting duplex soils. Sandplain and wodgil soils are found to varying extents on the ridges. Vegetation is mainly Tammar and mallees with white gum, York gum, salmon gums and gimlets (E. salubris) in the valleys.

Salt lake channels

Salt lake channels (Northcote SV4) are 13 per cent of the unit - mainly flooded, flat, salt lakes without true soils. The edges of the salt lake are often lined by gypsum dunes or saline parna soils ("fluffy morrel soils"). The fluffy morrel soils are naturally saline, silty clays and loams and only produce good crops in wet years. Morrel trees (E. longicornis) grow on the morrel soils. Saltbush (Atriplex spp.), bluebush (Kochia spp.) and samphire and boree (Melaleuca spp.) grow in and around salt lake channels.

Sandy soils with yellow mottled clay subsoils

These soils (Northcote Xd2) make up 10 per cent of the unit. These soils occur on the western edge of the unit. Gently rolling terrain of smooth ridges and spurs separated by valleys showing recently developed salinity.

Chief soils are sandy, neutral, yellow mottled soils containing some ironstone gravels. Natural vegetation is Tammar, mallee and white gum.

Red and brown earths

Red and brown earths (Northcote DD17, My41,42) form 7.5 per cent of the unit, chiefly around Dalwallinu and Jibberding with a small area west of Wongan Hills on flat to undulating land. Chief soils are brown calcareous earths (DD17 soils) and neutral and alkaline red earths (My. soils). Natural vegetation consists of salmon gum, gimlet, York gum and mallee.

Subsequent to clearing of this unit for development, large areas of the colluvial and alluvial soils in the valleys have become saline.

Hydrology

A highly saline watertable occurs below the valley floors over most of the unit. As a result of agricultual development, the level of the water table has risen. In many areas, the watertable has come within capillary range of the surface and given rise to surface salting. Approximately four per cent of farm land in this unit has become too saline for crop production. Underground water suitable for stock can often be found on the sandy interfluves. Bores are generally shallow (20 m) yielding low quantities of stock quality water. Suitable dam sites are very limited because of salinity, poor holding clays and poor natural catchments.

Water supplies on many farms (particularly those with rock, gravelly or salt affected soils) are adequate for the very low stock numbers present, but they could limit future increases in stock numbers.

The Comprehensive Water Supply is connected to farms in the southern quarter of Dalwallinu shire, and most of the shire of Wongan-Ballidu.

Land use

Before 1976 the major enterprise was wheat production after fallow, clover or unimproved pasture with some coarse grain, sheep and cattle production.

Drought and dry years from 1976 to 1980 inclusive, have greatly reduced sheep and cattle numbers. Farmers have substantially increased the area sown to wheat to recoup losses incurred by each drought. Many farms would have a stocking rate of one DSE/winter pasture hectare or less. Farmers are cropping between 50 and 70 per cent of their farms annually.

Medics (Medicago truncatula) are persisting on the alkaline loams but drought has almost eliminated subterranean clover from pastures in the eastern part of the unit.

The sub clover variety "Nungarin" has a relatively high hard seed content. Hopefully Nungarin will be able to persist in this area despite drought.

A short growing season is the main factor affecting crop yield and there is considerable innovation in terms of early planting, weed control, and tillage practices to maximise moisture utilisation.

There is much interest in a continuous cropping, stubble retention system. This is because of the high cost and unreliability of re-establishing sub clover pastures, relatively poor returns from animal enterprises, soil structure breakdown and wind erosion.

This system will be more attractive if and when a suitable lupin cultivar is bred as a legume crop to profitably provide nitrogen for a following cereal crop.

High intensity rainfall from thunderstorms occurs about one year in three over summer in the eastern part of this unit. These storms can cause extensive sheet and rill erosion on stubbles and fallow.

Fallowing is still a profitable practice on the heavy soils.

Relatively low cereal yields, lack of alternative enterprises and increasing costs of fertiliser (particularly nitrogen), fuel and machinery are reducing the profitability of farms in this unit.

Five very poor seasons (1976 - 1980) have depleted most farmers' financial resources.

