LANDS OF THE NOGOA–BELYANDO AREA, QUEENSLAND

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Lands of the Nogoa–Belyando Area, Queensland

Comprising papers by R. H. Gunn, R. W. Galloway,
L. Pedley, and E. A. Fitzpatrick

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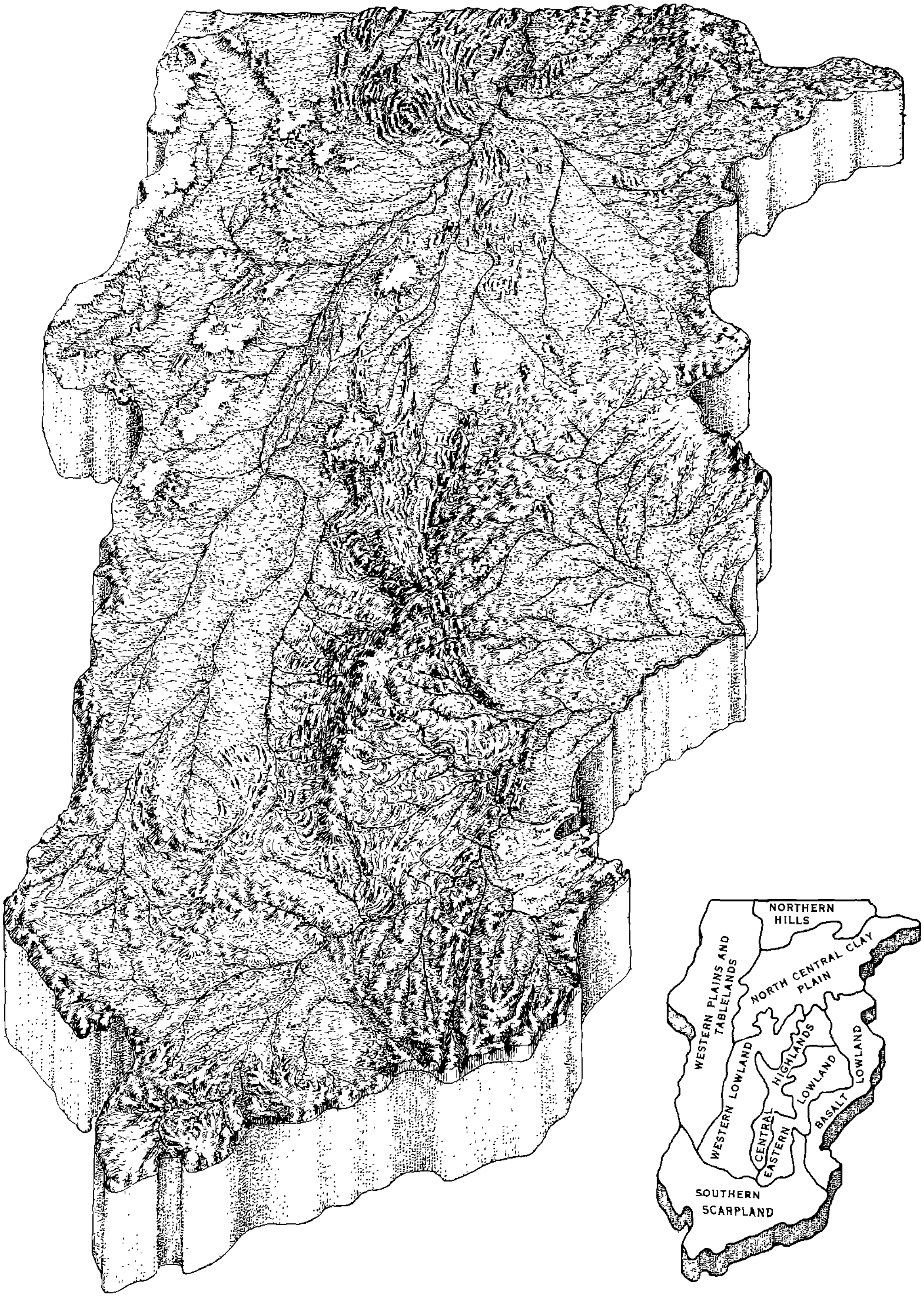

The Nogoa–Belyando area comprises eight physical regions each with distinctive relief and broadly related complexes of soil and vegetation.

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Soils }

Vegetation

Tree Communities } On one sheet
Grass Communities }

Pasture Lands

PART I. INTRODUCTION TO REPORT ON THE NOGOA–BELYANDO AREA

By R. H. Gunn*

I. Location

The survey area covers 35,000 sq miles in east-central Queensland. It includes most of the country known as the Central Highlands Region comprising the Shires of *Bauhinia*, *Emerald*, *Peak Downs*, and part of Jericho. It is bounded on the west and south by the Great Dividing Range and on the east by the Leichhardt, Denham, and Peak Ranges which coincide in part with the western boundary of the Isaac–Comet area surveyed in 1962. The northern boundary is the 21°S. parallel. The area includes

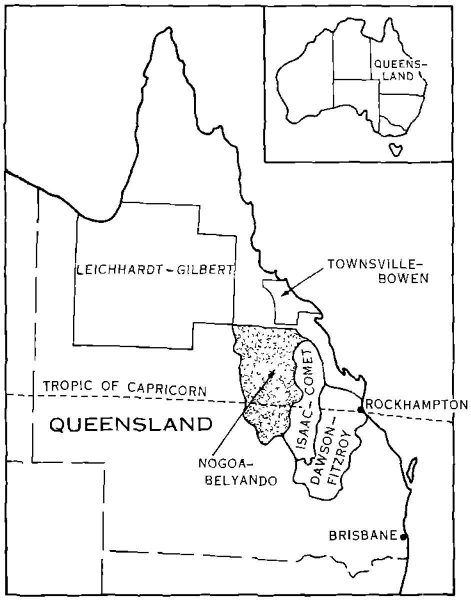

Fig. 1.—Location of the Nogoa–Belyando area in relation to other survey areas in Queensland.

the catchments of the Nogoa, a tributary to the Mackenzie–Fitzroy system, and of the Belyando and Suttor Rivers which flow north to the Burdekin, together with the internal drainage basins of Lakes Galilee and Buchanan. About two-thirds of the area lies north of the Tropic of Capricorn. The location of the area is shown in Figure 1 in relation to other survey areas in the Fitzroy Region and elsewhere in Queensland.

II. Survey Methods

Field work was carried out during three periods totalling 14 weeks in 1964 by a team comprising a geomorphologist, pedologist, and plant ecologist, and procedure

* Division of Land Research, CSIRO, Canberra.

followed that of similar reconnaissance surveys by the Division of Land Research. The main objectives of these surveys are to identify and describe the various types of land within large areas and to indicate those parts where more detailed investigation

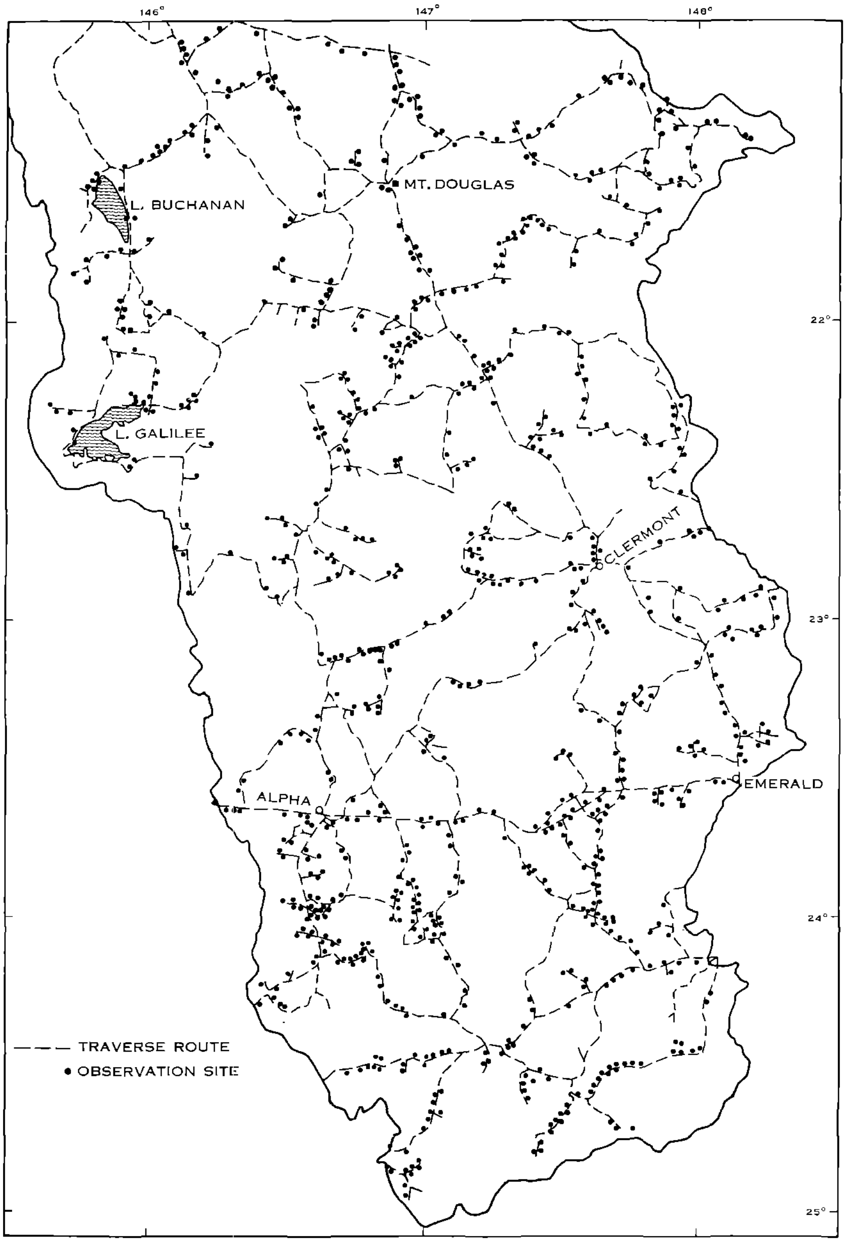

Fig. 2.—Traverse routes and observation sites.

may be warranted from the viewpoint of potential land use. The mapping units are termed "land systems", defined as areas with recurring patterns of land forms, soils, and vegetation.

Land system mapping is based on the identification of distinctive patterns on aerial photographs. These patterns are mapped initially by stereoscopic examination and are then studied systematically in the field. Variations in tone, texture, and relief in the patterns reflect mainly differences in land form and vegetation as governed by geomorphic history, lithology, soil, and climate. The final interpretation and mapping are done after completion of the field work. Complete photographic cover of the area was available at scales of 1 : 50,000 and 1 : 85,000.

Approximately 300 patterns were distinguished and delineated on the aerial photographs. This detail in mapping was deemed necessary for an understanding of the distribution and relationships of the various types of land in the area. These patterns reflected differences in lithology, relief, and vegetation, and because of the considerable degree of simplification imposed by the scale of mapping (1 : 500,000) they were later grouped into 43 land systems according to their affinities.

During the periods in the field the team traversed 7250 miles and observations were made at 800 sites. The traverse routes are shown in Figure 2, which is in the nature of a reliability diagram.

III. Towns and Communications

The largest town is Emerald on the eastern boundary of the area. It is situated on the left bank of the Nogoa River 175 miles from Rockhampton and has a population of 2029*. Clermont, Alpha, and Blair Athol are the only other important centres, with populations of 1737, 714, and 405 respectively. There are minor settlements at Capella, Anakie, Bogantungan, and Rubyvale.

The central railway from Rockhampton to Longreach passes through Emerald and Alpha and bisects the southern half of the area. There are branch lines from Emerald south to Springsure, which lies a few miles outside the area, and north to the coal-mining centre at Blair Athol. Emerald and Clermont have regular air services operating between Rockhampton and airports in western Queensland.

The area is served by a network of main and subsidiary roads. The northern inland highway from the coast to Charters Towers passes through Emerald and Clermont and there is a road west to Bogantungan and Alpha. A main road extends eastwards from Clermont to Mackay on the coast and a subsidiary road links Mt. Coolon and Collinsville. Westwards, there are roads from Springsure and Clermont to Tambo, which lies 50 miles outside the south-western boundary of the area. A new road has recently been constructed from north of Mt. Douglas on the northern inland highway to Mirtna and Natal Downs in the north-west.

IV. History

The discovery and development of the Peak Downs district in the eastern part of the area have been recorded by Rogers (1960) and the following brief outline is based largely on this source.

Leichhardt was the first European to enter the area on his expedition from Jimbour to Port Essington in 1844–45. He traversed parts of the Peak Downs and

* Population figures based on 1961 census.

Suttor River areas on his way north to the Burdekin. Settlement of the Peak Downs area followed some time later and by 1860 expanded north and west mainly for pastoral purposes, but the discovery of gold, copper, and coal hastened development and the construction of roads and railways. The coal seam at Blair Athol was opened in the 1860s.

In 1846 Sir Thomas Mitchell on his expedition in search of a route from New South Wales to the Gulf of Carpentaria entered the area from the south near Mt. Faraday. After crossing the headwaters of the Nogoa he followed the course of the Belyando almost as far north as the confluence with the Suttor.

Charles Gregory, the surveyor-explorer, demarcated sites for townships at Clermont and Capella in 1862 and a branch railway reached Clermont in 1864. Hart (1955) mentions that maps dated 1870 show the subdivision of numerous properties into square-mile blocks for the obvious purpose of farming but attempts at dairying and cotton-growing about 1900 were not successful. Sheep were at one time important in the Emerald–Clermont area and elsewhere but have been replaced almost entirely by cattle owing to the increase of white spear grass.

In 1948 the Queensland British Food Corporation acquired land in three areas near Wolfang, Peak Downs, and Cullin-la-ringo for the production of foodstuffs and other agricultural products. Grain sorghum was the main crop but this large-scale farming enterprise was not successful owing mainly to unfavourable weather conditions (Hart 1955). After considerable reduction of plantings in 1952, the scheme was abandoned in 1954. Within recent years the production of grain and fodder crops has expanded in these areas but cattle-raising is the major industry in the area as a whole.

V. Acknowledgments

Assistance and cooperation from the following authorities are acknowledged.

The Queensland Department of Primary Industries made available Mr. L. Pedley for the ecological work of the survey and botanists of the Department assisted with plant identifications. The Commonwealth Bureau of Meteorology supplied climatic data and the National Mapping Division, Department of National Development, compiled the base map of the area. The Bureau of Mineral Resources and the Queensland Department of Mines supplied information on the geology of the area.

VI. References

Hart, J. (1955).—The agricultural potential of the central Queensland highlands. *Qd agric. J.* **81**, 187–201.

Rogers, Penelope (1960).—The Peak Downs scheme. B.A.(Hons.) Thesis, University of Queensland.

PART II. SUMMARY DESCRIPTION OF THE NOGOA–BELYANDO AREA

By R. W. Galloway* and R. H. Gunn*

I. Introduction

In Section II of this Part the major features of the environment are considered systematically with reference to the coloured maps of geology–geomorphology, soils, and vegetation. In Section III the major types of country are described with reference to the plates and their relations to the land systems are discussed; these major types are used in grouping the land systems in the land system map. Finally, Section IV summarizes some aspects of land use with special reference to the map of pasture lands.

II. Major Features of the Environment

(*a*) *Climate*

The area has a subtropical to tropical, subhumid to semi-arid climate with mean annual rainfall decreasing inland from about 27 in. in the east to about 20 in. in the west. The rainfall is highly variable, particularly in the west, while the occasional occurrence of particularly wet years makes the mean annual rainfall considerably higher than the most commonly occurring annual rainfall. About three-quarters of the rain falls in the six summer months, with a rather higher proportion in the north and a rather lower proportion in the south where winter rains assume some significance. Throughout the area February is the wettest month with an average of at least 3·5 in. at most stations. The driest months are August and September, when most stations have less than 0·8 in. mean monthly rainfall.

Mean maximum temperatures range from approximately 70°F in July to 95°F in January. Very high temperatures, in excess of 100°F, are common during the early summer, but are much less frequent in February on account of increased cloudiness and rainfall. Mean minimum temperatures range from about 40°F in July to about 70°F in January. Diurnal temperature ranges are high, particularly in winter and spring, on account of the continental situation. Frosts occur in winter, especially in low-lying sites in the southern part of the area.

Relative humidities are highest in February and March and lowest in October and November. Calculations indicate that mean annual pan evaporation ranges from 71 in. at Springsure to 82 in. at Tambo.

(*b*) *Geology*

Six major structural units are present in the area. The oldest is the Anakie Inlier of tightly folded metamorphic rocks and granite which forms an elongated belt

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near the centre of the area. The Drummond Basin to the west of the Anakie Inlier contains a thick sequence of volcanics, sandstone, mudstone, and shale of Devonian to Carboniferous age. These rocks are folded along meridional lines into fairly narrow anticlines and wide, shallow synclines. The Bulgonunna Block on the north-eastern side of the Anakie Inlier consists mainly of folded and fractured Carboniferous volcanics. The eastern edge of the survey area extends onto the Permian quartz or lithic sandstones and shales of the Bowen Basin. The Springsure Shelf in the south has alternating sandstone and shale beds of Permian to Mesozoic age, which dip gently to the west and south. The west of the area is underlain by Permian to Mesozoic sediments of the Great Artesian Basin which dip very gently westwards towards the heart of the continent.

In addition to the rocks associated with these six structural units, the eastern part of the area has extensive sheets of Tertiary basalt and limited Tertiary igneous intrusions. Over most of the area Tertiary continental sediments, ranging from sandstone to clay, were laid down and deep weathering of these and older rocks occurred. Post-Tertiary alluvium is widespread along all the major rivers.

(c) *Geomorphology*

The relief of the area is illustrated by the frontispiece block diagram. After the formation of extensive basalt sheets in early Tertiary times, prolonged erosion etched out areas of softer rocks to form lowlands while leaving harder rocks standing up as scarps and hill masses. Later in the Tertiary, erosion attacked these higher areas and covered the adjacent lowlands with detrital deposits ranging from conglomerate and sandstone to clay. The result was a gently undulating Tertiary land surface that was depositional over extensive lowland areas and erosional on limited higher areas. Deep weathering associated with this landscape produced the Tertiary weathered zone with laterite overlying mottled and pallid zones.

Subsequently the Tertiary land surface and weathered zone were partially eroded and in places removed entirely. This erosion resulted in the development of a soil catena and associated vegetation types on a wide range of rocks, particularly the Tertiary sediments. Little removal has taken place in the west and here the gently undulating to level Tertiary land surface with loamy or sandy soils has survived. Partial removal of the Tertiary land surface has taken place in the centre, east, and north of the area, and consequently all parts of the catena and also some areas of fresh pre-Tertiary rocks are represented. Almost complete removal in the south of the area has given a landscape conditioned by the lithology of the exposed unweathered pre-Tertiary rocks.

Renewed deposition in late Tertiary times formed extensive clay sheets in the north-east and sandy fans in the north-west, while gravel terraces formed along the major streams. Two phases of alluvial deposition, separated by a period when wind deposition was significant, occurred in the Quaternary.

(d) *Soils*

Seven major groups of soils have been recognized in the area. The generalized distribution of six of these groups is shown on the soils map.

(i) *Cracking Clay Soils.*—These widespread soils have medium to high clay contents and pronounced swelling and shrinking properties. Deep clays, generally strongly alkaline at depth, have formed on alluvium. Gilgaied, deep, medium to heavy clays occur in low-lying areas on truncated deep weathering profiles; the surface is generally neutral to strongly alkaline while the lower horizons are moderately to strongly acid. Non-gilgaied clay soils of similar properties occur on slightly higher sites on the same material. Dark, gypseous clay soils occur on transported material in the north of the area. Sedentary cracking clays, usually strongly alkaline, occur on basalt in the east. Shallow cracking clays occur on hilly areas of basalt and sedimentary rocks and are usually strongly alkaline and often stony.

(ii) *Dark Brown and Grey-brown Soils.*—These soils are developed mainly on shales and have either uniform medium to fine textures or a gradual increase in clay with depth. They are generally moderately to strongly alkaline, though surface layers may be acid. Surface texture is loamy and there is little cracking on drying.

(iii) *Texture-contrast Soils.*—These are probably the most widespread in the area. They have formed on a wide range of parent materials and are particularly associated with the middle parts of the Tertiary catena. They are often alkaline at depth with poor physical properties and on sloping ground have a high susceptibility to erosion. They have been subdivided into those with shallow sandy or loamy surface soils, deep sandy surface soils, and shallow total depth.

(iv) *Uniform Coarse-textured Soils.*—These soils occur on sandstone and associated colluvial spreads. They are acid, moderately deep to deep, and have low fertility.

(v) *Red and Yellow Earths.*—These soils characterize the intact remnants of the Tertiary land surface in the west of the area, and also some coarse alluvia. The more argillaceous have massive structure while the sandy types are less compact. Fertility and water-retaining capacities are low.

(vi) *Shallow Rocky Soils.*—Mountains and hills on resistant rocks generally have little more than shallow rocky soils of negligible economic value.

Alluvial soils with minimal profile development are widespread along the major streams but occurrences are too small to be shown on the soils map. Saline mudflats with no profile development occupy the floors of Lakes Galilee and Buchanan.

(*e*) *Vegetation*

The major plant formations are grassland, open tree communities (woodland), and closed tree communities (scrub).

(i) *Grass Communities.*—Seven of the 10 grass communities recognized are shown on the vegetation map. Eastern mid-height grass is the most extensive and comprises a dense layer of drought-resistant grasses, predominantly *Bothriochloa ewartiana*. Scrub grass, dominated by *Paspalidium* spp., occurs throughout the area but is best developed in association with brigalow, gidgee, blackwood, and softwood communities. Arid scrub grass, mainly *Chleistochloa subjuncea* and *Aristida caput-medusae*, is associated with lancewood and bendee scrubs. Eastern spinifex, mainly *Triodia* *mitchellii* and *T. pungens*, occurs on sandy or loamy country with less than 22 in. rainfall while sandstone spinifex, dominated by a variety of *Triodia mitchellii*, occurs on sandstone ranges in the south. The blue grass community, dominated by *Dichanthium sericeum*, occurs mainly on cracking clay soils in the east and south. A samphire community occurs on the outer floors of Lakes Galilee and Buchanan. Smaller grass communities, not mappable, include *Tripogon loliiformis*, *Sporobolus virginicus*, and frontage communities.

(ii) *Woodland Communities*.—Six of the 15 woodland communities recognized have been mapped. *E. melanophloia* woodland is the most extensive and occurs on a wide range of soils. *E. populnea* woodland is likewise very extensive; in the north it sometimes occurs in communities adjacent to lancewood scrubs. Narrow-leaved ironbark, with *E. drepanophylla* and *E. crebra*, is common on sandy or rocky areas; it exists as almost pure stands and also intermixed with sandstone woodland and with lancewood, brigalow, or gidgee scrubs. *E. orgadophila* woodland is mainly restricted to cracking clays on basalt. *E. microtheca* often forms pure stands on flooded, fine-textured alluvium. Smaller communities, not mapped, include woodlands with *E. polycarpa*, *E. normantonensis*, *E. cambageana*, *E. thozetiana*, *Grevillea* spp., and sandstone and frontage woodlands.

Associated sporadically with the woodland communities are seven mid-storey communities. A community dominated by *Eremophila mitchellii* and *Carissa ovata* is widespread on texture-contrast soils in association with *E. populnea* woodland. On sandier areas a community with *Callitris columellaris*, *Acacia cunninghamii*, *Petalostigma pubescens*, and *Alphitonia excelsa* is common.