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Appendix i. Rainfall (mm) and number of raindays of the West Midlands (Zone A)

	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
BADGINGARRA RES. STN.													
Mean	8	20	16	35	73	170	108	95	49	36	13	10	633
Median	2	9	9	39	62	167	114	81	43	28	7	12	684
Raindays													
Mean (No)	3	3	4	8	11	19	17	16	12	9	6	3	111
MOORA													
Mean	11	14	20	23	60	96	90	64	39	26	11	9	463
Median	4	3	8	17	57	91	86	58	35	24	7	3	462
Raindays													
Mean (No)	2	2	3	6	10	15	16	14	10	8	4	2	92
DANDARAGAN													
Mean rainfall	11	14	14	45	80	145	136	91	49	42	14	8	649
GINGIN													
Mean rainfall	8	12	18	36	105	156	159	119	71	53	18	11	766
LANCELIN													
Mean rainfall	5	10	18	39	76	155	127	88	57	31	14	7	627

Mean rainfall: The January average was obtained from all January totals on record and similarly for other months. The year mean is the sum of the monthly averages.

Median rainfall (middle value). That monthly value not reached in half the years and which is exceeded in the other half of the years. The yearly median is obtained from all available yearly totals and not by summation of the monthly median value : it usually differs from that sum.

Raindays: Those with 0.2 mm or more of precipitation. The yearly mean is the sum of the monthly averages.

Source: Climatic Averages W.A. (Metric), Bureau of Met., August 1975. 551.5 (941)

Appendix ii. Agricultural statistics (1965-1979) of the West Midlands (Zone A)

	SHIRE					
	DANDARAGAN			GINGIN		
	1965-69	1970-74	1975-79	1965-69	1970-74	1975-79
No. Farms			198 (1979)			172 (1979)
Total area rural holdings			390,729 (1979)			181,823 (1979)
Area wheat (ha)	11,511	10,535	16,852	2,318	1,351	1,660
Yield t/ha	0.74	0.89	1.05	0.72	0.95	0.85
Area oats (ha)	5,261	2,389	8,305	1,651	1,063	1,892
Yield t/ha	0.52	0.76	0.9	0.45	0.75	0.71
Area 2 row barley (ha)	907	4,126	2,861	315	1,270	1,005
Yield t/ha	0.91	0.83	0.97	0.32	0.82	0.85
Area 6 row barley (ha)	660	92	245	375	119	94
Yield t/ha	0.67	0.62	0.63	0.49	0.94	0.89
% cleared area that has become saline			<0.1% (1979)			<0.1% (1979)
No. cattle	10,185	33,457	43,126	16,631	29,010	31,774
% Breeders	56.8	58.9	52	55.6	56.7	56
No. sheep	380,129	511,168	583,956	151,703	127,328	139,326
% Breeding ewes	39	42.2	46	47.9	54.3	55
Lambing %	68	65.2	69	72	71.8	75
% Ewes mated to merinos			55			29
Wool production	1,648,239	2,317,003	2,675,492	555,576	553,193	569,487
No. pigs	1,702	2,340	2,204	776	1,277	2,380

Appendix iii. Soil physical properties from soil samples of the West Midlands (Zone A)

RED BROWN SANDS - (Dandaragan Sub-unit)

(a) Red brown to brown sand which becomes finer textured with depth (marri vegetation).

(b) Orange coloured sand (marri vegetation).

		% Coarse sand	% Fine sand	% Silt	% Clay	pH
(a)	Surface	61	23	3.5	9	6.2
(b)	Surface	65	26	2	5	6.1

YELLOW SAND

(a) Yellow coarse sand of uniform texture (Native pear and pine or banksia spp vegetation)

(b) Grey yellow sand with increasing yellow colour below 15 cm.

		% Coarse sand	% fine sand	% Silt	% Clay	pH
(a)	Surface	83	8	3.5	4	5.9
(b)	Surface	60.5	34.5	1.5	4	6

GRAVELLY SOILS

(a) Grey sand over dense laterite at 15 - 60 cms (low scrub vegetation)

(b) Grey yellow sand over gravel at 15 cms (low scrub vegetation)

		% Coarse sand	% fine sand	% Silt	% Clay	pH
(a)	Surface	72	23	1.5	1.5	6.2
	Subsoil (28% gravel discarded)	64	31	1.5	3	6.3
(b)	Surface (18% gravel)	21.5	70	2.5	5	6
	Subsoil (83% gravel)	23	68	3.5	5.5	6.2

GREY AND WHITE SANDS

(a) Deep white sand (banksia, woolly bush vegetation).

(b) Grey sand (banksia, woolly bush vegetation).

(c) Grey sand over pale yellow sand (blackbutt, banksia vegetation).

		% Coarse sand	% fine sand	% Silt	% Clay	pH
(a)	Surface	95	4	0.5	0.5	5.3
(b)	Surface	60.5	35.5	1	2.5	6
(c)	Surface	63.5	34	1	1	6.3

Appendix iv. Rainfall (mm) and number of rain days of the Great Plateau (Zone B).