(iii) *Scrub Communities*.—Five of the eight scrub communities recognized have been mapped. Brigalow (*A. harpophylla*) and gidgee (*A. cambagei*) are the most extensive. Softwood scrubs occur in the extreme south and north-east of the area on soils derived mainly from basalt. Lancewood scrubs grow mainly on breakaways and rocky dissected areas on deeply weathered rocks. Minor scrub communities are dominated by belah, bendee, cypress pine, and *Melaleuca*. Four mid-storey communities are recognized in the scrubs and also four mixed communities with emergent eucalypts (*E. populnea*, *E. microtheca*, *E. thozetiana*, and *E. cambageana*).

III. Major Types of Country

Within the survey area 11 broad types of country can be recognized and the land systems have been arranged accordingly.

(*a*) *Mountains*

Carborough, Bogantungan, and Percy land systems (Plate 1, Figs. 1 and 2) are mountainous country on quartz sandstone, sandstone, and mudstone of the Ducabrook Formation, and Tertiary basalt. There is little trace of Tertiary deep weathering and consequently land forms, soil, and vegetation are related to the lithology. Local relief ranges from 500 to 2500 ft and this type of country includes the highest ground in the area where the Buckland Tableland in the extreme south rises to about 3500 ft. Shallow rocky soils predominate and the vegetation is mainly narrow-leaved ironbark over eastern mid-height grass.

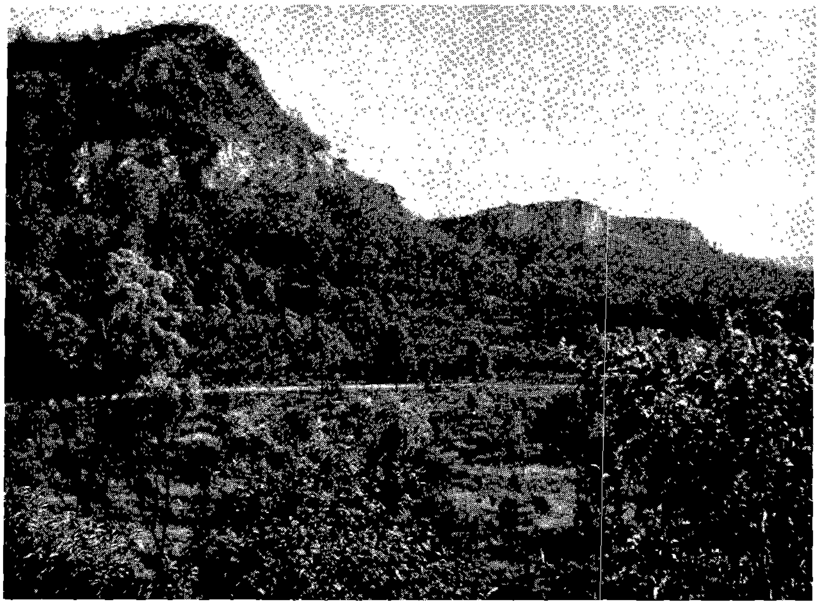

Fig. 1.—Rugged sandstone hills form Carborough land system.

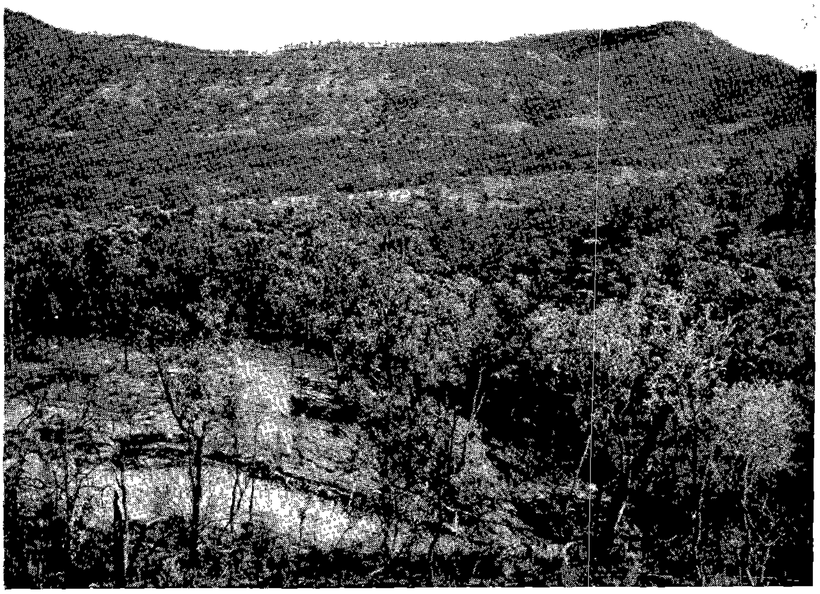

Fig. 2.—Steep hills and mountains with shallow rocky soils and ironbark form Bogantungan land system.

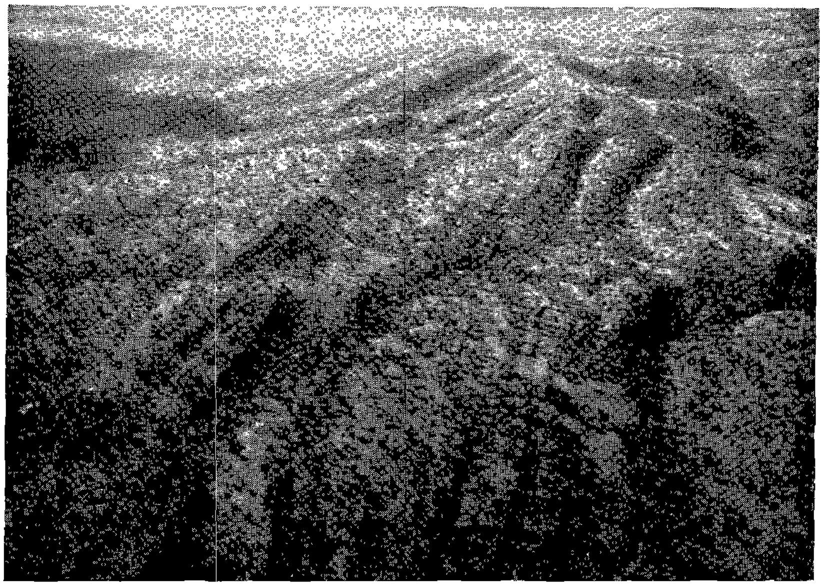

Fig. 1.—On the folded sedimentary rocks of the Ducabrook Formation, strike control of relief and vegetation is a prominent feature. Strike ridges, shallow soils, and narrow-leaved ironbark are features of Portwine land system.

Fig. 2.—Dissection of the Tertiary weathered zone has formed steep scarps with exposures of laterite and mottled- and pallid-zone materials. Durrandella land system comprises mainly shallow rocky soils on these materials under lancewood or bendee scrubs.

FIG. 1.—In the drier western quarter of the area extensive remnants of more or less intact Tertiary land surface have survived. Ronlow land system occupies the more elevated parts of this region and is characterized by red earths, groved yellowjack woodlands, and eastern spinifex pastures.

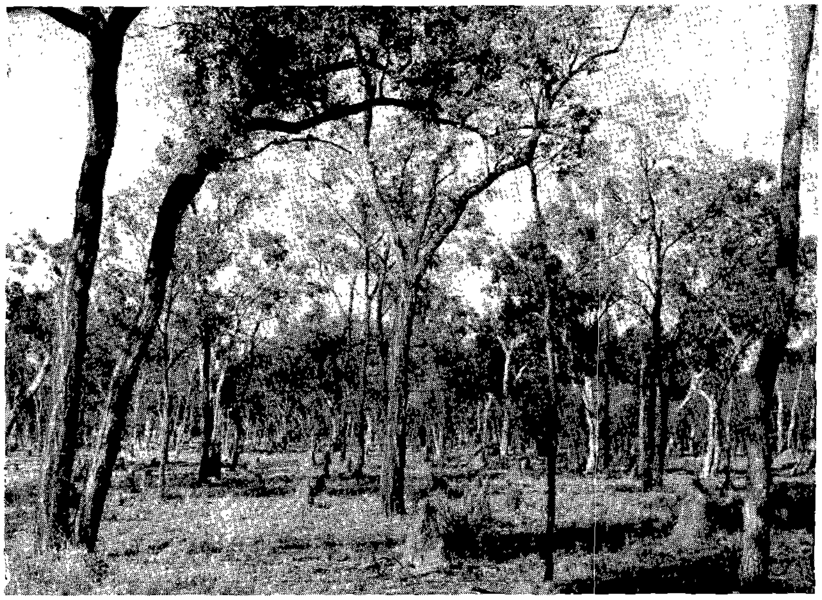

Fig. 2.—Lennox land system occupies 3800 sq miles of nearly intact Tertiary land surface. It consists of level to gently undulating land with yellow and red earths, mainly silver-leaved ironbark woodland, and eastern spinifex pasture.

Fig. 1.—Uniform sandy soils on gently undulating land in Playfair land system commonly support extensive stands of cypress pine.

Fig. 2.—A well-marked pattern of groves is common in woodlands developed on folded sedimentary rocks. This vertical air photograph of part of Craven land system at a scale of approximately 1¼ in. to the mile clearly shows this groving. (Reproduction courtesy Director of National Mapping, Department of National Development, Canberra.)

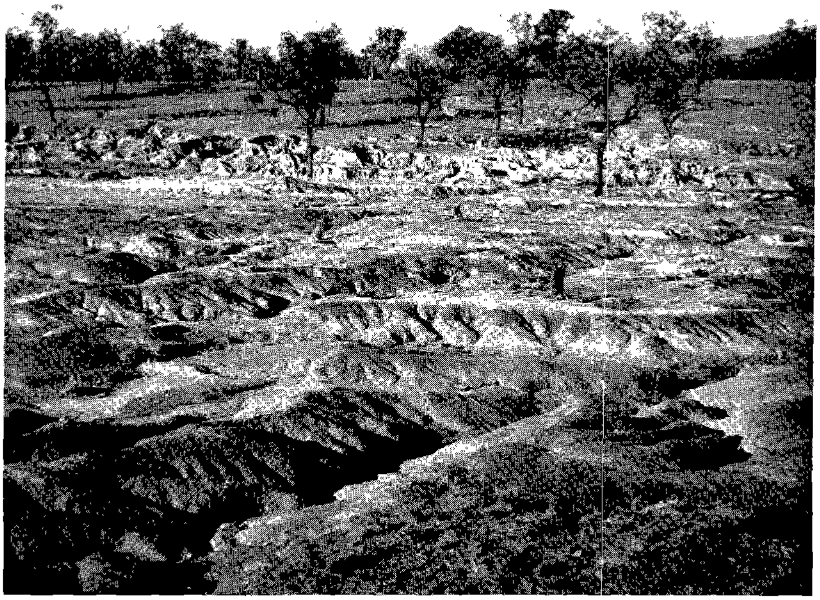

Fig. 1.—Undulating country on sediments of the Drummond Basin with shallow texture-contrast soils and open ironbark woodland or brigalow scrub are features of Rutland and Craven land systems. Erosion is a moderate to severe hazard.

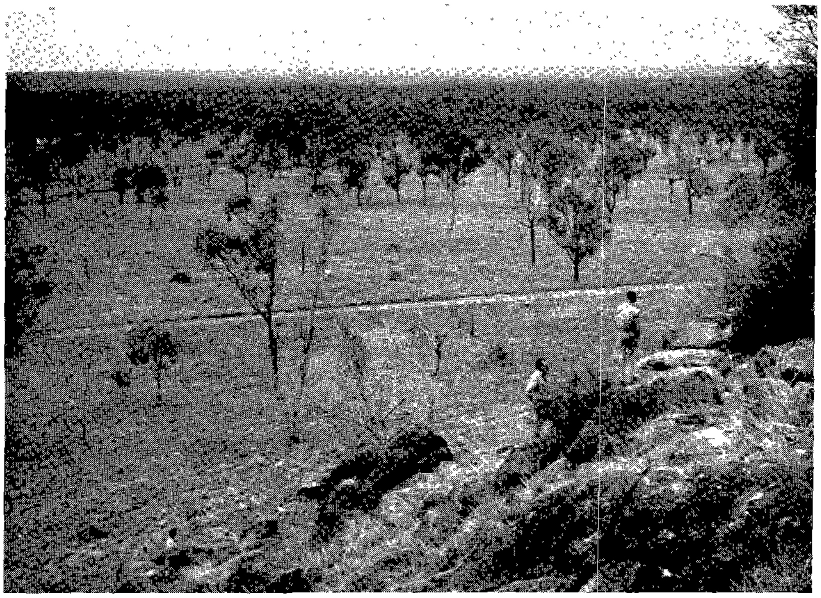

Fig. 2.—The rolling Peak Vale land system comprises undulating terrain on granite with texture-contrast soils under silver-leaved ironbark woodland and eastern mid-height pasture. Limited cultivation and pasture improvement are possible.

Fig. 1.—On colluvial slopes and slightly stripped Tertiary land surface Monteagle and Pinehill land systems are characterized by gently undulating relief, texture-contrast soils with sandy surface horizons, poplar box woodland, and eastern mid-height pasture.

Fig. 2.—Solodized solonetz and solodic soils commonly occur on intermediate and lower slopes of denuded Tertiary weathering profiles. In this example the sandy surface soil has been removed to expose the extremely hard subsoil with degraded columnar structure.

Fig. 1.—Humboldt land system consists mainly of blackbutt–brigalow scrub and texture-contrast soils with thin loamy surface horizons. It occurs on very gentle slopes below Monteagle and Pinehill land systems.

Fig. 2.—Gidgee scrub on texture-contrast and cracking clay soils occurs in Ulcanbah land system generally where the average annual rainfall is less than 24 in.

Fig. 1.—Gidgee scrub on gilgaied deep cracking clay soils characterizes Islay land system. The pronounced microrelief and regeneration of false sandalwood following clearing are problems in the development of this land.

Fig. 2.—Brigalow scrubs on gilgaied cracking clay soils are characteristic of Somerby land system. Similar country but without gilgais forms Blackwater land system.

Fig. 1.—Abundant billy gravel is a feature of Willows land system that would impede cultivation if the brigalow scrub were cleared.

Fig. 2.—Dark brown and grey-brown soils under brigalow–wilga scrub occur in Wharton land system. Much of this land system is being cleared for pasture improvement and cultivation may be a possibility in areas of suitably low relief.

Fig. 1.—Deep cracking clay soils under blue grass downs form Avon land system. The natural pastures have a fairly high yield but quality is low during the dry season.

Fig. 2.—On account of the extreme seasonality of the rainfall, stream beds are dry for most of the year. A fringing community of blue gums (*E. tereticornis*) with box flats further away from the channels is a common feature in Alpha land system.

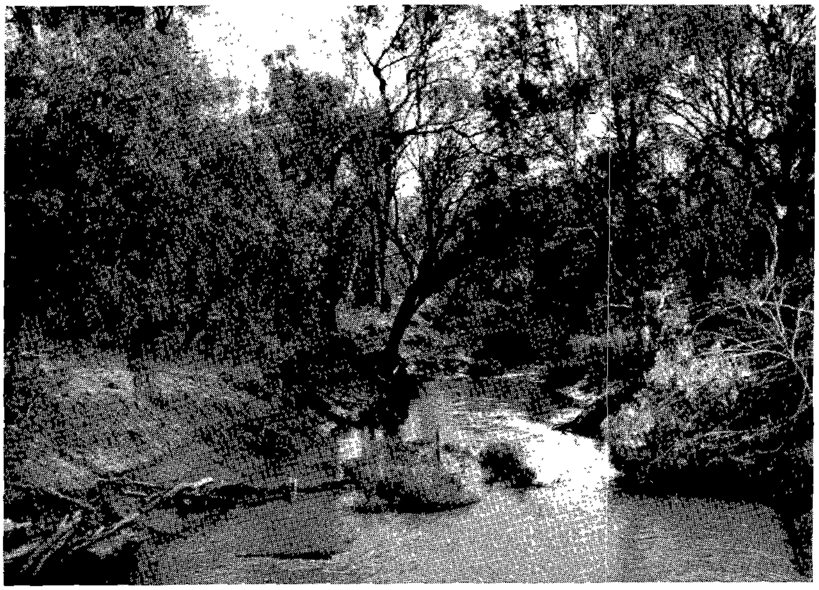

Fig. 1.—After heavy rains the stream channels carry water and there is often extensive flooding of the alluvial flats with brigalow which form Comet land system.

Fig. 2.—Alluvial flats with cracking clay and fine-textured soils and coolibah with blue grass pasture are mapped in Funnel land system. It occurs near major streams and is subject to prolonged deep flooding during the wet season.

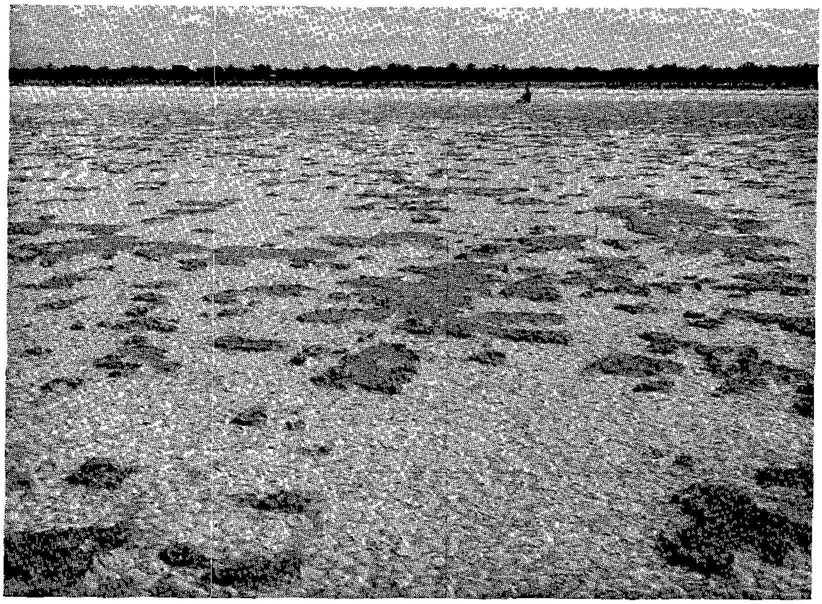

Fig. 1.—The flat lake beds in Galilee land system consist of saline clay which is frequently flooded. Sparse samphire pastures grow on slightly higher parts and *Grevillea* woodland on sandy beach features.

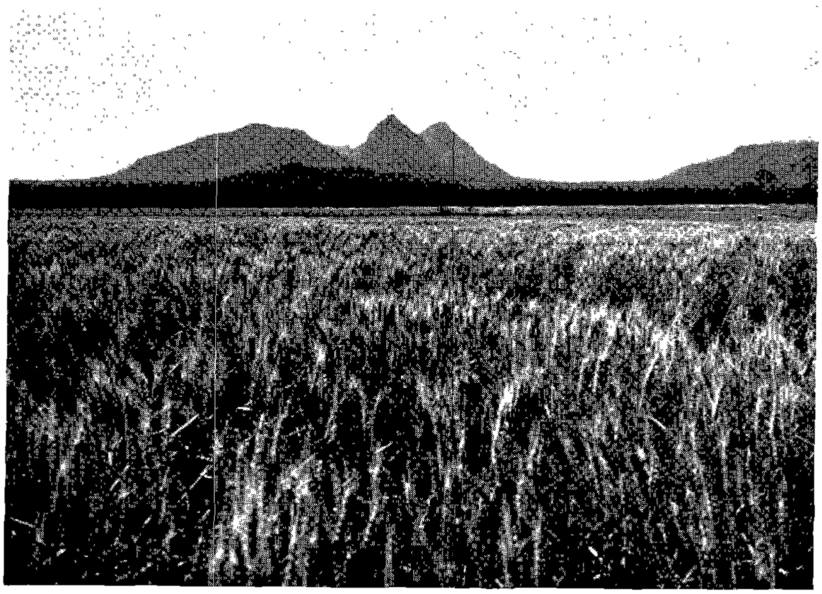

Fig. 2.—Gently undulating basalt downs along the eastern border of the area have deep, fertile clay soils and adequate moisture for cultivation. Considerable parts of Oxford land system are now used for grain and fodder crops. Rugged hills and mountains on Tertiary intrusions overlook the downs at many points.

(b) *Hills with Woodlands and Eastern Mid-height Grass*

This type of country is made up of the Portwine (Plate 2, Fig. 1), Hope, Copperfield, and Borilla land systems on unweathered Ducabrook Formation, metamorphics, and granite in the south and centre and on volcanics in the north-east. Stony hills from 50 to 300 ft high with shallow rocky soils predominate with some texture-contrast soils and limited lowlands on less resistant rocks. Narrow-leaved and silver-leaved ironbark woodlands and eastern mid-height grass form the dominant vegetation, which often is arranged in long groves following the strike of the underlying rocks.

(c) *Hills with Woodlands and Blue Grass*

Only Waterford land system occurs in this type of country. It consists of tabular hills on relatively unweathered basalt in the east and south-east, together with limited intervening lowlands. Shallow rocky soils occur on the steeper parts with shallow to moderately deep cracking clay soils elsewhere. An open woodland of mountain coolibah (*E. orgadophila*) prevails.

(d) *Hills with Softwood Scrub*

Kareela land system consists of softwood scrub and scrub grass over slumped basalt and shale around the Buckland Tableland. Dark brown and grey-brown soils, cracking clays, and some texture-contrast soils occur. The relief includes many steep, rocky scarps and limited benches with deeper soils.

(e) *Hills with Bendee and Lancewood Scrub*

Durrandella and Loudon land systems are stony hills on dissected, weathered rocks mainly in the north. Lancewood and bendee scrubs over sparse arid scrub grass and eastern spinifex form the characteristic vegetation (Plate 2, Fig. 2). Shallow rocky soils or shallow red and yellow earths are the dominant soils and sheet erosion is a common feature.

(f) *Tablelands and Lowlands with Red and Yellow Earths*

This major type of country is formed on little-disturbed Tertiary land surface and younger sandy fans mainly in the west, but with outliers in the centre and north-east. It includes Tichbourne, Ronlow (Plate 3, Fig. 1), Lennox (Plate 3, Fig. 2), and Degulla land systems. Gently undulating topography and infertile sandy or loamy red and yellow earths are characteristic, and the vegetation consists of silver-leaved ironbark, narrow-leaved ironbark, or yellowjack over eastern spinifex and eastern mid-height grass. The trees often form irregular groves aligned along the contour.

(g) *Lowlands with Cypress Pine Scrub and Uniform Coarse-textured Soils*

Playfair land system in the south-west comprises lowlands on sandstone and it usually has deep sandy soils, although more resistant rock strata have given rise to shallow soils. Cypress pine scrub is common (Plate 4, Fig. 1) with some silver-leaved ironbark over sparse eastern mid-height grass.

(*h*) *Lowlands with Woodlands and Texture-contrast Soils*

This type of country has mainly box or ironbark woodlands, often arranged in groves (Plate 4, Fig. 2), over eastern mid-height grass. Texture-contrast soils are predominant and soil erosion is a hazard on slopes (Plate 5, Fig. 1). Craven (Plate 4, Fig. 2), Hillalong, Skye, and Rutland land systems are formed on sedimentary rocks from which the Tertiary weathered zone has been largely stripped. Peak Vale land system (Plate 5, Fig. 2) is on fresh granite. Monteagle (Plate 6, Fig. 1) and Pinehill land systems are on lightly stripped parts of the Tertiary land surface and adjacent colluvial areas; well-marked texture-contrast soils are characteristic (Plate 6, Fig. 2). Disney land system is a mosaic of intact Tertiary residuals, dissected weathered zone, and areas on fresh underlying rocks; it consequently has a wide range of vegetation and soils.

(*i*) *Lowlands with Softwood Scrub*

In Cungelella land system softwood scrub and scrub grass predominate on gravelly fans overlying shales. Cracking clays, dark brown and grey-brown soils, and texture-contrast soils of varying depths occur.

(*j*) *Lowlands with Brigalow, Gidgee, and Blackwood Scrub*

Gidgee, brigalow, and blackwood scrubs over scrub grass on clay plains and lowlands occur widely, especially in the north-east. Soils are either deep clays, often with gilgai, or texture-contrast. Humboldt (Plate 7, Fig. 1), Ulcanbah (Plate 7, Fig. 2), Islay (Plate 8, Fig. 1), Blackwater, and Somerby (Plate 8, Fig. 2) land systems are on Tertiary acid clays mainly in the north and centre; the soils often have an alkaline surface horizon over acid layers and are sometimes very stony (Willows land system, Plate 9, Fig. 1). Moray land system in the north is on stone-free gypseous clay. Wondabah and Kinsale land systems are on deeply weathered basalt in the east, while Wharton land system (Plate 9, Fig. 2), distinguished by a close association of wilga with brigalow, is on little-weathered Mesozoic shales in the south, sometimes with surficial gravel.

(*k*) *Lowlands with Grassland*

Downs country is common on gypseous Tertiary clay in the north (Avon land system, Plate 10, Fig. 1), on unweathered basalt in the east (Oxford land system), and on fresh Permian shale in the south (Mantuan land system). The soils are usually fertile deep cracking clays occasionally somewhat shallower on the rises. The vegetation is dominantly blue grass.

(*l*) *Alluvium*

Alluvium is common along all streams in the area but only where it is more than half a mile wide has it been mapped as a separate land system. Higher alluvial plains and terraces forming the Alpha land system are rarely flooded and have a wide range of soils including alluvial soils, red earths, texture-contrast soils, and cracking clays which support poplar box and gums over eastern mid-height grass (Plate 10, Fig. 2). The lower alluvial land systems are frequently flooded and are generally formed on finer-textured material. Banchory, Comet (Plate 11, Fig. 1), and

Funnel (Plate 11, Fig. 2) land systems have cracking clay soil with gidgee scrub, brigalow scrub, and coolibah woodland respectively. Galilee land system comprises intermittently flooded lake beds with samphire or no vegetation on saline clay (Plate 12, Fig. 1); margining sandy or silty beach features have *Grevillea* woodland.

IV. Land Use

Because of restrictions imposed by climate, soil, and topography, the dominant land use is, and will remain, grazing of natural pastures. However, there is scope in more favoured areas for pasture improvement, cultivation, and some irrigation.

(*a*) *Natural Pastures*

The natural pastures grow rapidly in early and mid summer when adequate moisture is available and the temperatures are optimal, but later they quickly degenerate into poor-quality dry feed. The mean annual period of pasture growth decreases from 20 weeks in the wettest parts to less than 12 weeks in the extreme west. The pastures are used mainly for beef cattle production, with some sheep in a few areas. Seven pasture lands have been recognized and mapped.

Scrub country has low-yielding but high-quality grasses growing under brigalow, blackwood, or gidgee scrubs. Eastern mid-height grass country consists of pastures with moderate yield and low quality during the dry season. Eastern spinifex country is very poor, with a carrying capacity of no more than 10 cattle per square mile. Mixed eastern spinifex and eastern mid-height grass country have moderate value in the lower parts, while the higher, rocky parts are virtually useless. Blue grass country forms downs and open woodlands in the east and south of the area; pasture yield is high although quality deteriorates greatly during the dry season. Lake country with very sparse samphire pastures is of little or no value. Non-range country, too rugged, stony, or barren for grazing, occupies about 5000 sq miles.

(*b*) *Improved Pastures*

Considerable scope for pasture improvement exists in the scrub country, which is currently (1965) being extensively cleared by mechanized methods and sown to improved pasture grasses or fodder crops (Plate 9, Fig. 2). The soils are generally fertile with good water-retaining capacity, but problems include high costs of clearing where *E. cambageana* and other eucalypts are present, regrowth of the scrub, soil erosion on steeper slopes, and large gilgai impeding cultivation. There is only moderate scope for significant pasture improvement on the other pasture lands on account of unfavourable soils and low rainfall. The blue grass country has some potential but here improvement is directed more towards cropping.

(*c*) *Cultivation*

Cultivation for forage and grain crops, mainly sorghum, wheat, and oats, is becoming increasingly important on the basalt country in the east of the area (Plate 12, Fig. 2). Here the more favourable climate and the fertile cracking clay soils with good water-retaining properties are favourable factors. About 100,000 acres are already utilized in this way and there is undoubtedly scope for considerable extension. Some of the cleared scrub country and the cracking clay soils on shales in the south of the area may likewise be cultivated, but unreliable rainfall presents a major hazard. Mainly winter crops are grown, but there is some possibility for summer crops in the Emerald area.

(*d*) *Irrigation*

A proposed irrigation scheme affecting 19,000 acres north-west of Emerald and 57,000 acres just outside the survey area is at present under consideration. Cultivation of alluvial flats irrigated by natural flooding may be worth examination.

PART III. LAND SYSTEMS OF THE NOGOA–BELYANDO AREA

By R. W. GALLOWAY,* R. H. GUNN,* and L. PEDLEY†

I. INTRODUCTION

The area has been mapped and described in terms of 43 land systems, which are composite mapping units delineating landscapes with similar recurring patterns of land forms, soils, and vegetation. In this Part the land systems and their component land units are described in tabular form and illustrated by block diagrams. The land systems are arranged in alphabetical order and the land units are in the order from highest to lowest in the landscape.

TABLE 1

SIMILAR LAND SYSTEMS IN THE NOGOA–BELYANDO, ISAAC–COMET, AND DAWSON–FITZROY AREAS

Nogoa–Belyando	Isaac–Comet	Dawson–Fitzroy
Wharton	Arcadia	—
—	Barwon	Barwon
Kareela	Bedourie	Womblebank
Blackwater	Blackwater	Wandoan
Carborough	Carborough	Carborough
Comet	Comet	Coreen
Alpha	Connors	Dingo
Hope	Cotherstone	—
Durrandella	Durrandella	—
Funnel	Funnel	Coolibah
Hillalong	Hillalong	—
Humboldt	Humboldt	Thomby
Lennox (in part)	Junee	Kaiuroo
Monteagle	Monteagle	—
Oxford	Oxford	—
Percy	Percy	—
—	Planet	Nathan (in part)
—	Racecourse	Eurombah
Somerby	Somerby	Highworth
Waterford	Waterford	—
Skye	—	Woleebee

The heading to each land system gives a brief description and emphasizes the distinguishing features of the land system as a whole. It also indicates how and on what rock the land system has evolved. The identification of land units is based mainly on their vegetation. The areas were determined by the dot-grid method from the land system map (25 dots/sq in. at scale 1 : 500,000) and the proportional areas of land units were estimated from photographic patterns. Some complex land systems

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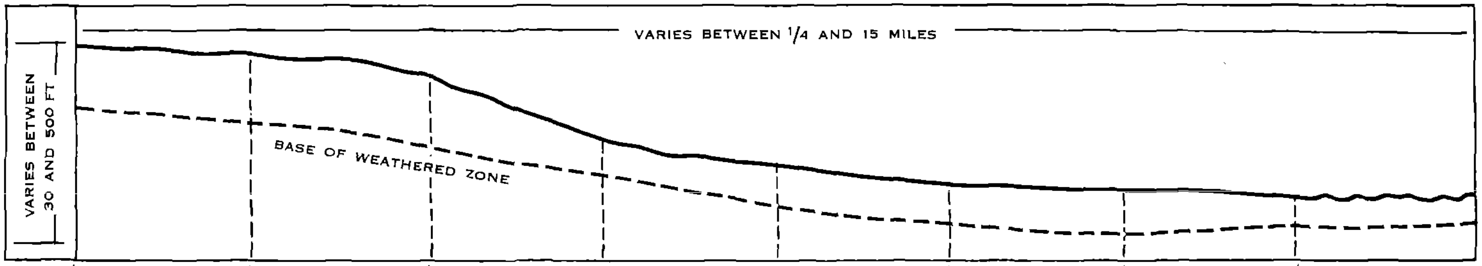
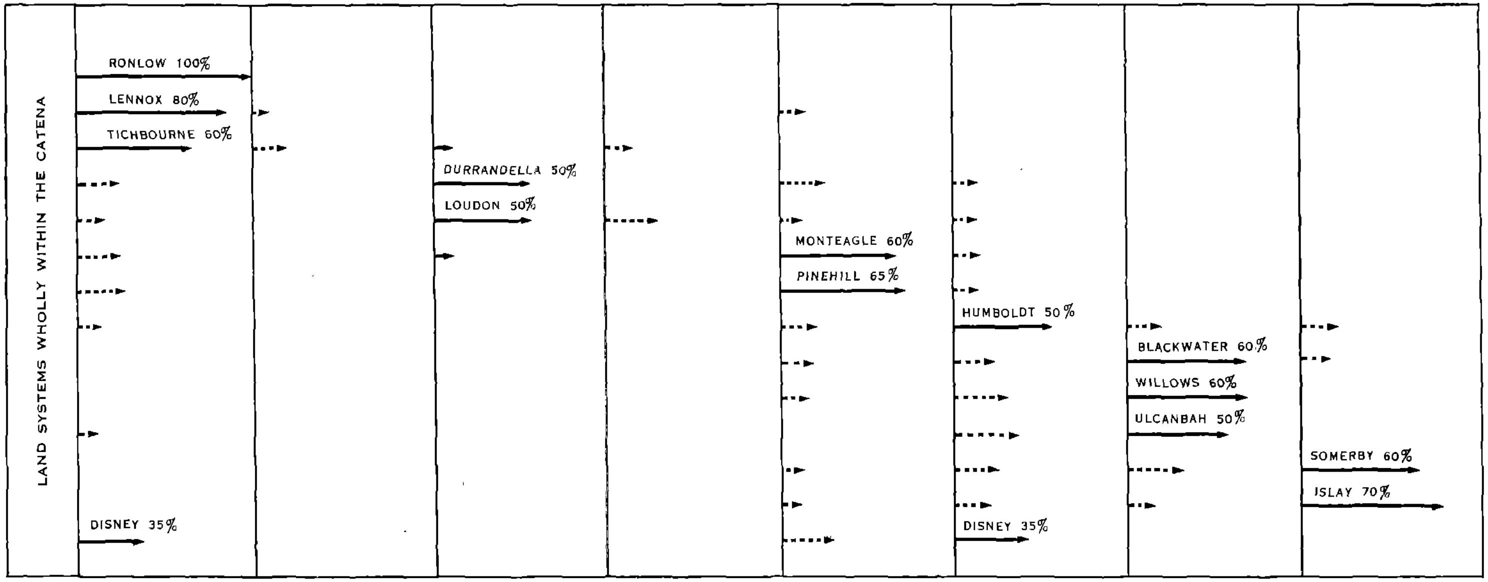
TABLE 2

CATENARY SEQUENCE OF LAND FORMS, SOILS, AND VEGETATION ON PARTLY DENUDED WEATHERING PROFILES, MAINLY ON TERTIARY SEDIMENTS



LAND FORM	Undulating, more or less intact Tertiary weathered surface. Slopes 2%. Local sheet erosion on rises with deposition of sand in depressions	Stripped margin of Tertiary surface. Slopes 2–5%. Sheet erosion and gullying. Occasional laterite outcrops	Scarp on Tertiary or pre-Tertiary rocks. Slopes 20–100%. Sheet erosion (Not always present)	Dissected scarp foot zone. Slopes 5–15%. Gullies, outcrops, sheet erosion	Colluvial slope 2–7%. Deposition of sand and silt over weathered clay. Gullies not uncommon	Gently undulating clay lowland. Slopes 1–3%. Thin colluvial cover. Some sheet erosion and gullying. Gravel common	Clay plains and very gently undulating areas. Slopes 0–2%. Some gravel	Clay plains with gilgai. Minor braided channels in lower parts
SOILS	Red and yellow earths, generally deep, commonly with concretionary ironstone in subsoils	Truncated red and yellow earths, underlain by concretionary or massive laterite	Shallow red and yellow earths. Outcrops of laterite and mottled- and pallid-zone materials	Shallow texture-contrast soils with neutral to alkaline clayey subsoils	Texture-contrast soils with coarse-textured surface horizons and neutral or alkaline clayey subsoils	Texture-contrast soils with thin loamy surface soils, commonly with gravel, and clayey, generally strongly alkaline subsoils	Deep cracking clay soils, generally strongly alkaline at or near the surface, becoming strongly acid and prominently mottled at depth	Gilgaied, very deep cracking clay soils, generally strongly alkaline at or near the surface, becoming strongly acid and prominently mottled at depth
VEGETATION	*E. similis*, *E. polycarpa*, *E. papuana*, *E. melanophloia*, and in the north-east, narrow-leaved ironbark woodlands	*E. normantonensis* woodland. *Acacia leptostachya* community	Lancewood and/or bendee scrub	*E. normantonensis* and *E. thozetiana* woodland	*E. populnea* woodland, usually with *Eremophila mitchellii*	*E. cambageana*–brigalow, less commonly *E. thozetiana*–brigalow scrub; *Eremophila mitchellii* and *Carissa ovata* conspicuous	Brigalow and/or gidgee scrub usually with *Eremophila mitchellii*	Brigalow and/or gidgee scrub with *Eremophila mitchellii* and *Terminalia oblongata*


LAND SYSTEMS WHOLLY WITHIN THE CATENA
RONLOW 100%
LENNOX 80%
TICHBOURNE 60%
DISNEY 35%
DURRANDELLA 50%
LOUDON 50%
MONTEAGLE 60%
PINEHILL 65%
HUMBOLDT 50%
DISNEY 35%
BLACKWATER 60%
WILLOWS 60%
ULCANBAH 50%
SOMERBY 60%
ISLAY 70%

formed on two or more lithologic types have units that do not occur regularly throughout. The sporadic occurrence and, where possible, the location of such units have been noted (e.g. Alpha land system).

The three main characteristics—land form, soils, and vegetation—are briefly described in respect of the component land units in each land system and more detailed information is given in Parts V–IX. The soils are described in terms of major groups, families, and principal profile forms (Northcote 1965*) and the formation and species of the plant communities are given. In the right-hand column of each description the estimated land capability class is given for each unit together with symbols denoting the kind and degree of limitations. The classes and symbols are defined in Appendix I and land use is discussed broadly in Part X.

As mentioned in Part I, the area forms part of the Fitzroy Region (Fig. 1), where two adjoining areas (Isaac–Comet and Dawson–Fitzroy) have been surveyed recently by the Division of Land Research. The three areas together cover about 75,000 sq miles in east-central Queensland and, as would be expected, some land systems are similar to those in other areas. The correlations are shown in Table 1.

II. Catenary Relationships

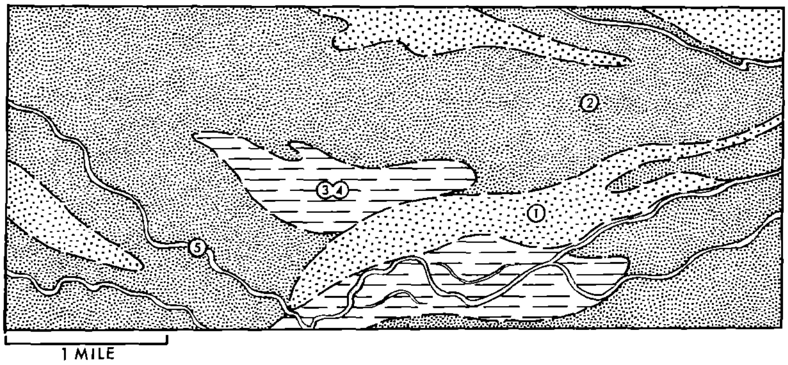
As explained in Part VI, in about mid-Tertiary times a gently undulating, deeply weathered landscape extended throughout almost the whole area. Subsequent denudation of this landscape exposed different horizons of the weathered profile each now having a distinctive land form, soil, and vegetation, while more or less intact remnants of the old surface survived on higher ground. Stratigraphic variations within the Tertiary deposits reinforced the contrast between sandy or loamy remnants of the old surface and the argillaceous mottled and pallid zones below. The catena formed by denudation of the weathered profile therefore provides a key to understanding the soils and vegetation over much of the area. The catenary sequence is shown in Table 2 together with the distribution of the 14 land systems that are dominant on the various landscapes formed mainly on weathered Tertiary sediments. These land systems together cover about 16,000 sq miles in the area.

It will be noted that some land systems, for example Monteagle, Humboldt, Blackwater, and Somerby, are composed of similar assemblages of land units but proportions differ. The largest land unit is naturally the distinguishing feature of each land system but upper or lower elements of the catena also occur. This is illustrated in Table 2.

* Northcote, K. H. (1965).—A factual key for the recognition of Australian soils. 2nd Ed. CSIRO Aust. Div. Soils divl Rep. No. 2/65.

ALPHA LAND SYSTEM* (1250 SQ MILES)

Alluvial plains with box and texture-contrast soils in non-basaltic alluvium.

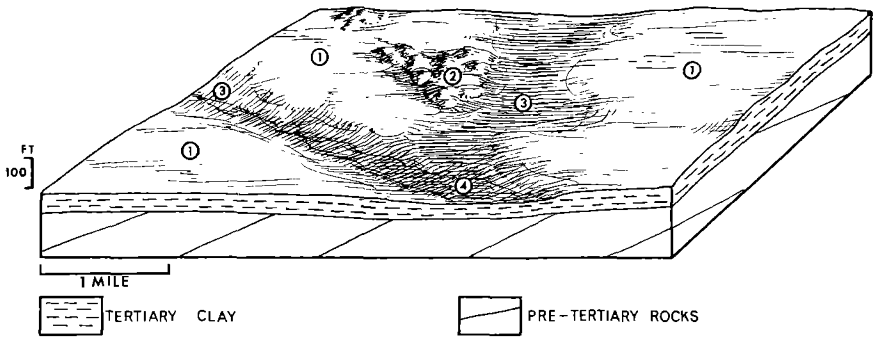


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	10% Mainly in the west and south	Higher sandy levees and sand sheets mainly associated with old channels; not flooded	Mainly coarse-textured alluvial soils, Davy (Uc1.23); some red and yellow earths, Wilpeena (Gn2.12)	Frontage woodland (*E. polycarpa, E. tessellaris, E. papuana*) over sparse frontage grass (*Aristida glumaris, Chloris acicularis, Heteropogon contortus*)	IVn_{3-4},m_3
2	70% Widespread	Alluvial plains, minor terraces, and lower levees up to 3 miles wide; occasionally flooded in lowest parts only and in north-east of the area	Red and yellow earths, Wilpeena (Gn2.12), and texture-contrast soils, Luxor (Dy2.22) and Taurus (Dy2.23), on plains and terraces; minor alluvial soils, Davy (Uc1.23) and Warrinilla (Um5.5 on sand)	*E. populnea* woodland, usually without understorey, occasionally sparse argillicolous midstorey (*Eremophila mitchellii, Heterodendrum oleifolium, Flindersia dissosperma*); eastern mid-height grass	IVn_3, p_{3-4}
3	10% Mainly in the north	Back swamps and minor outcrops of deeply weathered clay; mostly flooded	Cracking clay soils, mainly Vermont (Ug5.24); minor occurrences of gilgaied clay soils, Pegunny (Ug5.24)	Brigalow and gidgee scrubs; midstorey of *Terminalia oblongata*; scrub grass (*Paspalidium* spp., *Chloris divaricata*)	Vw_{3-5}
4	5% Sporadic	Shallow back swamps and old channels; flooded	Cracking clay soils, Vermont (Ug5.16, 5.22)	*E. microtheca* woodland over blue grass and occasional eastern mid-height grass; sometimes blue grass without any associated tree community	Vw_{3-5}
5	5% Widespread	Channels; in most areas 15–35 ft deep with simple meandering pattern; in some minor valleys and in flood-out areas 5–15 ft deep with anastomosing pattern; bed load sand		Fringing forest (*E. tereticornis*, occasional *E. tessellaris, Melaleuca argentea, M. linariifolia*, and *Casuarina cunninghamiana*)	

*Similar to Dingo land system in the Dawson–Fitzroy area and Connors land system in the Isaac–Comet area.