Unit 4 Darling Range

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mooliabeenie - mean	8.5	14	21	36	11.5	152	155.5	118	67	50	21.5	15	751.5
New Norcia - mean	9	12	21	26	72	110	103	82	50	34	15	12	546

Unit 5 Area of Mature Natural Drainage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bolgart - mean	8	16	22	26	66	94	92	65	36	26	12	11	474
Calingiri - mean	9	12	20	27	64	95	88	64	32	27	11	10	499
Miling - mean	11	17	20	25	52	81	70	53	25	19	9	8	390

Unit 6 Area of Ancient Natural Drainage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Wongan Hills - mean	11	14	21	21	53	79	72	52	28	19	10	9	389
- median	5	3	9	18	47	71	66	49	24	16	8	2	398
Mean No. rain days	2	2	3	5	8	12	13	11	8	6	3	2	75
Dalwallinu - mean	11	14	22	22	52	84	72	55	29	17	10	9	397
- median	3	4	9	13	43	74	64	46	25	13	5	4	391
Mean No. rain days	2	2	3	5	8	13	13	11	8	6	3	2	76
Kalannie - mean	14	15	18	24	44	64	52	40	17	13	10	8	319

Appendix v. Agricultural statistics (1965-1980) of the Darling Range area of the Great Pleateau (Unit 4, Zone B)

	CHITTERING SHIRE		
	1965-1969	1970-1974	1975-1980
No. rural holdings			227 (1979)
Total area rural holdings			81,221 (1979)
Area wheat (ha)	959	699	944
Wheat yield t/ha	0.93	1.43	1.42
Area oats (ha)	1,406	1,036	2,068
Oat yield t/ha	0.87	1.18	1.27
Area 2 row barley (ha)	823	654	807
2 row barley yield t/ha	0.69	1.01	1.37
Area 6 row barley	184	67	44
Yield 6 row barley	1.07	1.31	1.36
% cleared area that has become saline			0.8 (1979)
No. cattle	7,728	18,543	17,226
% breeders	59	59	60
No. Sheep	150,249	151,359	127,578
% breeders	52.3	52	56
Lambing %	67.2	69.4	72
% Ewes mated to merinos			30
Wool production kg	574,235	617,839	546,397
No. pigs	1,107	1,317	1,105

Appendix vi. Agricultural statistics (1965-1979) of the Zone of Mature Natural Drainage on the Great Plateau (Unit 5, Zone B)

	SHIRE					
	MOORA			VICTORIA PLAINS		
	1965-69	1970-74	1975-79	1965-69	1970-74	1975-79
No. rural holdings			194 (1979)			166 (1979)
Total area rural holdings			354,139 (1979)			226,625 (1979)
Area wheat ha	58,398	49,274	71,375	39,087	28,175	43,712
Wheat yield t/ha	1.14	1.34	1.35	1.24	1.58	1.55
Area oats ha	8,992	6,796	5,984	5,689	3,676	4,569
Oats yield t/ha	0.74	0.9	1.12	0.77	1.08	1.19
Area 2 row barley ha	1,466	10,455	6,228	3,381	12,769	6,541
Yield 2 row barley	0.9	1.05	1.29	1.05	1.3	1.53
Area 6 row barley	2,258	1,692	680	1,010	349	140
Yield 6 row barley	0.76	0.89	1.18	0.83	0.87	1.15
% cleared area that has become saline			3.9% (1979)			2.7% (1979)
No. cattle	6,886	14,383	14,707	4,692	13,908	14,094
% Breeders	58.5	58.1	58	59.6	60	57
No. sheep	665,848	807,830	674,828	527,714	597,822	525,226
% breeding ewes	46.8	45.7	49	38	40.8	46
Lambing %	69	62	64	65	64	65
% Ewes mated to merinos			77			81
Wool production	2,929,385	3,672,699	3,352,146	2,321,050	2,703,343	2,512,264
No. pigs	2,537	5,030	3,414	2,758	6,325	3,450

Appendix vii. Agricultural statistics (1965-1979) of the Zone of Ancient Natural Drainage on the Great Plateau (Unit 6, Zone B)