AVON LAND SYSTEM (460 SQ MILES)

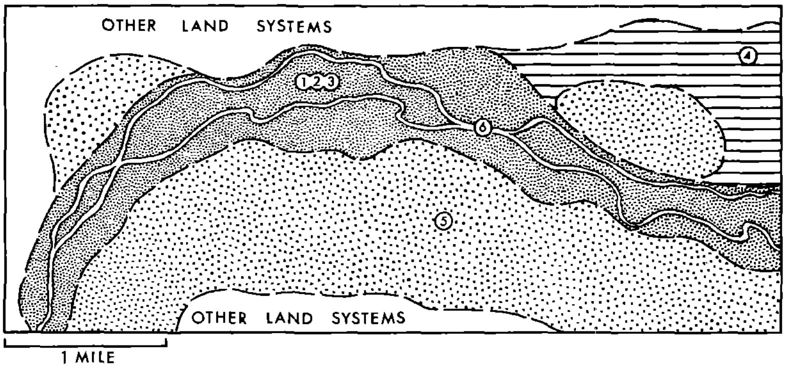
Gently undulating grassland with cracking clay soils on alkaline clays deposited within the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	65% Widespread	Clay plains and gently undulating lowlands; slopes less than 2%	Very deep cracking, self-mulching clay soils, mainly alkaline/acid, Logan (Ug5.24), with extensive areas of clay soils alkaline throughout, Natal (Ug5.15). Moderate to large quantities of gypsum frequently present	Grassland, blue grass (*Dichanthium sericeum*, *Astrebla* spp., *Panicum decompositum*, *Aristida leptopoda*), rarely eastern mid-height grass (*Bothriochloa ewartiana*, *Dichanthium fecundum*) near Bulliwallah	$IIIs_3$, k_3
2	5% Sporadic	Sporadic minor occurrences of Tertiary gravel and older rocks both fresh and weathered; plains and lowlands	Cracking clay soils, Logan (Ug5.24, 5.34); minor occurrences of texture-contrast soils, Retro, thin loamy surface soils, alkaline subsoils (Dy2.13)	*Terminalia oblongata* community without tree layers, low brigalow and blackwood scrubs, stands of *Bauhinia carronii*, sparse scrub grass where upper strata are dense, and blue grass in open places	$IIIs_3$, k_3
3	30% Widespread	Very shallow open valleys and poorly drained clay plains	Very deep cracking clay soils, alkaline or neutral at surface on acid, prominently mottled subsoils, Logan (Ug5.24, 5.34)	Open *E. microtheca* grassy woodland, small areas near Diamond Downs of *Acacia* sp. aff. *cana* woodland; blue grass (*Dichanthium sericeum*, *Astrebla* spp.)	$III\text{–}Vw_{3-5}$
4	<5% Sporadic	Narrow alluvial clay flats; anastomosing shallow channels	Cracking clay soils, no detailed observations; probably as unit 3	*E. microtheca* on channels, groves of *Melaleuca bracteata*, blue grass	Vw_5

Banchory Land System (300 sq miles)

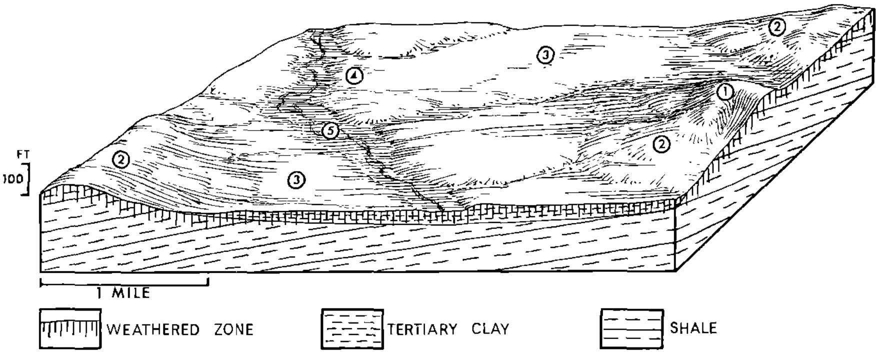
Alluvial plains with gidgee and cracking clay soils.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% In centre	Broad levees and slightly higher alluvial plains; not flooded	Texture-contrast soils, Broadmeadow (Db1.43) and Retro (Dr2.33)	Blue grass (*Astrebla lappacea*, *Dichanthium sericeum*), scattered gidgee, *Terminalia oblongata*, and *E. microtheca*	IVp$_{3-4}$, s$_3$
2	5% In north-east	Levees; rarely flooded	No observations; probably texture-contrast soils	Low open gidgee scrub with *Terminalia oblongata* midstorey and sparse blue grass; occasional *E. populnea* woodland, argillicolous understorey, and *Tripogon loliiformis* grass layer	IV–Vw$_{3-5}$
3	10% Widespread	Narrow silty levees; rarely flooded	Texture-contrast soils, Wyseby (Dd1.12) and Retro (Db1.33), thin silt loam surface soils and mildly to strongly alkaline subsoils	Clumps of gidgee, scattered *Eremophila mitchellii*, some *Tripogon loliiformis* grass layer and bare ground	IVw$_3$, p$_{3-4}$
4	5% In centre	Alluvial clay plains, usually on back-swamp sites or floors of broad, shallow, old channels; flooded	Cracking clay soils, Vermont (Ug5.16)	*E. microtheca* grassy woodland; blue grass (*Thellungia advena*) and some *Tripogon loliiformis* grass layer community	Vw$_5$
5	70% Widespread	Alluvial clay plains, occasionally with faint channels and levees; possibly flooded in part	Cracking clay soils, Vermont (Ug5.24, 5.34), uniform medium to heavy alkaline clays	Gidgee scrub, usually with *Terminalia oblongata* midstorey (*T. oblongata*, *Eremophila mitchellii*, *Carissa ovata*); scrub grass (*Paspalidium* spp., *Chloris divaricata*) and blue grass (*Astrebla* spp., *Thellungia advena*, *Dichanthium sericeum*) where open	III–V w$_{3-5}$,k$_{2-3}$
6	5% Widespread	Channels; 5–15 ft deep with anastomosing pattern; bed load sand and silt		Fringing woodland (*E. microtheca*, brigalow, gidgee, *Terminalia oblongata*); extremely sparse grass	

Blackwater Land System* (680 sq miles)

Brigalow plains with cracking clay soils on acid clay exposed within the Tertiary weathered zone.

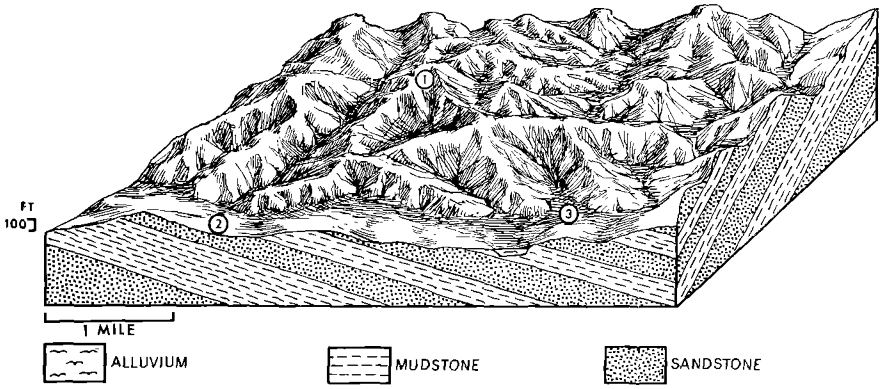


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	10% Widespread	Rises; local relief 20–50 ft; slopes up to 5%; gravelly in places; some sheet erosion; minor areas of strike ridges up to 100 ft high	Texture-contrast soils with thin sandy or loamy surface and strongly alkaline subsoils, Taurus (Dr2.23) and Retro (Db1.13)	*E. populnea* or *E. orgadophila* woodlands; argillicolous midstorey (*Eremophila mitchellii, Geijera parviflora, Ventilago viminalis, Carissa ovata*) sometimes well developed; eastern mid-height grass (*Bothriochloa ewartiana, Aristida* spp.) or scrub grass where upper strata are dense	IVp_{3-4}, s_3, e_3
2	15% Sporadic	Rises, breakaways, and immediately adjacent foot slopes; local relief 10–100 ft; some outcrop and stony areas; sheet erosion and gullying	Texture-contrast soils with thin loamy surface and strongly alkaline subsoils, Retro (Db1.33), commonly with gravel in surface horizons	*E. thozetiana*– or *E. cambageana*–brigalow scrubs; *Eremophila mitchellii* midstorey (*E. mitchellii, Carissa ovata*) or with the latter, occasional *Terminalia oblongata* midstorey; scrub grass (*Paspalidium* spp., *Chloris acicularis*). Occasional lancewood scrub with arid scrub grass (*Cleistochloa subjuncea*)	IV–VII t_{6-7}, p_{3-4} e_{3-4}
3	60% Widespread	Plains, lowlands; level to gently undulating; slopes less than 2%; mainly weathered Tertiary clay, frequently with billy gravel; also shallow strike vales on weathered sedimentary rocks	Mainly cracking clay soils, Rolleston (Ug5.24, 5.15), commonly strongly alkaline at or near the surface and acid beneath; minor Teviot (Ug5.24, 5.12), strongly alkaline throughout; extensive texture-contrast soils in some areas, Retro (Dd1.13)	Brigalow (or blackwood, in north) scrub; *Eremophila mitchellii* (*E. mitchellii, Flindersia dissosperma, Carissa ovata*), occasional *Terminalia oblongata* (*T. oblongata, Eremophila mitchellii, Carissa ovata, Heterodendrum diversifolium*) or no midstorey; scrub grass (*Paspalidium* spp., *Chloris divaricata, C. acicularis, Sporobolus* spp.), rarely eastern mid-height grass in open areas. Rarely gidgee or belah scrubs, *Terminalia oblongata* midstorey, and scrub grass	III–IV p_{3-4}, s_3
4	10% Sporadic	As unit 3 but slightly lower	Gilgaied deep clay soils, Pegunny (Ug5.24)	Brigalow, rarely gidgee or belah scrubs; *Eremophila mitchellii* (*E. mitchellii, Heterodendrum oleifolium, Bauhinia carronii, Carissa ovata*), *Terminalia oblongata* (*T. oblongata, Ehretia membranifolia, Eremophila mitchellii, Carissa ovata*), or rarely no midstorey; scrub grass (*Paspalidium* spp., *Chloris divaricata, Sporobolus* spp.)	IVg_4, s_{3-4}
5	5% Widespread	Alluvial flats; up to $\frac{1}{4}$ mile wide; clay; shallow braided channels; probably subject to flooding	Mainly cracking clay soils, Vermont (Ug5.16), generally neutral reaction at surface becoming strongly alkaline beneath; minor areas of texture-contrast and alluvial soils	Fringing forest (*E. tereticornis, E. microtheca*, brigalow, *Melaleuca* spp.) on channels; brigalow scrub as for unit 3	Vw_5

* Similar in part to Wandoan land system in the Dawson–Fitzroy area.

BOGANTUNGAN LAND SYSTEM (630 SQ MILES)

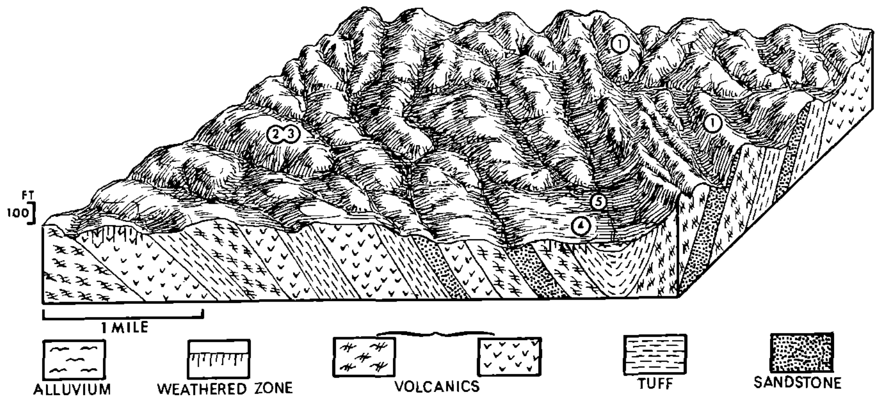
Mountains and hills with narrow-leaved ironbark and shallow, rocky soils cut below the Tertiary weathered zone on Drummond Basin sediments.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	70% Widespread	Mountains; extremely rocky with structural bluffs, benches, and strike ridges; local relief 300–1500 ft	Shallow rocky soils, Shotover (Uc1.2); extensive outcrop	Narrow-leaved ironbark (*E. drepanophylla*, *E. citriodora* on rocky sites) woodland, scattered *Macrozamia moorei*; eastern mid-height grass (*Themeda australis*, *Bothriochloa ewartiana*)	VII–VIII t_7,d_6
2	15% Sporadic	As unit 1 but lower and less steep	Shallow rocky soils, Shotover; some shallow texture-contrast soils, Southernwood (Db1.12) and Medway (Dy2.23); extensive outcrop	Narrow-leaved ironbark (*E. drepanophylla*) woodland, occasional *E. melanophloia* woodland with argillicolous mid-storey (*Albizia basaltica*); eastern mid-height grass (*Bothriochloa ewartiana*, *Themeda australis*, *Aristida* spp.)	VIIt_7, r_5
3	15% Widespread	Lower slopes and valley floors within units 1 and 2; occasional outcrop and stony areas; colluvial aprons; narrow terraced alluvial flats with single channel up to 20 ft deep	Texture-contrast soils, Broadmeadow (Dy2.23) and Springwood (Dy2.42); severe erosion in places	Fringing forest (*E. tereticornis*, *Acacia salicina*, *Melaleuca* spp.) on channels; *E. populnea* woodland with argillicolous mid-storey (*Eremophila mitchellii*, *Carissa ovata*), occasional narrow-leaved ironbark and *E. melanophloia* woodland as for unit 2; eastern mid-height grass (*Bothriochloa ewartiana*, *B. decipiens*)	IVp_{3-4}, e_3

Borilla Land System (400 sq miles)

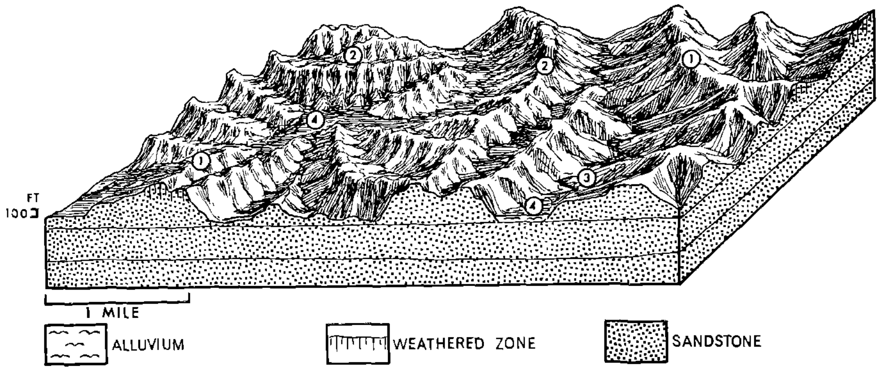
Rocky hills with ironbark and shallow, rocky soils cut below the Tertiary weathered zone on volcanics.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	40% In centre	Hills, strike ridges; hilly to steep; local relief 50–200 ft; slopes up to 80%	Mainly shallow rocky soils, Shotover (Uc1.2); minor areas of shallow uniform coarse-textured soils, Petrona (Uc1.2)	Narrow-leaved ironbark woodland (*E. drepanophylla*, occasional *E. polycarpa*, *E. peltata* on rocky sites) without midstorey or with arenicolous midstorey (*Acacia cunninghamii*, *Alphitonia excelsa*); eastern mid-height grass (*Themeda australis*, *Heteropogon contortus*)	VII–VIII t_7,r_5
2	45% In north-east	As unit 1 but somewhat lower and less steep; extremely rocky		Low *E. melanophloia* woodland usually without midstorey, occasionally with argillicolous midstorey (*Albizia basaltica*, *Eremophila mitchellii*); *E. populnea* woodland with argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*) on lower slopes; all with eastern mid-height grass (*Bothriochloa ewartiana*, *Themeda australis*, *Aristida* spp.)	VIIt_7,r_5
3	5% Sporadic		Shallow rocky soils, Shotover (Uc1.2)	Lancewood, bendee, occasional softwood scrub, or argillicolous community without tree stratum (*Ventilago viminalis*, *Acacia excelsa*, *Geijera parviflora*); sparse grass	VIIt_7,r_5
4	10% Sporadic	Depressions; undulating to level; weathered clay	No observations; probably texture-contrast soils	*E. cambageana*–brigalow, brigalow, gidgee scrubs; *Eremophila mitchellii* midstorey (*E. mitchellii*, *Carissa ovata*) and scrub grass (*Paspalidium* spp., *Chloris divaricata*)	IVp_{3-4}, s_3,e_3
5	<5% Widespread	Alluvial flats; less than ½ mile wide; clay with minor silty or sandy levees		Fringing forest (*E. tereticornis*, *Melaleuca* spp.) on channels; *E. populnea* woodland usually with argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*) and eastern mid-height grass (*Bothriochloa* spp., *Aristida ramosa*); rare brigalow scrub	IVw_4

CARBOROUGH LAND SYSTEM (2250 SQ MILES)

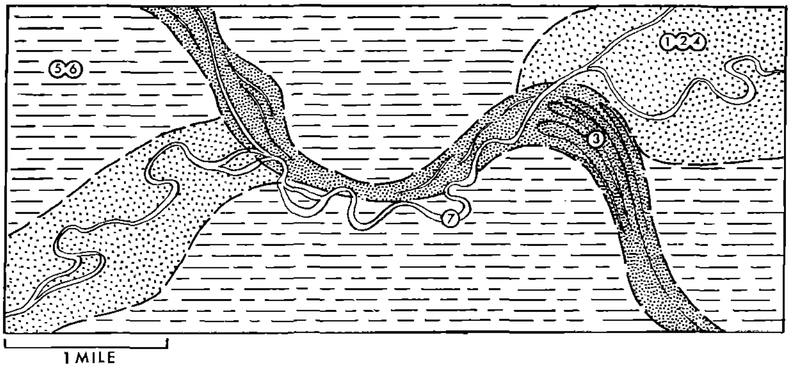
Mountains and hills with narrow-leaved ironbark and lancewood and shallow rocky soils formed on quartz sandstone mainly below the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	30% Widespread	Mountains and hills; very broken and dissected; 100–1500 ft high; slopes up to 100%; rocky with much outcrop; some deep weathering in more shaly zones	Mainly shallow rocky soils, Shotover (Uc1.2); minor uniform coarse-textured soils, Petrona and Highmount (Uc1.21), and red earths, Dunrobin (Um5.5)	Lancewood and bendee scrub (rare *E. exserta*); arid scrub grass (*Aristida caput-medusae*, *Cleistochloa subjuncea*), occasional *Tripogon loliiformis* community and bare ground	VII–VIII t_7, r_5
2	55% Widespread	Mountains and hills including slopes below unit 1; very steep to hilly; local relief 50–500 ft; rocky with much outcrop; occasional pockets of sand	Mainly shallow rocky soils, Shotover (Uc1.2); minor pockets of uniform coarse-textured soils, Petrona and Highmount (Uc1.23, 4.11)	Sandstone woodland (*E. decorticans*, *E. cloeziana*, *E. peltata*), sandstone midstorey (*Boronia* spp., *Dampiera* sp., *Acacia* spp.), and sandstone spinifex (*Triodia mitchellii*) in the extreme south; elsewhere narrow-leaved ironbark woodland (*E. decorticans* in the south, *E. drepanophylla* elsewhere, both with *E. peltata*, and *E. polycarpa*), arenicolous midstorey (*Casuarina luehmannii*, *Callitris columellaris*, *Acacia cunninghamii*), sparse eastern mid-height grass (*Cymbopogon refractus*, *Aristida* spp.) and eastern spinifex	VII–VIII t_7, r_5
3	10% Widespread, especially in the north	Lower slopes; hilly to undulating; local relief 30–200 ft; slopes up to 25%; associated sandy aprons and fans; occasional depressions with weathered shale and clays	Mainly deep uniform coarse-textured soils, Highmount (Uc1.23, 4.11, 4.2), on sandy aprons and fans; texture-contrast soils, mainly Taurus (Db1.33), some Medway (Dy3.43) and Broadmeadow	*E. populnea* woodland with argillicolous (*Eremophila mitchellii*, *Carissa ovata*) or arenicolous midstorey (*Acacia cunninghamii*), *E. normantonensis* woodland in the north, occasional *E. melanophloia* and narrow-leaved ironbark woodlands with arenicolous midstorey (*Acacia cunninghamii*, *A.* sp. aff. *burrowii*); eastern mid-height grass (*Bothriochloa* spp., *Aristida* spp.), eastern spinifex, occasional arid scrub grass (*Aristida caput-medusae*). Rarely *E. thozetiana*– and *E. cambageana*–brigalow scrubs	IV–VII t_7, n_4, m_3
4	5% Widespread	Alluvial flats along major rivers; rarely more than ¼ mile wide; mainly sandy; usually single channels; flooded	Uniform coarse-textured alluvial soils, Davy (Uc1.23)	Fringing forest (*E. tereticornis*) on channels; *E. populnea*, occasional *E. melanophloia*, woodlands, arenicolous, argillicolous, or no midstorey and eastern mid-height grass (*Bothriochloa decipiens*)	IVw_{3-4}, n_4, m_3

COMET LAND SYSTEM* (690 SQ MILES)

Flooded alluvial plains with brigalow and cracking clay soils.

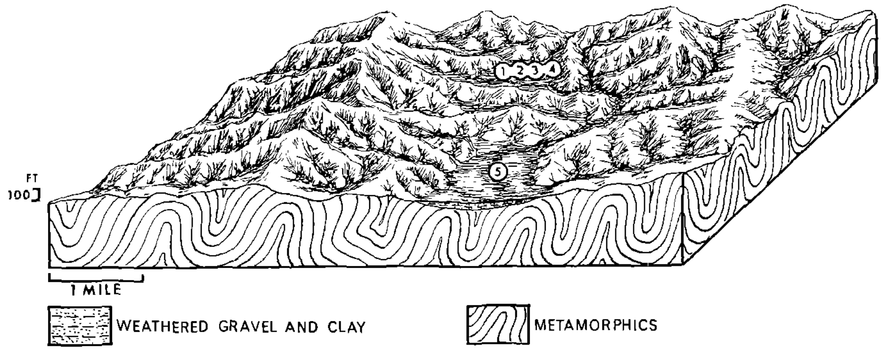


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	15% Widespread in north and centre	Higher alluvial plains and levees; not flooded	Mainly texture-contrast soils, Retro (Dr2.33); some loamy red earths, Wilpeena (Gn2.12)	*E. populnea* woodland with argillicolous midstorey, occasional *E. melanophloia* grassy woodland; eastern mid-height grass (*Bothriochloa ewartiana*, *Aristida ramosa*), occasional scrub grass	IVp_{3-4}, s_3
2	5% Along lower Belyando and Mistake Creek	Broad low levees and higher alluvial plains; not flooded	Cracking clay soils on alluvium, Vermont (Ug5.16)	Grassland, usually blue grass (*Astrebla lappacea*, *Thellungia advena*) usually with scattered *E. microtheca*	IIk_2
3	10% Sporadic along major valleys	Broad, shallow, dry channels and associated sandy levees; not flooded	Loamy yellow earths, Wilpeena (Gn2.22), and uniform coarse-textured alluvial soils on levees, Davy (Uc1.23)	Frontage woodland (*E. polycarpa*, *E. tessellaris*) over frontage grass (*Heteropogon contortus*, *Aristida ramosa*)	IVn_{3-4}
4	10% Mainly in upper valleys and along Mistake Creek	As unit 1, but slightly lower and liable to flooding	Texture-contrast soils, Retro (Db1.13)	Stands of low *Eremophila mitchellii*; sparse *Tripogon loliiformis* grass	IVp_{3-4}
5	10% In north and north-east	Alluvial clay plains; often in back-swamp sites or floors of some broad shallow old channels; flooded	Medium- to fine-textured alluvial soils, Clematis (Uf6.33 on clay loam) and Warrinilla (Uf6.33 on loamy sand)	*E. microtheca* woodland over blue grass (*Astrebla* spp.)	Vw_{3-5}
6	45% Throughout	As unit 5, but some minor occurrences of weathered clay	Mainly cracking clay soils, Vermont (Ug5.16); extensive texture-contrast soils, Taurus (Dy2.33) and Retro (Db1.13), thin sandy or loamy surface soils, and strongly alkaline subsoils	Brigalow (or blackwood) scrub, sometimes with high proportion of gidgee, usually *Eremophila mitchellii* and *Terminalia oblongata* midstoreys; scrub grass (*Paspalidium* spp., *Chloris divaricata*, *C. acicularis*), occasional blue grass where community is open	Vw_{3-5}, p_{3-4}, s_3
7	5% Throughout	Channels; in minor valleys 3–15 ft deep with anastomosing pattern; in larger valleys 10–40 ft deep with simple meandering pattern; on major rivers anastomosing sub-channels within single main channel; bed load sand and fine gravel	Mainly cracking clay soils, Vermont (Ug5.16); minor areas of recent alluvial soils	Fringing forest (*E. tereticornis*, *E. microtheca*, *Casuarina cunninghamiana*, *Melaleuca* spp.) on larger channels; brigalow and *E. microtheca* on smaller channels	Vw_5

* Similar to Coreen land system in the Dawson–Fitzroy area.

COPPERFIELD LAND SYSTEM (900 SQ MILES)

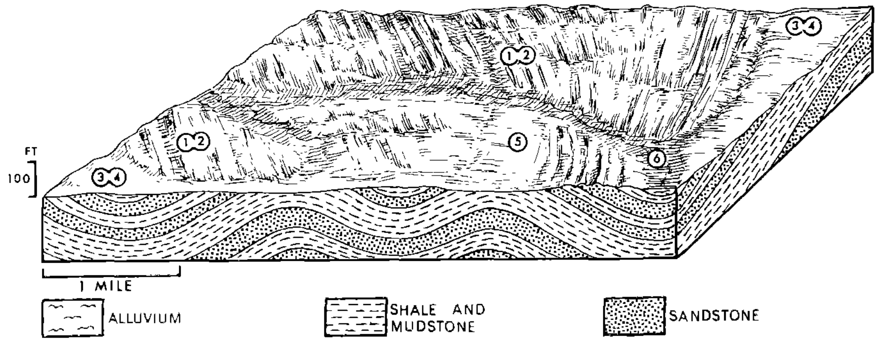
Stony, broken hills with ironbark and shallow rocky soils formed mainly below the Tertiary weathered zone on metamorphics.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	20% Widespread	Hills; closely dissected and fairly steep; local relief 50–400 ft; slopes 10–50%; very stony surface with considerable outcrop; sheet erosion and gullying	Mainly shallow rocky soils, Shotover (Uc1.2); minor areas of loamy red earths, Dunrobin (Um1.43), usually strongly acid and gravelly, and shallow red earths, Gregory (Gn2.11)	Lancewood, occasional bendee, scrub; arid scrub grass (*Cleistochloa subjuncea*; *Aristida caput-medusae*), *Tripogon loliiformis* community, and bare ground	VII–VIII t_7,r_5
2	35% Widespread	As unit 1, but slightly less stony	Shallow rocky soils, Shotover (Uc1.2)	Narrow-leaved ironbark woodland (*E. crebra*): dense *Acacia rhodoxylon* midstorey; bare ground and sparse eastern mid-height grass (*Eriachne* spp., *Aristida* spp.)	VII–VIII t_7,r_5
3	35% Widespread	As unit 1, but even more outcrop	Mainly shallow rocky soils, Shotover (Uc1.2); minor areas of shallow texture-contrast soils, Southernwood (Dr2.12)	Narrow-leaved ironbark woodland (*E. crebra*, *E. drepanophylla*); usually no midstorey; eastern mid-height grass (*Bothriochloa ewartiana*, *Heteropogon contortus*)	VII–VIII t_7,r_5
4	10% Widespread	As unit 1, but less outcrop	Deep texture-contrast soils with thin sandy or loamy, generally gravelly surface horizons, Springwood (Dr2.12), Wyseby (Db1.12), and Taurus (Dr2.13)	*E. melanophloia* woodland with argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*), occasionally *E. populnea* locally, narrow-leaved ironbark (*E. drepanophylla*) and *E. orgadophila* woodlands; eastern mid-height grass (*Bothriochloa ewartiana*, *Eriachne* spp., *Aristida* spp.), sparse in places	IVp_{3-4}, r_4,e_4
5	<5% Sporadic	Depressions; gently undulating weathered clay with gravel	Deep texture-contrast soils with thin loamy, gravelly surface soils and strongly alkaline subsoils, Retro (Db1.33)	*E. cambageana*–brigalow, occasionally *E. thozetiana*–brigalow, scrubs, *Eremophila mitchellii* midstorey (*E. mitchellii*, *Carissa ovata*); scrub grass and eastern mid-height grass	IVp_{3-4}

CRAVEN LAND SYSTEM (340 SQ MILES)

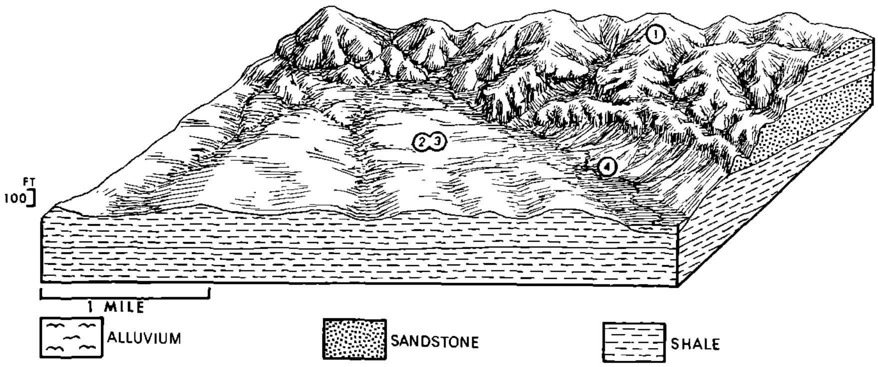
Lowlands with ironbark in groves and shallow texture-contrast soils formed below the Tertiary weathered zone on Drummond Basin sediments.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	40% Widespread	Undulating lowlands, low strike ridges, broad strike vales; slopes 4–12%; local relief 10–40 ft; gullying and sheet erosion; locally stony or sandy surface	Mainly shallow texture-contrast soils, Southernwood (Dr2.12) and Medway (Dd1.13, Dy3.23); some moderately deep soils, Broadmeadow (Dr2.43), and belts of cracking clay soils, Teviot (Ug5.22). Complex distribution governed by strike and lithology of parent rocks	*E. melanophloia* woodland, sparse argillicolous (*Eremophila mitchellii, Carissa ovata*), rarely arenicolous (*Callitris columellaris*), or no midstorey; occasional narrow-leaved ironbark (*E. drepanophylla*) woodland with argillicolous midstorey; all with eastern mid-height grass (*Bothriochloa ewartiana, B. decipiens, Themeda australis, Aristida* spp.); woodland usually groved with treeless intergroves	VIt_6,e_4,d_4
2	20% Widespread	Lower slopes and depressions; closely associated with unit 1	Shallow and moderately deep texture-contrast soils, Southernwood (Dy2.42) and Taurus (Db1.33)	*E. populnea* woodland with argillicolous (*Eremophila mitchellii, Carissa ovata*) or rarely no midstorey; eastern mid-height grass (*Bothriochloa ewartiana, Heteropogon contortus, Themeda australis*), rarely (in the north) eastern spinifex (*Triodia mitchellii*)	IV–VI t_6,e_4, p_{3-4},s_3
3	10% North and east of Alpha	Undulating lowlands; gravel and secondary carbonate fragments common	Texture-contrast soils with thin sandy or loamy surface and strongly alkaline subsoils, Taurus (Dr2.13) and Retro (Dr2.13, Db1.13)	*E. orgadophila* woodland, usually with argillicolous midstorey (*Geijera parviflora, Eremophila mitchellii, Ventilago viminalis*); eastern mid-height grass (*Bothriochloa ewartiana, Themeda australis*), scrub grass where upper layers dense	IV–VI t_6,e_4, p_{3-4},s_3
4	15% Widespread		Shallow and moderately deep texture-contrast soils, Medway (Db1.13) and Taurus (Dd1.33)	Brigalow scrub; *Eremophila mitchellii* understorey (*E. mitchellii, Carissa ovata*); scrub grass (*Paspalidium* spp., *Sporobolus* spp.), eastern mid-height grass where community is open	IV–VI t_6,e_4, p_{3-4},s_3
5	10% Mainly in Pioneer area	Level to gently undulating lowlands on carbonaceous shales; gullying and sheet erosion on slopes over 2%	Moderately deep cracking clay soils, Teviot (Ug5.22)	Grassland, eastern mid-height grass (*Bothriochloa ewartiana*), scattered *Acacia farnesiana, E. melanophloia, E. dichromophloia*	II–IIIe_{2-3}
6	5% Widespread	Alluvial flats; anastomosing channels 3–10 ft deep	No observations; probably texture-contrast soils mainly	Fringing forest and woodland (*E. microtheca, Melaleuca* spp.) on channels; *E. populnea* woodland and brigalow scrub with eastern mid-height and scrub grass respectively	III–IV p_{3-4},w_3

CUNGELELLA LAND SYSTEM (660 SQ MILES)

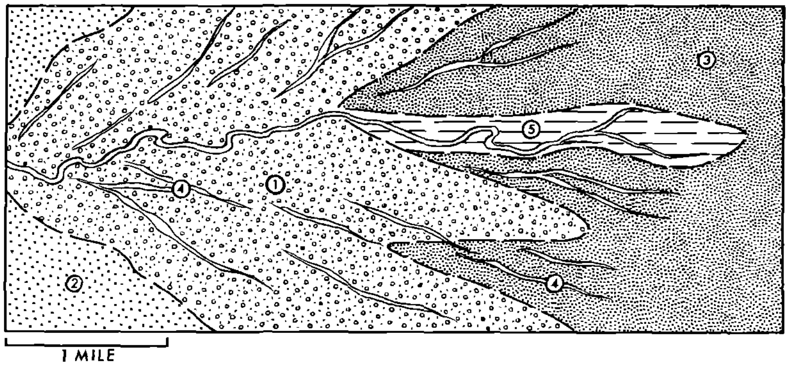
Softwood scrub on lowlands with dark brown and grey-brown soils on unweathered mixed sediments.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	30% Widespread	Hills and scarps; undulating to broken; local relief 40–200 ft; slopes up to 35%; gravelly clay with very stony surface	Mainly deep texture-contrast soils, Wyseby (Dr2.11) and Retro (Db2.13); some areas of cracking clay soils, Rolleston (Ug5.24), with much coarse billy gravel on surface	*Macropteranthes leichhardtii* scrub (*M. leichhardtii*, *Croton insularis*, *C. phebalioides*, *Geijera parviflora*, *Brachychiton rupestre*) with sparse scrub grass (*Paspalidium* spp., *Ancistrachne uncinulata*, *Eragrostis megalosperma*); minor brigalow scrub with *Geijera parviflora* (shrub wilga) midstorey and scrub grass; rare *E. populnea* and *E. melanophloia* woodlands with mid-height grass	VIt_6, r_5
2	45% Widespread	Lowlands and valley floors; undulating; local relief 10–100 ft; slopes up to 9%; gravelly clay and some sandy colluvium; gullying and sheet erosion	Moderately deep, dark brown and grey-brown soils, Cheshire (Gn3.93, Uf6.33), underlain by coarse-textured materials in places	*Macropteranthes leichhardtii* softwood scrub, sparse scrub grass (as unit 1)	IVe_{3-4}
3	20% Widespread		Texture-contrast soils, Luxor (Dy3.22) and Taurus (Db1.13)	Brigalow scrub; *Geijera parviflora* (shrub wilga) midstorey (*G. parviflora*, *Brachychiton rupestre*, *Eremophila mitchellii*), occasional *Eremophila mitchellii* midstorey (*E. mitchellii*, *Carissa ovata*); scrub grass (*Paspalidium* spp., *Chloris divaricata*); occasional *E. cambageana* woodland with arenicolous midstorey (*Acacia sparsiflora*) and eastern mid-height grass	IVe_{3-4}, p_{3-4}, s_3
4	5% Widespread	Alluvial flats and fans; gently sloping (up to 1%) and terraced in places; up to 1 mile wide; scalded areas; channels 5–15 ft deep	Cracking clay soils, Vermont (Ug5.16)	Brigalow scrub with *Eremophila mitchellii* midstorey and scrub grass; bare ground and *Tripogon loliiformis* community alone; *E. microtheca* on channels	Vw_{3-5}

Degulla Land System (980 sq miles)

Extensive, stable fans with bloodwood and ironbark and uniform coarse-textured soils derived from weathered Tertiary and older sandstones.

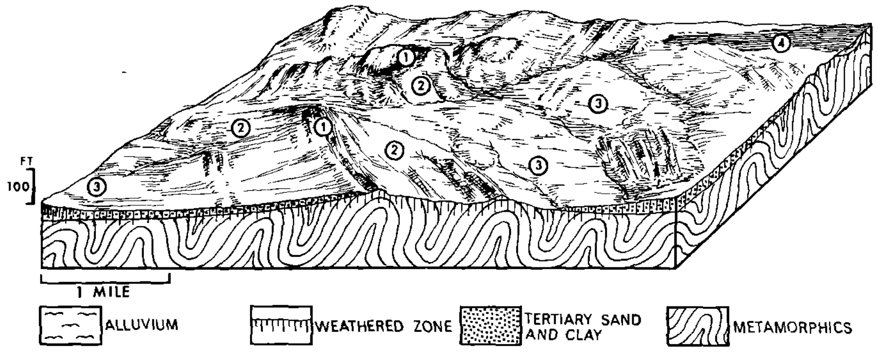


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	50% Widespread	Gently sloping central and upper parts of fans; up to 3 miles across; sandy slopes up to 1%	Mainly deep uniform coarse-textured soils, Highmount (Uc1.21, 1.22); minor areas of sandy yellow earths, Forrester (Gn1.22), and loamy red earths, Dunrobin (Gn2.12)	*E. melanophloia* woodland, usually *Acacia coriacea* (*A. coriacea*, *A. tenuissima*, *A. laccata*), occasionally argillicolous (*Eremophila mitchellii*, *Albizia basaltica*), rarely no midstorey; eastern spinifex (*Triodia mitchellii*) and eastern mid-height grass (*Bothriochloa ewartiana*, *Themeda australis*, *Eriachne* spp., *Aristida* spp.), sometimes mosaics	VI*n_4,m_3
2	20% Mainly east side of Lake Buchanan	Sandy plains, smaller fans, low rises; possibly some wind-blown sand	Deep uniform coarse-textured soils, Highmount (Uc1.22), and sandy yellow earths, Forrester (Gn1.22, 2.22), with concretionary ironstone at depth	*E. polycarpa*–*E. papuana* woodland, usually with *Melaleuca nervosa* (*M. nervosa*, *E. setosa*), rarely no midstorey; eastern spinifex (*Triodia mitchellii*), rarely eastern mid-height grass; rarely *E. populnea* woodland with arenicolous midstorey (*Petalostigma pubescens*) and eastern mid-height grass (*Aristida* spp., *Bothriochloa ewartiana*)	VIn_4, m_3
3	20% Widespread	Very gently sloping lower parts of fans and alluvial plains; up to 3 miles across; loamy, slopes less than ½%	Loamy yellow earths, Struan (Gn2.22, 2.82), merging with deep texture-contrast soils with thick sandy surface soils, Luxor (Dy3.42)	*E. populnea* woodland; argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*); eastern mid-height grass (*Bothriochloa ewartiana*, *B. decipiens*, *Aristida glumaris*, *Dichanthium fecundum*)	IV–VI n_4, m_3
4	10% Widespread	Shallow, anastomosing disused distributaries forming linear depressions 6 in.–3 ft deep and 10–300 yd wide	One observation; deep uniform coarse-textured soil, Highmount (Uc1.22)	As unit 3, but argillicolous midstorey denser and *Cassia brewsteri* prominent	VIn_4, m_3
5	<5% Widespread	Alluvial flats mainly in unit 3; sandy; not flooded except on lowest parts; single meandering channels 5–15 ft deep	One observation; loamy yellow earth, Wilpeena (Gn2.82)	Fringing forest (*E. tereticornis*, *Melaleuca* spp.) on channels; frontage woodland (*E. polycarpa*, *E. melanophloia*) over frontage grass (*Heteropogon contortus*, *Rhynchelytrum repens*), occasionally *E. populnea* woodland	IVn_4, m_3

* Land class downgraded on account of low rainfall.

Disney Land System (450 sq miles)

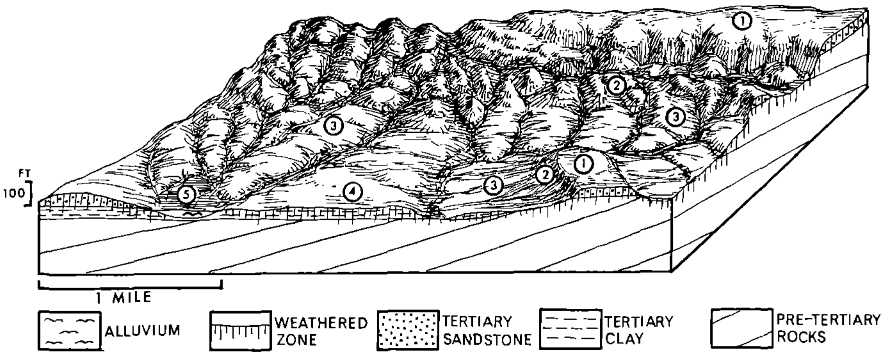
Small lateritic mesas with ironbark and red or yellow earths on Tertiary sandstone; **surrounding lowlands with box and brigalow** and texture-contrast soils on weathered Drummond Basin sediments.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	35% Widespread	Rises, low mesas, interfluves; gently undulating to undulating; up to 2 miles wide; slopes generally 1–5%, steepening to 8% on margins; mainly sandy surface with some ironstone gravel; sheet erosion on steeper margins; minor associated colluvial aprons	Mainly loamy red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.82), minor sandy earths, Annandale (Gn2.12) and Forrester (Gn2.61), on rises and mesas; uniform coarse-textured soils, Petrona (Uc5.11) and Highmount, often gravelly, on aprons	Narrow-leaved ironbark (*E. drepanophylla*) woodland with arenicolous (*Acacia cunninghamii*), *Acacia leptostachya* (*A. leptostachya*, *Petalostigma banksii*), or no midstorey; occasional *E. polycarpa–E. papuana* woodland with arenicolous midstorey (*Lysicarpus angustifolius*, *Petalostigma pubescens*); *E. melanophloia* woodland with *Acacia coriacea* midstorey, *Melaleuca tamariscina* scrub, and treeless *Acacia leptostachya* community; eastern mid-height grass (*Aristida* spp., *Bothriochloa ewartiana*, *Cymbopogon bombycinus*) and eastern spinifex (*Triodia mitchellii*)	IV–VI n_{3-4}, m_3
2	25% Mainly in the north	Slopes below unit 1, lowlands and colluvial aprons; gently undulating to undulating; generally ½–1 mile wide; slopes up to 5%; stable but occasional gullying	Shallow to moderately deep texture-contrast soils, mainly Southernwood (Db1.22) and Luxor (Dy3.42), minor Retro (Db1.13)	*E. populnea* woodland, with argillicolous (*Eremophila mitchellii*, *Carissa ovata*), arenicolous (*Acacia cunninghamii*), or no midstorey; eastern mid-height grass (*Bothriochloa ewartiana*, *B. decipiens*, *Heteropogon contortus*, *Aristida glumaris*); occasional *E. normantonensis* woodland with eastern spinifex (*Triodia mitchellii*)	IV–VI e_4, d_4
3	35% Widespread	Lowlands, very low strike ridge-and-vale, plains; up to 2 miles wide; slopes 0–2%; billy gravel and weathered clay common, especially in lowest sites; some gullying and sheet erosion on steeper parts	Deep texture-contrast soils with thin sandy or loamy surface soils, mainly Retro (Db1.13, 1.33), with areas of Springwood (Dr2.11), Taurus (Dy2.13), and Wyseby (Dy2.32); minor areas of gilgaied, cracking clay soils, Pegunny (Ug5.16)	Brigalow (and blackwood), *E. cambageana*–brigalow, rarely gidgee scrubs (sometimes groved); *Eremophila mitchellii* midstorey (*E. mitchellii*, *Carissa ovata*); scrub grass (*Paspalidium* spp., *Enneapogon* spp., *Chloris acicularis*) and eastern mid-height grass (*Bothriochloa ewartiana*, *Heteropogon contortus*) in open places	IVp_{3-4}, s_3, e_2
4	5% Widespread	Alluvial flats; minor terraces and levees; generally less than ¼ mile wide; predominantly fine-textured; only lower parts flooded; single channels 3–10 ft deep, bed load fine gravel to clay	Texture-contrast soils, Wyseby (Dy2.22)	*E. populnea* woodland, usually without midstorey, over eastern mid-height grass (*Bothriochloa decipiens*, *B. ewartiana*); brigalow and blackwood scrubs; fringing forest (*E. tereticornis*, *E. microtheca*) on channels	IVp_{3-4}, s_2

DURRANDELLA LAND SYSTEM (650 SQ MILES)

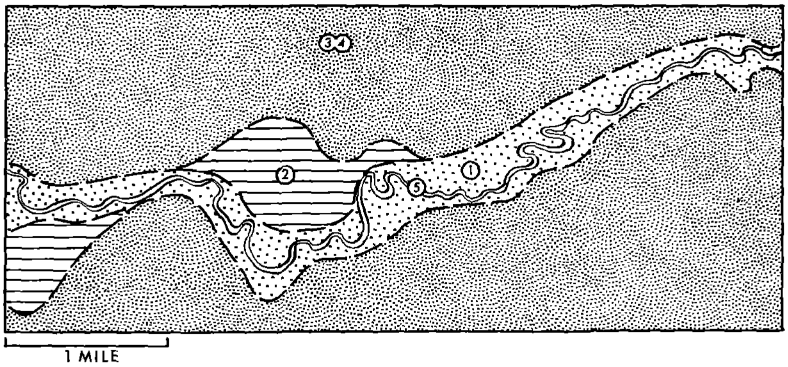
Stony hills with lancewood or bendee and shallow rocky soils or shallow red earths on pre-Tertiary rocks within the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	20% Widespread	Mesa tops; undulating; rarely exceeding ½ mile in breadth, 10–100 ft high; slopes up to 6%; sandy as a rule; sheet erosion and gullying especially on margins	Sandy red earths, Annandale (Gn1.12), and uniform coarse-textured soils, Highmount (Uc1.23)	Narrow-leaved ironbark (*E. drepanophylla*, occasional *E. decorticans*) and *E. polycarpa–E. papuana* woodlands, arenicolous midstorey (*A. cunninghamii*), occasionally none; eastern mid-height grass (*Aristida* spp.) and arid scrub grass (*Aristida caput-medusae, Neurachne mitchellii*)	VIn_4, e_3
2	50% Widespread	Scarps and hills; broken and dissected; 10–150 ft high; slopes 10–60%; rocky; strong sheet erosion; minor gently sloping benches and quartz sandstone ridges	Shallow rocky soils, Shotover (Uc1.1), and shallow red earths, Gregory (Gn2.11), minor areas of loamy red earths, Dunrobin (Gn2.11)	Bendee and lancewood scrub; occasional narrow-leaved ironbark woodland (*E. drepanophylla, E. peltata, E. citriodora*), arenicolous midstorey (*Acacia cunninghamii*); arid scrub grass (*Aristida caput-medusae, Neurachne mitchellii*) or bare ground	$VIIt_7$, e_4, d_4
3	20% Widespread	Lower slopes and spurs, open valleys; below unit 2; undulating to low hilly; up to ½ mile wide; slopes up to 20%; some gullying	Texture-contrast soils, mainly with thick sandy surface and neutral subsoils, Luxor (Dy2.42, Db2.22), some Southernwood (Dr2.32), Wyseby (Dr2.22), and Retro (Dy 2.23)	*E. populnea* (*E. populnea, E. melanophloia*), occasionally narrow-leaved ironbark woodland (*E. drepanophylla*) with arenicolous (*Acacia cunninghamii*), argillicolous (*Eremophila mitchellii, Carissa ovata*), or no midstorey, arid scrub grass (*Aristida caput-medusae*) or eastern mid-height grass (*Cymbopogon refractus, Aristida* spp.); in the north some *E. normantonensis* woodland with eastern spinifex	IVp_{3-4}, e_3, s_3
4	10% Sporadic	Lowlands and plains; undulating to level; local relief 5–20 ft; rarely more than ½ mile across; slopes up to 8%; clay with some gravel; sheet erosion; minor clay aprons	Texture-contrast soils, mainly with thin loamy surface and strongly alkaline subsoils, Retro (Dy2.33, Dr2.23), some Springwood (Dy2.32) and Taurus (Db 1.23)	*E. cambageana–E. thozetiana*–brigalow, rarely brigalow scrub, *Eremophila mitchellii* midstorey; occasionally *E. cambageana* or *E. thozetiana* woodland; scrub grass (*Paspalidium* spp., *Sporobolus* spp.), eastern mid-height grass (*Bothriochloa ewartiana*), and occasional *Tripogon loliiformis* community	IVp_{3-4}, e_3
5	<5% Sporadic	Alluvial flats; very small; mainly clay but some sand; shallow anastomosing channels; probably flooded	No observation; probably texture-contrast soils mainly	Fringing community (*E. tereticornis, Melaleuca* spp.) on channels; *E. populnea* woodland with eastern mid-height grass, occasional brigalow scrub with *Eremophila mitchellii* midstorey and scrub grass	Vw_{3-5}

FUNNEL LAND SYSTEM* (1000 SQ MILES)

Flooded alluvial plains with coolibah and cracking clay soils.