	SHIRE					
	DALWALLINU			WONGAN-BALLIDU		
	1965-69	1970-74	1975-79	1965-69	1970-74	1975-79
No. rural holdings			206 (1979)			179 (1979)
Total area rural holdings			551,921 (1979)			336,809 (1979)
Area wheat ha	151,521	138,203	197,247	89,526	79,221	115,202
Wheat yield t/ha	1.01	1.19	0.78	1.13	1.39	1.21
Area oats ha	14,048	18,712	11,632	7,385	6,996	4,420
Oats yield t/ha	0.62	0.74	0.54	0.68	0.91	0.87
Area 2 row barley ha	85	4,032	1,468	171	11,470	5,820
Yield 2 row barley	0.35	1.0	0.78	1.03	1.2	1.23
Area 6 row barley	1,477	9,009	1,884	2,011	6,120	1,228
Yield 6 row barley	0.81	1.0	0.69	0.99	1.05	0.92
% cleared area that has become saline			2.5% (1979)			5.8% (1979)
No. cattle	1,345	4,295	2,589	933	2,800	3,391
% breeders	51.4	56	57	54.2	54.6	56
No. sheep	459,209	515,414	375,739	462,065	557,164	477,333
% breeding ewes	52.6	51.4	54	49.7	49.9	51
Lambing %	72.8	64.4	65	73	66	70
% Ewes mated to merinos			92			91
Wool production	1,497,609	2,195,831	1,754,469	2,155,158	2,538,587	2,315,121
No. pigs	2,288	6,123	3,464	2,374	7,030	3,588

Appendix viii. Soil physical properties from soil samples of the Great Plateau (Zone B).

DARLING RANGE (UNIT 4) AND AREA OF MATURE NATURAL DRAINAGE (UNIT 5).

LATERITIC SOILS

Buckshot gravel (Unit 4) Marri - White gum vegetation.
Sample contained 48% gravel.

% Coarse sand	% Fine sand	% Silt	% Clay	pH
35	41	11.5	12.5	

Sand over gravel (Unit 5)

(a) Yellowish brown sandy loam becoming gravelly with depth.

(b) Greyish brown sand becoming yellow brown and gravelly with depth.

(c) Greyish brown sand over gra l.

		% Coarse sand	% ne sand	% Silt	% Clay	pH
(a)	Surface	50	30	4	11	5.5
(b)	Surface	67	26	3	4	6.2
(c)	Surface	66	30	1	3	6.7

Gravel soil (Unit 5)

Pale brown gravelly soils over dense gravel subsoil.

	% Coarse sand	% Fine sand	% Silt	% Clay	pH
Surface	49	40	4	5	6.2

Sand over lateritic clay

(a) 15 cm greyish brown loamy sand over mottled sandy clay loam.

(b) 20 cm dark grey brown loamy sand over mottled yellow brown and grey clay loam.

		% Coarse sand	% Fine sand	% Silt	% Clay	pH
(a)	Surface	49	37	4	9	5.8
(b)	Surface	42	34	8	9	6.2

SOILS FORMED FROM PARENT ROCK

(a) Dark brown loamy sand becoming yellow with increasing gravel and clay at depth.

(b) Dark reddish brown gritty loam sand with stones and gravel. Increasing clay and gravel content with depth.

(c) Dark reddish brown loamy sand with granite fragments. Increasing clay and rock fragments with depth.

(d) Reddish brown loamy sand with gravel. Increasing clay with depth.

(e) Reddish brown clay.

(f) Dark brown sandy loam. Increasing clay and rock fragments with depth.

(g) Alluvial soil. Greyish brown sandy loam over clay subsoil.

		% Coarse sand	% Fine sand	% Silt	% Clay	pH
(a)	Surface	50	30	4	13	6.2
(b)	Surface	64	23	4	7	6.9
(c)	Surface	44	36	6	9	5.6
(d)	Surface	43	42	7	7	6.3
(e)	Surface	23	30	2	48	7.8
(f)	Surface	30	39	10	12	6.4
(g)	Surface	37	37	7	15	8.4
(h)	Surface	33	40	5	17	6.4

AREA OF ANCIENT NATURAL DRAINAGE (UNIT 6)

LATERITIC SOILS ON DIVIDES

(a) Grey brown gravelly sandy loam over gravelly clay loam.

(b) Grey brown sandy loam over sandy clay and decomposing kaolinite rock fragments.

(c) Brownish grey clayey coarse sand with increasing clay and gravel with depth.

(d) Greyish yellow brown clayey sand, becoming loamy with gravel at depth.

(e) Yellowish brown loamy sand becoming loamy with gravel at depth.