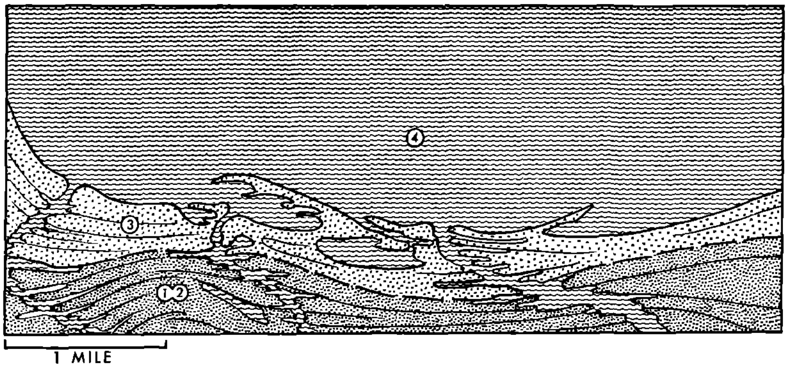


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	15% Non-basaltic areas in the north and centre	Levees; mainly silty; not flooded	Mainly texture-contrast soils with thin loamy surface soils, generally strongly alkaline subsoils, Retro (Dy2.33) and Wyseby (Dd1.12); minor alluvial soils, Clematis (Um1.21) and Moolayember (Um1.21 on silty clay)	*E. populnea* woodland, occasionally with argillicolous midstorey (*Eremophila mitchellii, Carissa ovata*) over eastern mid-height grass (*Bothriochloa ewartiana, B. decipiens, Chloris acicularis, Aristida ramosa*); occasional *E. microtheca* woodland over very sparse grass, and stands of low *Eremophila mitchellii* with *Tripogon loliiformis* grass layer; rarely frontage woodland over frontage grass	IVp$_{3-4}$, s$_3$
2	10% Sporadic	Alluvial terraces; up to 1 mile across; level; not flooded	Cracking clay soils, Vermont (Ug5.16)	Grassland of blue grass (*Dichanthium sericeum, Thellungia advena, Aristida latifolia*, occasional *Astrebla* spp.); some *E. microtheca* grassy woodland and groves of *Melaleuca bracteata* and *Acacia pendula*	II–IIIk$_{2-3}$
3	15% Widespread	Alluvial clay plains; up to 3 miles across; occasionally with faint channels and levees; partly flooded	Cracking clay soils, Vermont (Ug5.16), on plains; texture-contrast soils with thin sandy or loamy surface and strongly alkaline subsoils, on levees, Taurus (Dr2.33) and Retro (Db1.33)	Mostly gidgee, occasionally brigalow scrub; *Eremophila mitchellii* and *Terminalia oblongata* midstorey communities; sparse scrub grass (*Paspalidium* spp., *Sporobolus* spp., *Chloris acicularis, Bassia* spp.)	IV–V w$_{3-5}$, p$_{3-4}$,s$_3$
4	55% Widespread	As unit 3 but more liable to flooding	Mainly cracking clay soils, Vermont (Ug5.16); minor texture-contrast soils, Retro (Dy2.33), and alluvial soils, Clematis (Um5.5) and Warrinilla (Um5.5 on loamy sand)	*E. microtheca* grassy woodland, with argillicolous midstorey (*Eremophila mitchellii, Carissa ovata*); blue grass (*Thellungia advena, Astrebla pectinata, A. lappacea, Dichanthium sericeum*) with *Marsilia* spp., *Leptochloa* sp. in depressions, occasionally eastern mid-height grass (*Bothriochloa* spp.). Small areas of brigalow and gidgee scrub; *Eremophila mitchellii* and *Terminalia oblongata* midstoreys, scrub grass, *Tripogon loliiformis* community or rarely blue grass	III–V w$_{3-5}$,k$_{2-3}$
5	5% Widespread	Channels; 3–25 ft deep; usually braided; bed load sand, silt, and clay	Cracking clay soils, Vermont (Ug5.16), and medium- to fine-textured alluvial soils, Clematis (Uf1.41)	Fringing forest and woodland (*E. tereticornis, E. microtheca, Acacia salicina* on larger channels, *E. microtheca*, occasional brigalow, *Acacia stenophylla* on smaller channels)	Vw$_5$

*Similar to Coolibah land system in the Dawson–Fitzroy area.

Galilee Land System (180 sq miles)

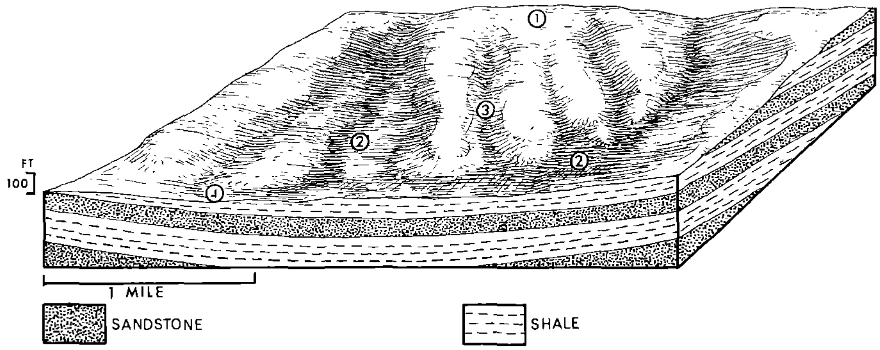
Intermittent salt lakes and fringing shore-line features.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	20% Mainly in Lake Buchanan basin	Sand plains and old beach ridges; up to ½ mile wide; level or gently undulating; up to 30 ft above lake bottom; very loose sandy surface; minor linear or oval clay-floored depressions between ridges	Deep texture-contrast soils mainly with thick sandy surface and very strongly alkaline, mottled subsoils, Broadmeadow (Dy3.43, 3.23), some Taurus (Dy3.23); uniform deep sands, Highmount (Uc1.23), on ridges	*Grevillea* woodland (*G. striata*, *G. parallela*, *Acacia bidwillii*) over eastern mid-height grass (*Chrysopogon fallax*, *Aristida* spp.); areas of samphire (*Arthrocnemum* spp., *Atriplex* spp.) and *Sporobolus virginicus* grassland	VIs_6,n_4,m_3
2	5% Mainly in Lake Galilee basin	Old beach ridges; up to 4 parallel sets forming a belt up to 1 mile wide; up to 35 ft above lake bottom; sandy or silty surface; sheet wash and minor gullying; intervening linear clay-floored depressions	Deep texture-contrast soils mainly with thick sandy surface horizons and mottled, strongly alkaline subsoils, Broadmeadow (Dy3.43), some Taurus (Dy4.53); uniform fine-textured alluvial soils, Clematis (Uf6.33), very strongly alkaline, in depressions	Gidgee scrub with *Eremophila mitchellii* midstorey (*E. mitchellii*, *Myoporum deserti*); woodland of *Acacia excelsa*, *Geijera parviflora*; *E. microtheca* woodland; all with extremely sparse grass	VIs_6, w_5, n_4
3	15% Both lake basins	Outer lake floor and young beach ridges; broad very low ridges 1–3 ft high and 50–200 yd wide; thin sand layers over saline gypseous clay; severe sheet erosion, occasional flooding	Deep texture-contrast soil with thin sandy surface and strongly alkaline subsoils, Taurus (Dy3.23); uniform fine-textured alluvial soils, Clematis (Uf6.33), prominently mottled and strongly affected by salts, underlain by mottled-zone materials at moderately shallow depth in places	Samphire (*Arthrocnemum* spp.) sometimes with dead *E. microtheca* and low dense stands of *Acacia stenophylla*	$VIIs_7, w_4$
4	60% Both lake basins	Inner lake floors; practically flat; heavy, saline, gypseous clay; flooded in most wet seasons	Alluvial land; sticky, saline clay, salt-encrusted during dry season	Barren	$VIIIs_8,w_5$

HILLALONG LAND SYSTEM (110 SQ MILES)

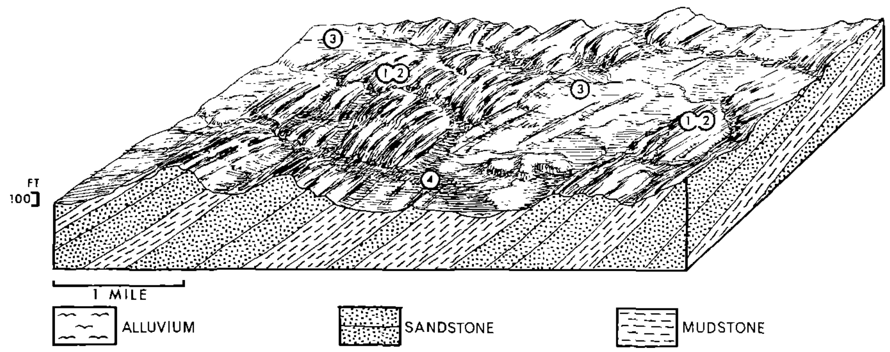
Lowlands with box and brigalow and texture-contrast soils formed on mixed sediments mainly below the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	50% Widespread	Undulating terrain and very low strike rises; local relief 20–50 ft; slopes up to 6% but usually less; gravelly with some outcrop; minor gullying	Deep texture-contrast soils, thin sandy surface and strongly alkaline subsoils, Taurus (Dy3.43)	*E. populnea* woodland (high proportion *E. drepanophylla* and some *E. alba*): argillicolous midstorey (*Eremophila mitchellii, Carissa ovata*); eastern mid-height grass (*Aristida glumaris, Bothriochloa decipiens*)	IVp_{3-4}, e_3,s_3
2	20% Sporadic	Lowlands; up to ¼ mile across; undulating to level; local relief 5–20 ft; slopes up to 5%	No observations; probably cracking clay soils, Teviot	Grassland–blue grass (*Dichanthium sericeum, Panicum* spp.); occasional open *E. melanophloia* woodland (*E. melanophloia, E. dichromophloia*) with blue grass	$II–IIIe_{2-3}$
3	25% Widespread	Shallow strike vales and lowlands; undulating; local relief 10–30 ft; slopes up to 5%; gravelly clay	Deep alkaline/acid cracking clay soils, gilgaied in places, Pegunny and Rolleston (Ug5.34), commonly with coarse billy gravel on surface	Brigalow scrub, *Eremophila mitchellii* and softwood midstorey; sparse scrub grass (*Sporobolus* spp., *Paspalidium* spp., *Ancistrachne uncinulata*)	IVs_{3-4},g_4
4	5% Widespread	Alluvial flats	No observations; probably texture-contrast soils mainly, with minor areas of cracking clays	*E. populnea* woodland and eastern mid-height grass (as unit 1); minor brigalow scrub (as unit 2)	IVp_{3-4}

Hope Land System* (760 sq miles)

Low stony hills and lowlands with narrow-leaved ironbark and texture-contrast soils on Drummond Basin sediments below the Tertiary weathered zone.

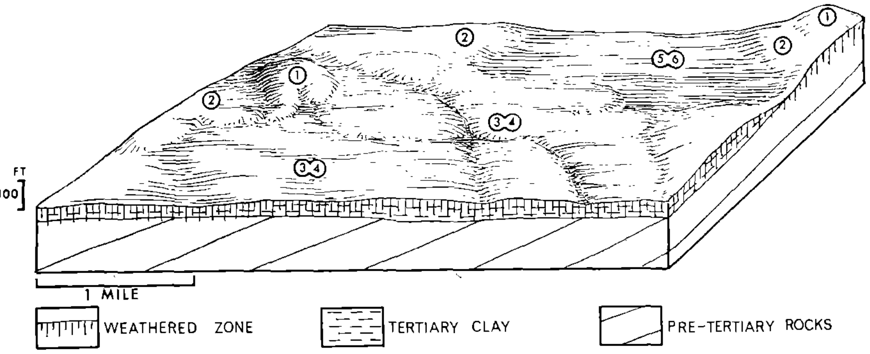


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	45% Widespread	Strike ridges, cuestas, low mesas, broken hills; local relief 30–300 ft; slopes 5–40%; much outcrop; gullying and sheet erosion	Mainly shallow and moderately deep texture-contrast soils, Medway (Dy2.43, Db1.13), Luxor (Db1.22), Broadmeadow (Dy2.23), and Springwood (Dr3.22); extensive shallow rocky soils, Rugby and Shotover. Complex distribution governed by strike and lithology of parent rocks	Narrow-leaved ironbark woodland (*E. drepanophylla*, some *E. citriodora* on shallow rocky soils) sometimes groved, usually arenicolous midstorey (*Acacia cunninghamii*) and eastern mid-height grass (*Bothriochloa ewartiana, Heteropogon contortus, Aristida* spp.); occasionally in the north, groves of *E. normantonensis* woodland with glades of grassland (eastern mid-height grass and *Tripogon loliiformis*) and scattered *Eremophila mitchellii*; rarely bendee and lancewood scrub with arid scrub grass	VIt_6,e_4,d_4
2	15% Mainly in the south	As unit 1	Texture-contrast soils, Southernwood (Dr2.22) and Wyseby (Dr2.22), commonly with gravelly surface soils; extensive outcrops. Distribution as unit 1	*E. melanophloia* and *E. orgadophila* woodlands, both with argillicolous midstorey (*Albizia basaltica, Eremophila mitchellii*), sometimes groved with no trees between groves; eastern mid-height grass (*Bothriochloa ewartiana, Themeda australis*)	VIt_6,e_4,d_4
3	35% Widespread	Undulating lowlands; very low strike ridges; colluvial sheets; fans; most slopes less than 5%	Shallow texture-contrast soils, Southernwood (Dy 2.42) and Medway (Db1.13); extensive shallow rocky soils, Shotover. Distribution as unit 1	Narrow-leaved ironbark (as unit 1); inclusions of *E. populnea* and *E. orgadophila* woodlands moderate to dense argillicolous midstorey (*Eremophila mitchellii, Geijera parviflora, Carissa ovata*); eastern mid-height grass (*Heteropogon contortus, Aristida* spp., *Eriachne* spp.)	IV–VI d_4,e_3,r_5
4	5% Widespread	Alluvial flats, channels 3–10 ft deep, generally single but sometimes anastomosing	One observation; texture-contrast soil, Springwood (Dy2.22)	Fringing community on channels (*E. tereticornis, E. microtheca*); *E. populnea* woodland with open argillicolous midstorey and eastern mid-height grass; brigalow scrub with scrub grass; treeless area with sparse *Tripogon loliiformis* community	IVp_{3-4}

* Similar to Cotherstone land system in the Isaac–Comet area.

HUMBOLDT LAND SYSTEM* (2140 SQ MILES)

Lowlands and plains with blackbutt and brigalow with texture-contrast soils formed on acid clay exposed within the Tertiary weathered zone.

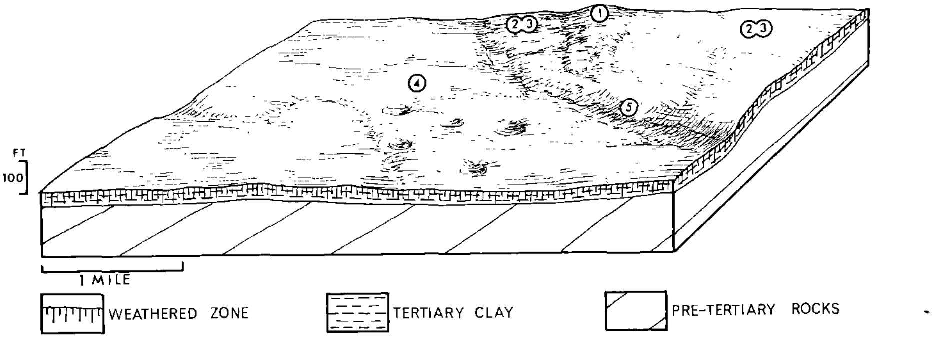


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% Sporadic	Crests of rises and low hills, old levees, dunes; sandy; local relief 5–50 ft	Loamy red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.22); minor areas of uniform coarse-textured soils, Petrona (Uc4.12)	*E. melanophloia* and *E. populnea* woodlands, both usually with argillicolous midstorey (*Eremophila mitchellii*) and eastern mid-height grass (*Bothriochloa ewartiana*, *Aristida* spp.); lancewood scrub with arid scrub grass; small area of *E. exserta* near Anakie	IVn_{3-4},m_3
2	15% Widespread	Slight rises; local relief 5–30 ft; sandy or loamy; some gullying and sheet erosion; includes sandy colluvial aprons below unit 1	Mainly texture-contrast soils with sandy surface soils, Luxor (Dr2.22), Broadmeadow (Db1.23), Springwood (Dy2.12), and Taurus (Dr2.13); minor areas of loamy yellow earths, Struan (Gn2.22), on upper slopes	*E. populnea* woodland, mostly with argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*, brigalow sometimes prominent), rare arenicolous midstorey; eastern mid-height grass (*Bothriochloa ewartiana*, *B. decipiens*, *Aristida glumaris*, *Heteropogon contortus*)	IVp_{3-4}, s_3,e_3
3	50% Widespread	Plains and lowlands; slopes less than 2%; up to 5 miles across; deeply weathered Tertiary clay and older rocks; billy and quartz gravel common, especially on metamorphics; occasional hills up to 100 ft high	Texture-contrast soils, mainly with thin loamy surface and strongly alkaline subsoils, Retro (Db1.33, Dd1.13), some Springwood (Dd1.32), Taurus (Db1.33), and Wyseby (Dd1.12); commonly with billy or quartz gravel in subsurface horizons; minor areas of cracking, alkaline/acid clay soils, Rolleston (Ug5.24), and dark brown and grey-brown soils, Cheshire (Gn3.43)	*E. cambageana*–brigalow scrub, usually *Eremophila mitchellii* (*E. mitchellii*, *Carissa ovata*), rarely *Terminalia oblongata*, or no midstorey; rarely *E. cambageana* woodland with arenicolous (*Acacia sparsiflora*) or argillicolous (*Eremophila mitchellii*) midstorey; scrub grass (*Paspalidium* spp., *Chloris acicularis*, *Sporobolus* spp.) and eastern mid-height grass in open places	IVp_{3-4}, r_{3-4},s_3
4	15% Widespread	As unit 3 but no hills	Cracking, alkaline/acid clay soils, Rolleston (Ug5.15, 5.24)	Brigalow scrub; *Eremophila mitchellii* (*E. mitchellii*, *Carissa ovata*), rarely *Terminalia oblongata* (*T. oblongata*, *E. mitchellii*, *Heterodendrum diversifolium*), or no midstorey; sparse scrub grass (*Paspalidium* spp., *Chloris* spp.)	$IIIs_3,k_{2-3}$
5	10% Widespread	Plains and shallow depressions; slopes less than 1%; up to 4 miles across; weathered clay with deep gilgai; narrow alluvial flats with braided channels	Gilgaied cracking clay soils, Pegunny (Ug5.15, 5.24)	Brigalow scrub; *Eremophila mitchellii* (*E. mitchellii*, *Carissa ovata*), rarely *Terminalia oblongata* (*T. oblongata*, *E. mitchellii*, *Heterodendrum diversifolium*), or no midstorey; sparse scrub grass (*Paspalidium* spp., *Chloris* spp.) and eastern mid-height grass in open places	IVg_4, s_{3-4},k_{2-3}
6	5% Widespread		Mosaic of texture-contrast soils with thin sandy or loamy surface and strongly alkaline subsoils, Retro (Db1.33), and Taurus (Dr2.33), and cracking clay soils, Pegunny and Rolleston (Ug5.24)	*E. cambageana*–brigalow and brigalow scrub; *Eremophila mitchellii* midstorey, rarely *Terminalia oblongata* or no midstorey; sparse scrub grass (*Paspalidium* spp.) or eastern mid-height grass (*Bothriochloa ewartiana*) in open places	IVp_{3-4}, g_4,k_4

* Similar to Thomby land system in the Dawson–Fitzroy area.

ISLAY LAND SYSTEM (870 SQ MILES)

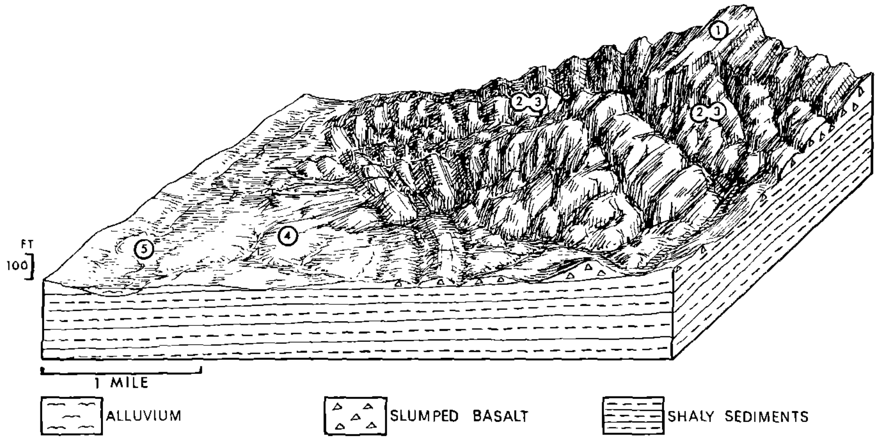
Gidgee plains with gilgaied clay soils on acid clay exposed within the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% Sporadic	Rises; 10–30 ft high; slopes up to 5%	Mainly texture-contrast soils, Luxor (Dy3.22) and Springwood (Dy2.32); minor areas of red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.22)	*E. populnea*, occasionally *E. melanophloia*, woodlands, both with argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*) and eastern mid-height grass; small areas of blue grass without trees	IVp_{3-4}, s_2,e_3
2	10% Widespread	Foot slopes around unit 1; slopes up to 2%	Texture-contrast soils with thin sandy or loamy surface and strongly alkaline subsoils, Retro (Db1.13) and Taurus (Dy2.23)	*E. cambageana*-brigalow scrub with *Eremophila mitchellii* midstorey and scrub grass (*Paspalidium* spp., *Chloris acicularis*), eastern mid-height grass where upper strata are dense	IVp_{3-4}, s_3,e_2
3	15% Widespread		Texture-contrast soils, Retro (Db1.13), merging with deep cracking clay soils, Rolleston (Ug5.34)	Brigalow scrub with *Eremophila mitchellii*, *Terminalia oblongata*, or no midstorey; usually scrub grass, but eastern mid-height grass and blue grass where upper strata are open. Occasional *Terminalia oblongata* and *Eremophila mitchellii* communities without taller trees	IVp_{3-4}, s_3,e_2
4	70% Widespread	Plains, lowlands, depressions; level to very gently undulating; up to 6 miles across; slopes less than 1%; deeply weathered clay, gravelly in places; some gullying along depressions	Gilgaied deep clay soils, Pegunny (Ug5.24), mainly strongly alkaline at or near the surface becoming strongly acid at depth; occasionally strongly alkaline throughout	Gidgee scrub with *Eremophila mitchellii* (*E. mitchellii*, *Ventilago viminalis*, *Carissa ovata*, *Cassia nemophila*), *Terminalia oblongata* (*T. oblongata*, *E. mitchellii*, *Ehretia membranifolia*, *Heterodendrum diversifolium*), or no midstorey, scrub grass (*Paspalidium* spp., *Sporobolus* spp., *Chloris divaricata*, *C. acicularis*, *Atriplex* spp.)	IVg_4, s_{3-4},k_{2-3}
5	<5% Widespread	Alluvial flats; mainly level but narrow levees up to 3 ft high; channels generally narrow, anastomosing, and 3–12 ft deep but some wide shallow abandoned channels; much flooding	Alluvial red earths, Wilpeena (Gn2.12), and texture-contrast soils, Luxor (Dy2.22) and Taurus (Dy2.23); minor areas of cracking clay soils, Vermont (Ug5.16), and uniform medium- to fine-textured alluvial soils, Clematis	Fringing forest (*E. microtheca*, *Melaleuca* spp.) on channels; *E. populnea* woodland, usually with argillicolous midstorey and eastern mid-height grass; occasionally brigalow scrub and scrub grass	IVp_{3-4},n_3, s_2

KAREELA LAND SYSTEM* (170 SQ MILES)

Broken country with softwood scrub and dark brown and grey-brown soils on slumped, mainly unweathered basalt and Permian shales.

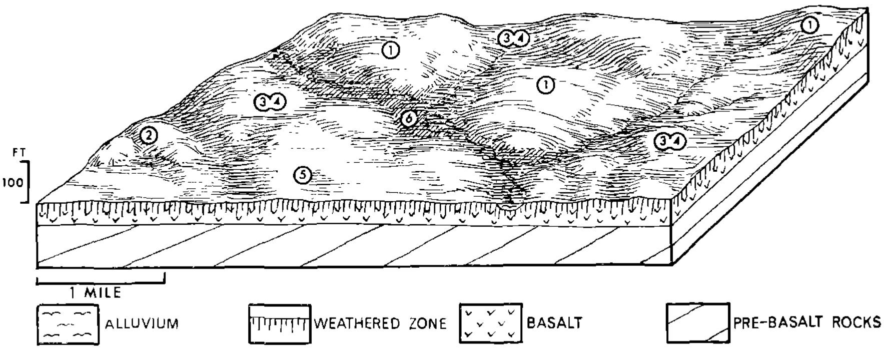


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% Widespread	High rocky ridge crests with much outcrop	Shallow rocky soils, Rugby (Um1)	*E. orgadophila* woodland (*E. orgadophila*, *E. dichromophloia*), occasionally narrow-leaved ironbark (*E. drepanophylla*) woodland with scattered *Macrozamia moorei*; eastern mid-height grass (*Themeda australis*, *Heteropogon contortus*)	VIIIt_{7-8}
2	40% Widespread	Steep rocky slopes 100–300 ft high; mainly bounding bluffs of benches; gradients up to 80%	Mainly shallow dark brown and grey-brown soils on carbonate, Gindie (Um6.21), minor areas of deeper soils, Cheshire (Um5.5); generally with large basalt boulders on surface	Bonewood scrub (*Macropteranthes leichhardtii*, *Geijera parviflora*, *Brachychiton rupestre*, *Carissa ovata*, *Heterodendrum diversifolium*); sparse scrub grass (*Paspalidium* spp., *Eragrostis megalosperma*)	VII–VIII t_{6-7}, r_5
3	35% Widespread	Irregular benches and linear valleys 10–100 yd wide; locally stony	Cracking, alkaline/acid clay soils on weathered materials, Rolleston (Ug5.15), and reddish brown alkaline clay soils, Glenora (Ug5.33), generally with large basalt boulders	Brigalow scrub, wilga midstorey (*Geijera parviflora*, *Eremophila mitchellii*), scrub grass (*Paspalidium* spp., *Chloris divaricata*)	VIIt_{6-7}, r_{4-5}
4	15% Widespread	Undulating foot slopes, largely colluvial; some gullying	Mainly cracking clay soils, May Downs (Ug5.16); minor areas of texture-contrast soils, Taurus (Db1.13), with thin sandy surface and strongly alkaline subsoils	Brigalow scrub with wilga midstorey and bonewood scrub and mixtures of the two; scrub grass	II–III k_{2-3}, e_2
5	5% Sporadic	Alluvial flats with narrow terraces and single meandering channel 20–30 ft deep	Cracking clay soils and uniform fine-textured soils, Vermont (Ug5.16) and Clematis (Uf6.33)	Fringing forest (*E. tereticornis*, *Casuarina cunninghamiana*, *Callistemon viminalis*) on channels; *E. melanophloia* grassy woodland with blue grass on flats	III–V w_{3-5}, k_{2-}[illegible]

* Similar to Bedourie land system in the Isaac–Comet area and Womblebank in the Dawson–Fitzroy area.

Kinsale Land System (590 sq miles)

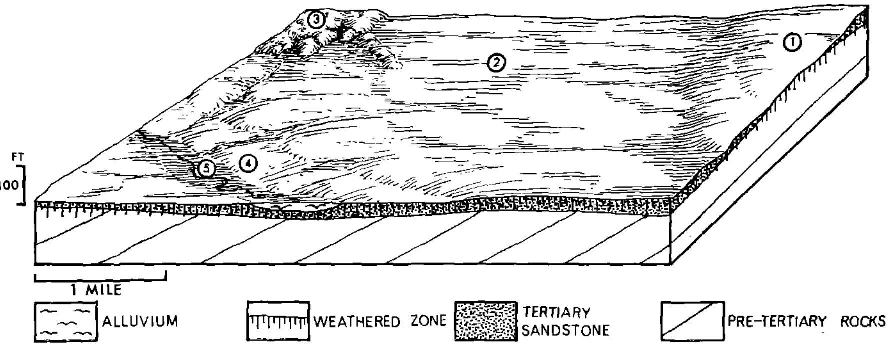
Brigalow scrub on rolling basalt country with cracking clay soils within the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	20% Confined to extreme north-east	Undulating country and low rises with occasional outcrops; minor patches of quartzose sand; slopes up to 4%	Moderately deep to deep, brown or reddish brown cracking clay soils, Glenora (Ug5.34), generally strongly alkaline below neutral surface soil; minor occurrences of shallow clay soils, Bruce (Ug5.12), and shallow rocky soils, Rugby (Um1.21)	Brigalow, rarely gidgee, scrub; softwood midstorey (*Eremophila mitchellii, Terminalia oblongata, Ehretia membranifolia, Citriobatus spinescens*); sparse scrub grass (*Paspalidium* spp., *Chloris acicularis*) with blue grass in open places. Occasional softwood scrub and scrub grass	II–IIIk_{2-3}, e_{2-3}
2	5% In Capella–Clermont area	As unit 1, but quartzose gravel more common		*E. orgadophila* grassy woodland (*E. orgadophila, E. dichromophloia*), occasional *E. melanophloia* grassy woodland; blue grass (*Dichanthium sericeum*) and eastern mid-height grass (*Bothriochloa ewartiana, Heteropogon contortus*)	II–IIIk_{2-3}, e_{2-3}
3	20% Widespread	Gently undulating country and plains; some colluvial clay aprons; occasional quartz or basalt gravel and secondary carbonate; slopes up to 2%	Deep cracking clay soils, May Downs (Ug5.14, 5.24), frequently with much carbonate at depth	Belah (*Casuarina cristata*, brigalow), occasionally brigalow scrub; *Terminalia oblongata* midstorey (*T. oblongata, Eremophila mitchellii, Carissa ovata*), sometimes extensive stands of *T. oblongata;* sparse scrub grass (*Paspalidium* spp.) and blue grass in open areas	II–III k_{2-3}, e_2
4	35% Widespread		Cracking clay soils, strongly alkaline surface soils over acid, mottled subsoils, Rolleston (Ug5.16, 5.34)	Brigalow scrub; *Terminalia oblongata* midstorey (*T. oblongata, Brachychiton rupestre, Eremophila mitchellii, Carissa ovata*); sparse scrub grass (*Paspalidium* spp., *Chloris acicularis*) with blue grass and eastern mid-height grass in open places	II–III k_{2-3},s_3,e_2
5	15% Widespread	Plains and lower slopes of gently undulating country; slopes up to 1%; as unit 3 of Oxford land system	Mainly deep cracking clay soils, May Downs (Ug5.18, 5.12), minor areas of shallower soils, Arcturus (Ug5.12)	Grassland, blue grass (*Dichanthium sericeum, Panicum* spp.), rarely eastern mid-height grass (*Bothriochloa ewartiana, Heteropogon contortus*); occasionally *E. orgadophila* grassy woodland with blue grass and eastern mid-height grass	IIk_2,e_2
6	5% Widespread	Alluvial clay flats; generally with shallow anastomosing channels; occasionally single deeper channels with distinct levees; flooded	No observations; probably cracking clay soils and uniform fine-textured alluvial soils	*E. microtheca* on channels, blue grass with groves of *Melaleuca bracteata*; rarely *E. populnea* grassy woodland and fringing forest with eastern mid-height grass	Vw_5,k_{2-3}

LENNOX LAND SYSTEM* (3720 SQ MILES)

Plains and lowlands with silver-leaved ironbark and yellow and red earths on intact Tertiary land surface.



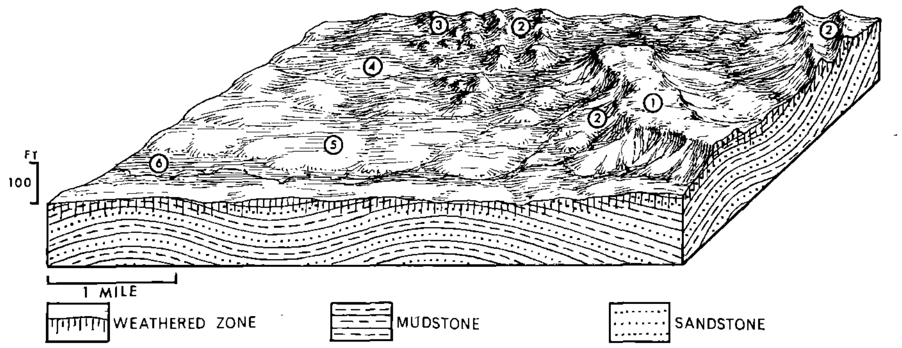
Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	15% In west	Rises and plains; level to gently undulating; slopes generally less than 2%; sandy surface with scattered ironstone gravel; patches of loose sand, possibly wind-blown	Mainly loamy red earths, Dunrobin (Gn2.12); extensive areas of loamy yellow earths, Struan (Gn2.22), sandy red and yellow earths, Annandale (Gn2.12, 1.12) and Forrester (Gn2.22, 1.22), and shallow red and yellow earths, Gregory (Gn2.12); minor deep uniform coarse-textured soils, Highmount (Uc1.23)	*E. polycarpa–E. papuana* woodland (rare *E. tessellaris*), arenicolous (*Lysicarpus angustifolius*, *Acacia cunninghamii*, *Callitris columellaris*), rarely argillicolous midstoreys (*Eremophila mitchellii*); eastern spinifex (*Triodia mitchellii*) and/or eastern mid-height grass (*Aristida* spp., *Cymbopogon bombycinus*)	IV–VI n_{3-4},m_3
2	65% Widespread	Plains; level to very gently undulating slopes generally less than 1½%; sandy or loamy surface subject to sheet erosion locally but mainly stable	Mainly loamy yellow earths, Struan (Gn2.22), extensive loamy red earths, Dunrobin (Gn2.12); minor areas of sandy red and yellow earths, Annandale (Gn2.12, 1.12) and Forrester (Gn2.22, 1.22)	*E. melanophloia* woodland; *Acacia coriacea* (*A. coriacea*, *A. tenuissima*), occasional argillicolous (*Eremophila mitchellii*, *Albizia basaltica*) or, in the south-west, arenicolous (*Callitris columellaris*) midstorey; eastern spinifex (*Triodia mitchellii*) and/or eastern mid-height grass (*Bothriochloa ewartiana*, *Aristida glumaris*). In the north-east narrow-leaved ironbark woodland (*E. drepanophylla*, *E. polycarpa*) and eastern mid-height grass, rarely eastern spinifex. Small areas of *Melaleuca tamariscina* scrub and treeless *Acacia leptostachya* community with eastern spinifex	V–VI† n_{3-4},m_3
3	5% Sporadic	Hills, scarps, incised valleys; generally not steep; small; local relief 10–100 ft; slopes up to 20%; occasional outcrop; sheet erosion and gullying	Shallow red and yellow earths, Gregory (Gn2.12, 2.11)	Low open *E. melanophloia* woodland, *Acacia coriacea* midstorey, and sparse eastern mid-height grass and eastern spinifex; lancewood scrub with arid scrub grass	VIIt$_6$,d$_4$, m_3
4	10% Widespread	Lowlands; gently undulating and usually below units 1 and 2; slopes up to 3%; some gullying	Mainly texture-contrast soils, Luxor (Dy3.42), Broadmeadow (Dy2.43), and Wyseby (Dr2.32); minor areas of loamy and sandy red and yellow earths, Struan (Gn2.22), Annandale (Gn2.12), and Forrester (Gn1.22)	*E. populnea* woodland; argillicolous midstorey (*Eremophila mitchellii*, *Ventilago viminalis*, *Carissa ovata*, occasional brigalow) sometimes well developed, sometimes absent; eastern mid-height grass (*Bothriochloa ewartiana*, *Aristida* spp., *Chloris acicularis*), occasional eastern spinifex	IV–VI p_{3-4},s_{2-3}, e_{2-3}
5	5% Widespread	Alluvial flats; up to ½ mile wide; associated alluvial terraces, minor fans, and meandering channels 3–8 ft deep	Mainly texture-contrast soils, Luxor (Dy2.22), Retro (Dd1.13), and Broadmeadow (Dy3.43); extensive loamy red earths, Wilpeena (Gn2.12), minor alluvial soils	Fringing forest and woodland (*E. tereticornis*, *E. microtheca*, *Melaleuca* spp.); *E. populnea* woodland and eastern mid-height grass; minor *E. microtheca* woodland, brigalow, and gidgee scrubs	IV–VI p_{3-4},s_{2-3}, e_{2-3}

* In the north-east this land system is similar to Junee land system in the Isaac–Comet area and Kaiuroo in the Dawson–Fitzroy area.

† The average annual rainfall over the greater part of this land system is less than 22 in. and the land capability class has been downgraded accordingly.

LOUDON LAND SYSTEM (1440 SQ MILES)

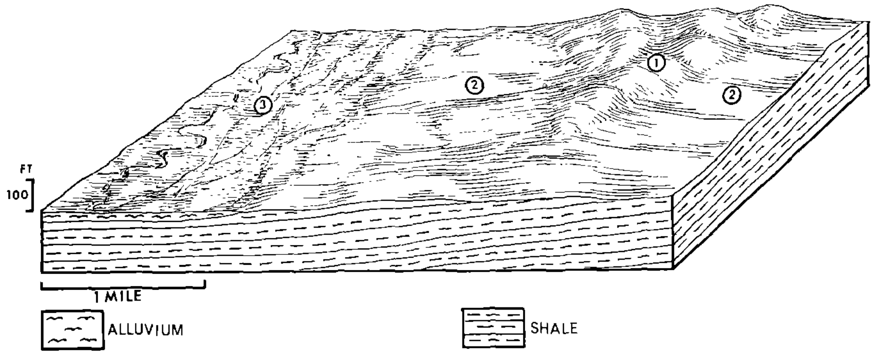
Low hills with lancewood and some ironbark on weathered volcanics and Drummond Basin sediments plus intervening lowlands with box, brigalow, and blackwood; shallow rocky soils.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	10% Widespread	Small lateritic mesa tops; level to undulating with stripped margins	Loamy and sandy red earths, Dunrobin (Gn2.12) and Annandale (Gn2.11), shallow near margins, Gregory (Gn2.22)	*E. melanophloia* woodland with *Acacia coriacea* midstorey, occasional *E. polycarpa–E. papuana* woodland, *Melaleuca tamariscina* scrub, and treeless *Acacia leptostachya* community; sparse eastern mid-height grass and eastern spinifex	IV–VI n_{3-4}, m_3, e_3
2	50% Widespread	Breakaways, rocky hills, and steep strike ridges; local relief 10–150 ft, usually 30–50 ft; rocky; frequent silicified beds; rapid sheet and gully erosion	Mainly shallow rocky soils, Rugby (Um1.2) and Shotover (Uc1.2); minor areas of red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.21)	Bendee and lancewood scrubs with sparse arid scrub grass (*Cleistochloa subjuncea*); occasional narrow-leaved ironbark woodland (*E. drepanophylla, E. citriodora*) with eastern mid-height grass (*Aristida* spp.)	VIIt_{6-7}, r_5
3	<5% North-east of Mt. Coolon	Low hills on volcanic rocks; extremely rocky	Shallow rocky soils, Shotover (Uc1.2)	Low *E. melanophloia* and narrow-leaved ironbark (*E. drepanophylla*) woodlands; eastern mid-height grass and eastern spinifex	VIIt_{6-7}, r_5
4	25% Widespread	Undulating lowlands, middle slopes below unit 2 and colluvial fans; some gullying	Shallow and moderately deep texture-contrast soils, Southernwood (Dr3.12, Db1.43), Luxor (Dy2.22, 3.41), and Broadmeadow (Dg3.81), commonly with columnar structure	*E. normantonensis* woodland with eastern spinifex and eastern mid-height grass (*Aristida* spp., *Cymbopogon bombycinus*); *E. populnea* woodland sometimes with argillicolous midstorey (*Eremophila mitchellii*) and eastern mid-height grass (*Bothriochloa ewartiana*), rarely eastern spinifex; some narrow-leaved ironbark (*E. drepanophylla*) woodland	IV–VI p_{3-4}, d_4, s_3
5	10% Widespread	Lowlands, depressions, and lower slopes below unit 4; patches of gravelly weathered clay	Mainly shallow and deep texture-contrast soils, Southernwood (Dr2.12) and Wyseby (Dy3.32); minor shallow rocky soils, Rugby and Shotover	Brigalow (blackwood in north), *E. thozetiana*–brigalow, *E. cambageana*–brigalow scrubs, rarely *E. cambageana* and *E. thozetiana* woodlands, all with *Eremophila mitchellii* midstorey; mosaic of eastern mid-height grass and scrub grass	IV–VI p_{3-4}, d_4
6	5% Widespread	Alluvial flats; single channels 5–15 ft deep; not flooded	No observations; probably texture-contrast soils mainly	*E. populnea* woodland with argillicolous (*Eremophila mitchellii, Carissa ovata*) or no midstorey; brigalow scrub with *Eremophila mitchellii* midstorey; eastern mid-height grass and scrub grass; fringing woodland (*E. tereticornis*) on channels	IVp_{3-4}

MANTUAN LAND SYSTEM (280 SQ MILES)

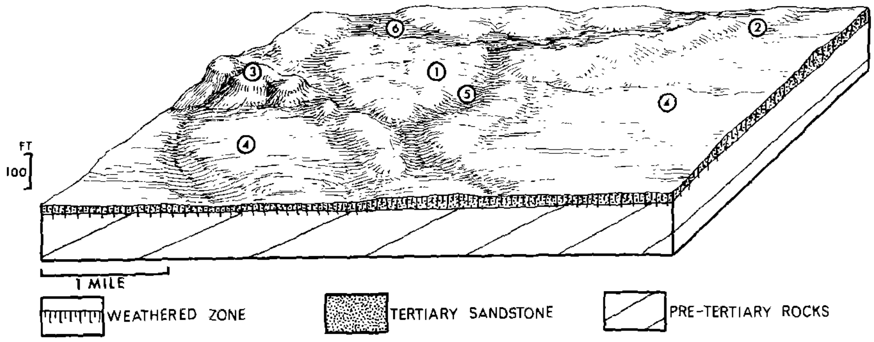
Grassland and cracking clay soils on Permian shale exposed below the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	20% Widespread	Rises; rolling hill crests and upper slopes; local relief 50–100 ft; slopes 2–8%; mainly clay but occasional outcrops	Sedentary, dark, self-mulching, cracking clay soils, Teviot (Ug5.12, 5.14), strongly alkaline and somewhat shallower than in unit 2; minor areas of dark brown and grey-brown soils, Gindie (Uf6.12)	*E. melanophloia*, occasionally *E. orgadophila*, rarely *E. populnea* woodlands; blue grass (*Dichanthium sericeum*, *Panicum* spp.), eastern mid-height grass (*Bothriochloa ewartiana*, *Heteropogon contortus* on upper slopes)	II–III k_{2-3}, e_{2-3}
2	50% Widespread	Lowlands; gently rolling downs; local relief 10–60 ft; slopes 0·5–5%; stone-free clay	Sedentary, dark, self-mulching, cracking clay soils, Teviot (Ug5.15, 5.14), strongly alkaline, with linear gilgai in places	Grassland; blue grass (*Dichanthium sericeum*, *Thellungia advena*, *Panicum decompositum*) occasionally eastern mid-height grass (*Bothriochloa decipiens*, *B. ewartiana*)	II–III e_{2-3}, k_{2-3}
3	30% Widespread	Alluvial clay flats; mainly level but some levees and back swamps; up to 2 miles wide; single channels 10–30 ft deep; not flooded	Dark grey-brown, alkaline cracking clay soils on basaltic alluvium, Vermont (Ug5.16)	Fringing community (*E. tereticornis*, *Callistemon viminalis*) on channels; usually grassland (as unit 2), some *E. microtheca* woodlands and *E. populnea* woodland with sparse blue grass, rarely eastern mid-height grass	IIk_2

Monteagle Land System (1710 sq miles)