		% Coarse sand	% Fine sand	% Silt	% Clay	pH
(a)	Surface	51	28	6	13	6
(b)	Surface	54	25	8	11	5.3
(c)	Surface	71	18	3	7	6.7
(d)	Surface	56	31	3	10	6.3
(e)	Surface	57	24	4	14	5.5

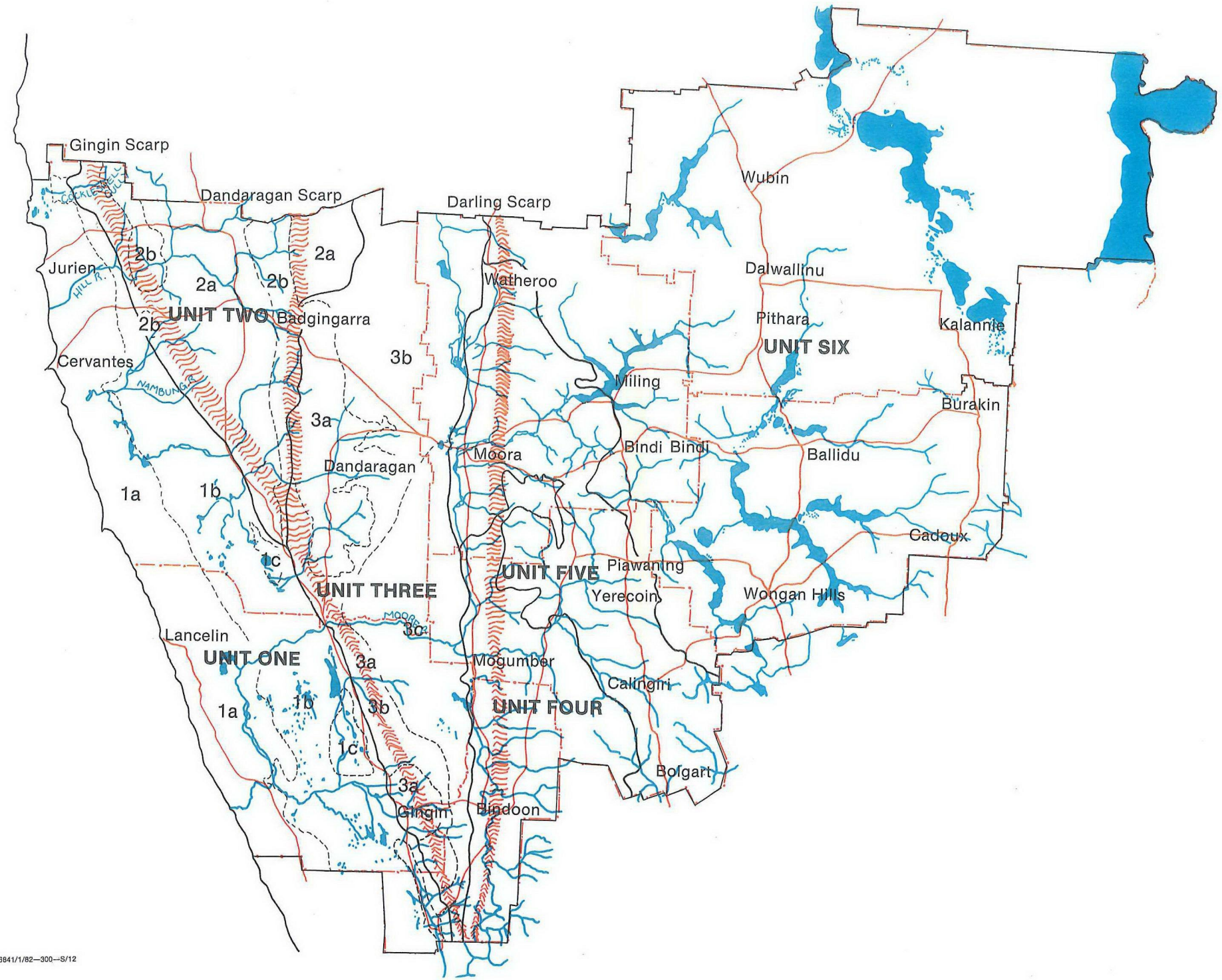
VALLEY SOILS

(a) Dark brown sandy loam over pale brown sandy clay.

(b) Dark brown sandy clay loam over brown clay.

(c) Dark reddish sandy loam over reddish brown clay.

		% Coarse sand	% Fine sand	% Silt	% Clay	pH
(a)	Surface	54	20	8	12	8.2
(b)	Surface	33	31	12	20	7.1
(c)	Surface	45	23	17	12	6.9



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