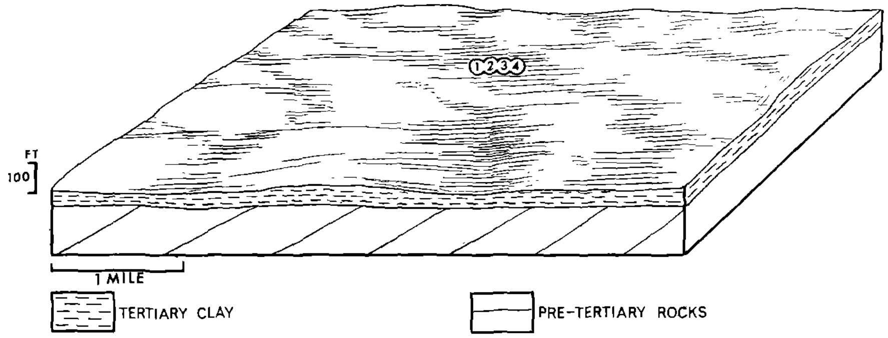
Lowlands with box and texture-contrast soils on slightly stripped Tertiary land surface.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	10% Widespread	Interfluves, rises; undulating; up to 1 mile across; slopes up to 3%; occasionally rocky but generally sandy or loamy	Mainly loamy red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.22); minor areas of shallow red and yellow earths, Gregory (Gn2.12)	*E. melanophloia* woodland; *Acacia coriacea* (*A. coriacea*, *A. tenuissima*), arenicolous (*Alphitonia excelsa*), or no midstorey; eastern mid-height grass (*Heteropogon contortus*, *Bothriochloa ewartiana*, *Aristida* spp.)	IVn_{3-4}, m_3
2	10% Sporadic	Plains; level to gently undulating; up to 1 mile across; loose sandy surface	Loamy red earths, Dunrobin (Gn2.12); minor areas of uniform coarse-textured soils, Petrona (Uc1.23) and Highmount (Uc1.23), underlain by laterite or mottled zone	*E. polycarpa*–*E. papuana* or narrow-leaved ironbark (*E. drepanophylla*) woodlands, eastern mid-height grass (*Aristida* spp., *Heteropogon contortus*); rarely on loose sand *E. melanophloia* woodland (*E. melanophloia*, *Angophora costata*) with sandstone spinifex or arid scrub grass	IVn_{3-4}, m_3
3	5% Sporadic	Breakaways, knolls; broken and stony; up to 50 ft high; sheet erosion and gullying	Mainly shallow rocky soils, Rugby (Um1.2) and Shotover (Uc1.2); minor areas of red and yellow earths, Dunrobin (Gn2.12) and Gregory (Gn2.12); shallow texture-contrast soils on rubbly lower slopes, Southernwood (Dy2.32) and Medway (Db1.33)	Lancewood bendee scrub with sparse arid scrub grass (*Cleistochloa subjuncea*); occasional *E. thozetiana* woodland with argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*) and scrub grass (*Ancistrachne uncinulata*)	$VIIt_{6-7}$, r_5
4	60% Widespread	Plains, colluvial foot slopes, lowlands, occasional low hills; level to undulating; local relief up to 10 ft, occasionally up to 80 ft; slopes up to 2%, occasionally to 10%; stony in part; some gullying; includes minor sandy fans and old alluvial terraces	A wide range of deep texture-contrast soils, mainly Luxor (Dy3.22, Db2.22) and Springwood (Dy2.32, Dr2.12), on upper slopes, Retro (Db1.13, Dy3.43) on lower slopes; some Broadmeadow (Dy2.23) and Taurus (Db1.13, Dy3.43); shallow texture-contrast soils commonly with columnar structure extensive in north, Medway (Db1.43, Dr2.13)	*E. populnea* woodland; argillicolous midstorey (*Eremophila mitchellii*, *Acacia excelsa*, *Ventilago viminalis*) occasionally without tree stratum, occasional arenicolous (*Acacia cunninghamii*, *Casuarina luehmannii*), rarely no midstorey; eastern mid-height grass (*Bothriochloa ewartiana*, *B. decipiens*, *Aristida ramosa*, *Heteropogon contortus*) or occasionally scrub grass or arid scrub grass; *E. normantonensis* woodland with eastern spinifex (*Triodia mitchellii*) occurs in the north	IVp_{3-4}, s_{2-3}, e_{2-3}
5	10% Widespread	Depressions, lowlands; level; weathered clay	Mainly texture-contrast soils with thin loamy surface soils, Wyseby (Db1.32) and Retro (Db1.33, Dy3.43); minor areas of cracking clay soils, Rolleston (Ug5.24)	*E. cambageana*–brigalow, brigalow, gidgee, or rarely *E. populnea*–brigalow scrubs; *Eremophila mitchellii* (*E. mitchellii*, *Carissa ovata*), rare *Terminalia oblongata* midstorey (*T. oblongata*, *Heterodendrum diversifolium*); scrub grass (*Ancistrachne uncinulata*, *Paspalidium* spp.) or eastern mid-height grass (*Bothriochloa ewartiana*) in open places	IVp_{3-4}, s_{2-3}
6	5% Widespread	Alluvial flats; up to ½ mile wide; not extensively flooded; minor poorly defined anastomosing channels or single, deep channel	Mainly texture-contrast soils, Luxor (Dy3.42) and Broadmeadow (Dr2.23); minor areas of recent alluvial soils	Fringing forest (*E. tereticornis*, *Melaleuca* spp., *E. tessellaris*); *E. populnea*, rare *E. melanophloia* woodlands with eastern mid-height grass; rare brigalow scrub with *Eremophila mitchellii* midstorey and scrub grass	IVp_{3-4}, s_{2-3}

MORAY LAND SYSTEM (400 SQ MILES)

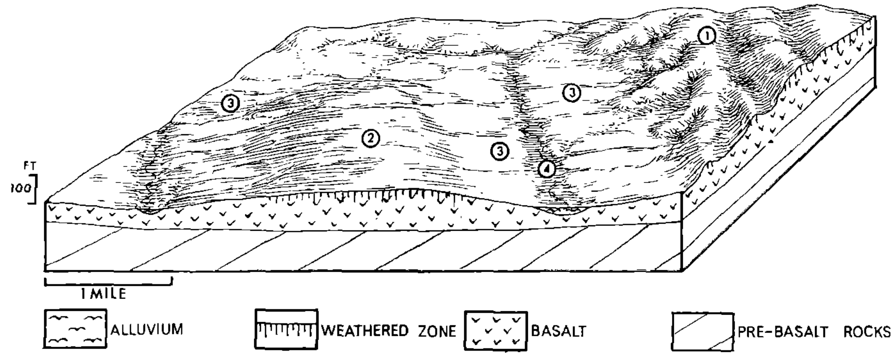
Plains and lowlands with gidgee and cracking clay soils on alkaline clay deposited within the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	70% Widespread	Clay plains and gently undulating lowlands; slopes less than 1%; occasional patches of sand and minor quartz gravel	Very deep cracking self-mulching clay soils on weathered materials, mainly alkaline throughout, Natal (Ug5.24, 5.34); some alkaline/acid, gypseous, clay soils, Logan (Ug5.34, 5.16); prominent red and grey mottling in subsoils	Mostly gidgee scrub, some brigalow scrub often with a high proportion of gidgee; both with *Terminalia oblongata* midstorey community (*T. oblongata, Ehretia membranifolia, Eremophila mitchellii, Carissa ovata*); scrub grass (*Paspalidium* spp., *Chloris divaricata*), rarely blue grass and eastern mid-height grass in open places	$IIIk_{2-3}$, s_3
2	15% Widespread			Usually *Terminalia oblongata* midstorey without tree layer, rarely low brigalow with *T. oblongata* midstorey and stands of *Bauhinia carronii*; sparse blue grass (*Dichanthium sericeum*)	$IIIk_{2-3}$, s_3
3	10% Widespread		As unit 1 but alkaline/acid clay soils, Logan (Ug5.16), more extensive	Grassland, blue grass (*Dichanthium sericeum, Thellungia advena*)	$IIIk_{2-3}$, s_3
4	5% Avon Downs area	As unit 1, but poorly drained	Very deep cracking self-mulching clay soils, Logan (Ug5.24); prominent red and grey mottling below 3 ft	*E. microtheca* grassy woodland; blue grass (*Thellungia advena, Astrebla* spp.)	III–IV k_{3-4}, w_{3-4}

OXFORD LAND SYSTEM (1450 SQ MILES)

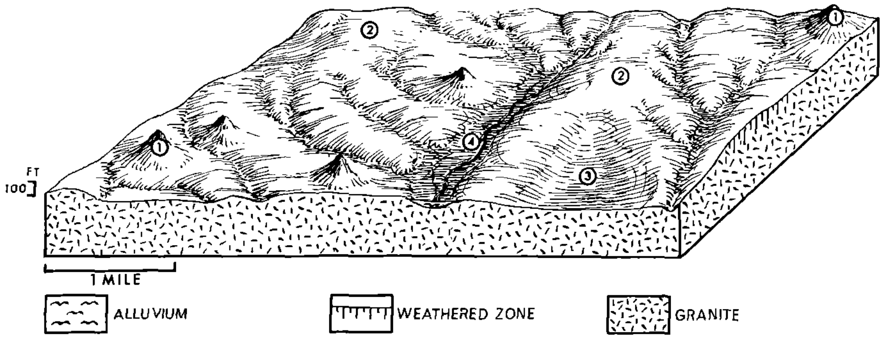
Undulating grassland and cracking clay soils on fresh basalt exposed below the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	20% Widespread	Low rises, ridge crests, and valley sides; slopes up to 6%; minor outcrops common	Brown to reddish brown cracking clay soils, Glenora (Ug5.34, 5.37); minor shallow clay soils, Bruce (Ug5.12, 5.14), near outcrops	*E. orgadophila* grassy woodland (*E. orgadophila*, *E. dichromophloia*); blue grass (*Dichanthium sericeum*) and eastern mid-height grass (*Bothriochloa ewartiana*, *Heteropogon contortus*)	II–III e_{2-3}, k_{2-3}
2	20% Mainly around Emerald	Broad, gently undulating to level interfluves and plains; slopes less than 2%	Cracking, self-mulching clay soils, Arcturus (Ug5.12), moderately shallow	Grassland, blue grass (*Dichanthium sericeum*, *Panicum decompositum*, *P. queenslandicum*, *Heteropogon contortus*, *Aristida leptopoda*, occasional *A. latifolia*, *Ophiuros exaltatus*); scattered *E. orgadophila*, *E. terminalis*, *E. dichromophloia*	II–III d_3, k_{2-3}, e_2
3	55% East and north of Clermont	Gentle middle and lower slopes, largely colluvial; slopes up to 2%; occasional gullies	Mainly deep, self-mulching clay soils, May Downs (Ug5.16, 5.12); minor areas of moderately shallow or reddish brown clay soils, Arcturus (Ug5.12) and Glenora (Ug5.37)	Grassland, blue grass (*Dichanthium sericeum*, *Aristida leptopoda*, occasional *Ophiuros exaltatus*, *Thellungia advena*, *Panicum queenslandicum*, *Enneapogon flavescens*, *Bothriochloa decipiens*), rarely eastern mid-height grass (*Bothriochloa ewartiana*, *Heteropogon contortus*); occasionally *E. orgadophila* woodland with blue grass and eastern mid-height grass	IIe_2, k_2
4	5% Widespread	Narrow alluvial clay flats; single or braided channels 3–10 ft deep; probably subject to flooding	Cracking clay soils on basaltic alluvium, Vermont (Ug5.15)	*E. microtheca* on channels, groves of *Melaleuca bracteata* and *Acacia pendula*, blue grass	III–V w_{3-5}

Peak Vale Land System (650 sq miles)

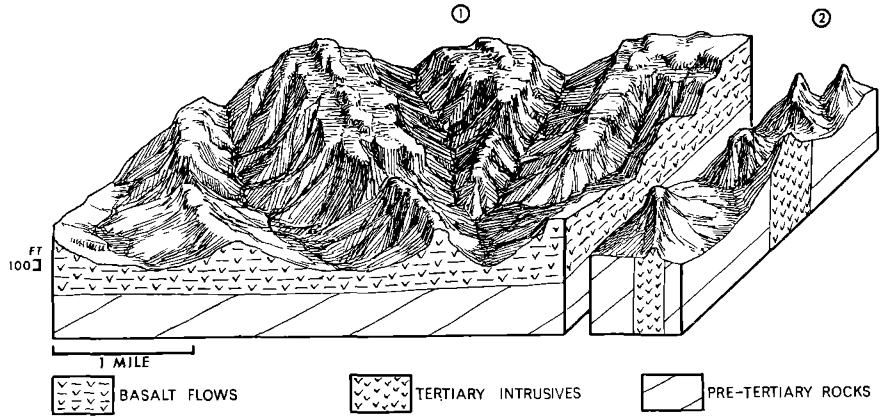
Undulating country with silver-leaved ironbark and texture-contrast soils on granite exposed below the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% Sporadic, absent in north	Basalt cones and granite tors; steep, rugged, isolated rocky hills 20–1000 ft high; slopes up to 100%; minor gravelly clay aprons	Mainly shallow rocky soils, Rugby (Um1) and Shotover (Uc1), with extensive outcrop; minor areas of shallow texture-contrast soils, Southernwood (Dr2.12), near tors and cracking clay soils at base of cones, Arcturus (Ug5.12)	On basalt cones: *E. orgadophila* woodland and eastern mid-height grass (*Themeda australis*), depauperate softwood scrub (*Brachychiton australe*), narrow-leaved ironbark (*E. drepanophylla*), and eastern mid-height grass on lower slopes. *E. orgadophila* woodland on aprons. On tors: *E. drepanophylla* woodland and depauperate softwood scrub	VII–VIII t_{6-8}, r_5, d_5
2	80% Widespread	Rolling country and low hills; broad undulating interfluves up to a mile wide; slopes up to 10%; fairly narrow dendritic valleys 30–150 ft deep and with slopes up to 20%; surficial quartz gravel common; sheet erosion and gullying in steeper slopes	Mainly deep texture-contrast soils, generally with thin sandy or loamy surface and red neutral to strongly alkaline subsoils, Wyseby (Dr2.12) and Taurus (Dr2.13); shallow and more sandy soils on ridge crests, Southernwood (Dr2.12) and Broadmeadow (Dy2.43)	*E. melanophloia* woodland (*E. melanophloia*, *E. dichromophloia*); eastern mid-height grass (*Bothriochloa ewartiana*, *Heteropogon contortus*, *Aristida glumaris*)	IVe$_{3-4}$, p_{3-4}
3	10% Sporadic	Lowlands; gently undulating; up to 1 mile across; gravelly Tertiary clay and weathered granite; also a few broad interfluves on weathered granite with much secondary carbonate	Texture-contrast soils, Retro (Db1.13), and cracking clay soils, Rolleston (Ug5.24)	Brigalow scrub, with *Eremophila mitchellii* and *Terminalia oblongata* midstorey, rarely *T. oblongata* community alone; scrub grass (*Paspalidium* spp.); *E. populnea* woodland with argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*) and eastern mid-height grass	IVp$_{3-4}$, s_3 k_{2-3}
4	5% Widespread	Alluvial flats; narrow with distinct levees; rather sandy; single channels up to 15 ft deep	No observations; probably texture-contrast soils mainly	Fringing forest (*Melaleuca bracteata*, *Callistemon viminalis* on small channels, *E. tereticornis*, *Casuarina cunninghamiana* as well, on larger); *E. populnea* woodland and eastern mid-height grass; limited frontage woodland (*E. polycarpa*) and frontage grass	IVp$_{3-4}$

Percy Land System (340 sq miles)

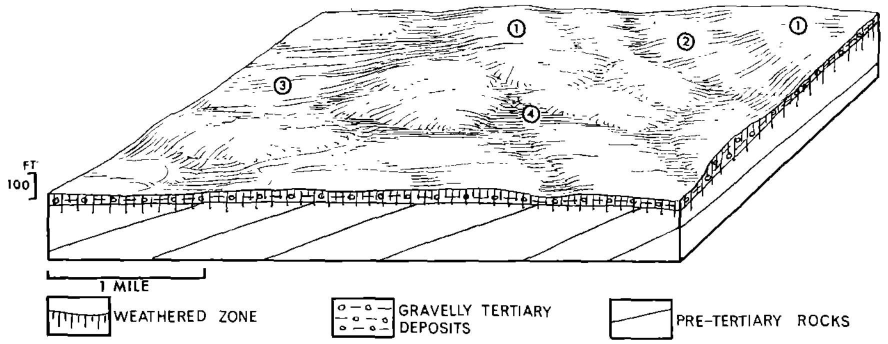
Mountains with narrow-leaved ironbark woodland and shallow rocky soils on unweathered basalt and Tertiary volcanics.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	90% South of Emerald	Basalt mountains; steep, benched and cliffed slopes; local relief 500–2000 ft; slopes up to vertical but generally around 60%; much outcrop; also undulating rocky summits and deep fairly narrow valleys with limited alluvial flats and bouldery terraces	Shallow rocky soils, Rugby (Um1.21); minor areas of dark brown and grey-brown soils, Cheshire (Um5.5)	*E. melanophloia*, *E. drepanophylla*, and *E. dichromophloia* woodlands, scattered *Macrozamia moorei*, eastern mid-height grass (*Themeda australis*, *Bothriochloa ewartiana*, *Heteropogon contortus*), rare softwood scrub (*Brachychiton rupestre*, *Geijera parviflora*, *Denhamia obscura*)	VII–VIII t_{7-8}, r_5, d_5
2	10% Peak Range	Volcanic plugs; very steep isolated mountains up to 1000 ft high; much bare rock	Shallow rocky soils, Rugby (Um1.2)	Narrow-leaved ironbark woodland (*E. drepanophylla*, *E. citriodora*), arenicolous midstorey (*Acacia bancroftii*)	VII–VIII t_{7-8}, r_5, d_5

PINEHILL LAND SYSTEM (420 SQ MILES)

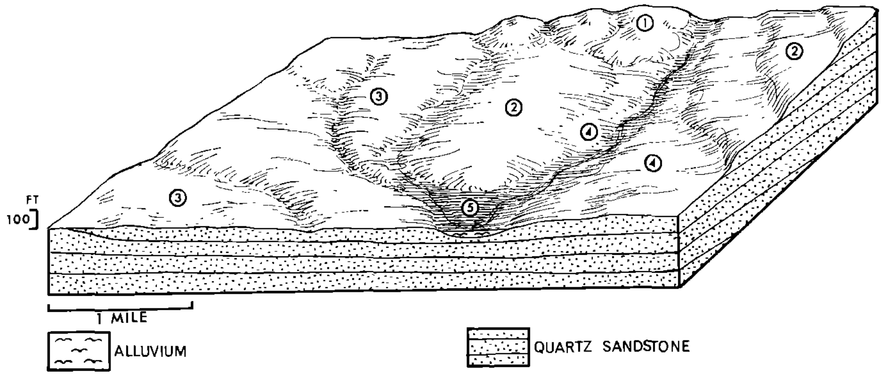
Lowlands with box and shrubs and texture-contrast soils on slightly stripped gravelly Tertiary land surface.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	25% Widespread	Interfluves, rises, plains; undulating to level; up to 5 miles across; slopes up to 4%; sandy or gravelly as a rule; minor occurrences of steeper rockier country	Loamy red earths, Dunrobin (Gn2.12)	*E. populnea* woodland, occasional *E. melanophloia* and *E. polycarpa–E. papuana* woodland; the first two with dense argillicolous midstorey (*Ventilago viminalis, Albizia basaltica, Heterodendrum oleifolium, Eremophila mitchellii, Geijera parviflora*) sometimes occurring without upper stratum; sparse eastern mid-height grass (*Bothriochloa ewartiana, Aristida* spp.), occasional scrub grass (*Ancistrachne uncinulata, Paspalidium* spp.)	IVn_{3-4},m_3
2	65% Widespread	Mid slopes, plains; usually slightly below unit 1; undulating to level; up to 3 miles across; slopes up to 4%; often sandy or gravelly surface	Deep texture-contrast soils, mainly with thick sandy surface horizons on neutral or strongly alkaline subsoils, Luxor (Dy3.22) and Broadmeadow (Db1.33); some loamy surface soils on strongly alkaline subsoils, Retro (Dr3.33)	As unit 1 except that *E. melanophloia* and *E. polycarpa–E. papuana* woodlands are absent and brigalow is prominent in argillicolous midstorey	IVp_{3-4}, s_{2-3},e_{2-3}
3	10% Sporadic	Depressions, lowlands; level to gently undulating; slopes up to 2%; weathered clay	Texture-contrast soils, Taurus (Dy2.23) and Retro (Db1.23, Dd1.13)	*E. cambageana*-brigalow, brigalow, and gidgee scrubs, usually *Eremophila mitchellii* midstorey (*E. mitchellii, Carissa ovata*) with scrub grass (*Paspalidium* spp., *Chloris divaricata*) or eastern mid-height grass (*Bothriochloa ewartiana, Cymbopogon refractus*) in places	IVp_{3-4}, s_3,e_2
4	<5% Sporadic	Alluvial flats; mainly clay; flooded; minor levees; single channels	No observations; probably texture-contrast soils mainly	Fringing forest (*E. tereticornis, E. microtheca*) on channels; *E. populnea* with eastern mid-height grass (*Bothriochloa decipiens, Aristida glumaris*), small areas of *E. microtheca* woodland, brigalow and gidgee scrubs	IV–Vw_{4-5}

Playfair Land System (330 sq miles)

Sandy lowlands with ironbark and cypress pine on uniform coarse-textured soils mainly on little-weathered quartz sandstone.

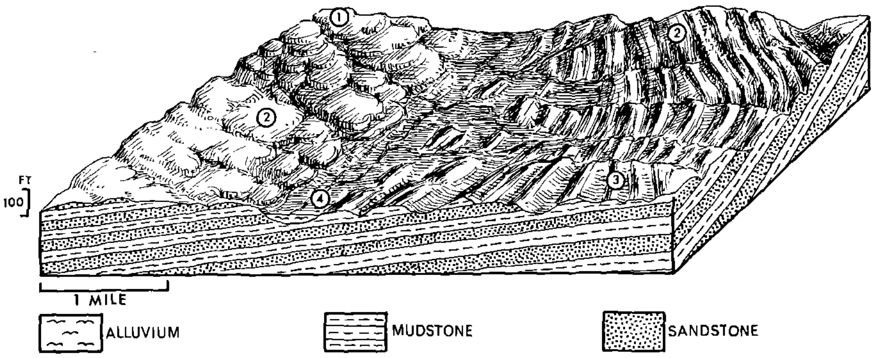


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% Sporadic	Low rises and breakaways; usually stony with much outcrop	Mainly shallow rocky soils, Shotover (Uc1.2); minor areas of red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.21)	Lancewood and bendee scrubs; arid scrub grass (*Aristida caput-medusae*, *Cleistochloa subjuncea*), *Tripogon loliiformis* community, and bare ground	VII–VIII t_{7-8}, r_5, d_5
2	45% Mt. Gregory area in the north	Low sandstone ridges and surrounding sandy aprons; local relief 20–50 ft; slopes generally 1–5% but locally up to 25%; sandy surface but with outcrop on steeper portions	Mainly shallow, uniform coarse-textured soils, Petrona (Uc1.21, 4.12), minor areas of deep soils, Highmount (Uc1.21, Uc2)	Mainly narrow-leaved ironbark woodland (*E. drepanophylla*, *E. citriodora*), open arenicolous midstorey (*Acacia cunninghamii*); occasional *E. polycarpa*–*E. papuana* woodland, arenicolous, or rarely (near Mt. Gregory) *Melaleuca nervosa*, midstorey; rarely frontage woodland (*E. polycarpa*, *E. dealbata*) and arenicolous midstorey on deep sand; eastern mid-height grass (*Aristida* spp.), but eastern spinifex (near Mt. Gregory) and frontage grass with frontage woodland	VII–VIII t_{7-8}, r_5, d_5
3	30% Widespread but especially in extreme south	Plains and lowlands; local relief 10–30 ft; sandy surface; minor sheet erosion and gullying on steeper slopes	Mainly shallow, uniform coarse-textured soils, Petrona (Uc4.12, 1.21), but extensive areas of deep soils in places, Highmount (Uc1.21, 4.12)	*Callitris columellaris* scrub and *E. melanophloia* woodland with arenicolous midstorey (*Callitris columellaris*, *Acacia cunninghamii*); usually sparse eastern mid-height grass (*Aristida* spp., *Eulalia fulva*, *Heteropogon contortus*), occasionally arid scrub grass (*Aristida caput-medusae*), rarely sandstone spinifex	VI*n_4, m_3, e_3
4	15% Sporadic	Lower slopes of units 2 and 3; undulating to level	Mainly texture-contrast soils with thick sandy surface horizons and acid to neutral subsoils, Luxor (Dy3.42, Dy3.22, Dr2.21); minor areas of sandy yellow earths, Forrester (Gn2.82)	*E. populnea* woodland, arenicolous midstorey (*Callitris columellaris*, *Acacia cunninghamii*), occasionally *E. cambageana*–*E. thozetiana*–brigalow and brigalow scrubs, rarely *E. cambageana* woodland with arenicolous midstorey (*Acacia sparsiflora*); eastern mid-height grass (*Aristida* spp., *Heteropogon contortus*), but scrub grass (*Paspalidium* spp.) beneath brigalow	IVp_{3-4}, e_3
5	5% Widespread	Alluvial flats; occasionally up to ½ mile wide; well-marked levees; single channels 3–10 ft deep	Uniform coarse-textured soils, Davy (Uc1.23), on levees; texture-contrast soils, Luxor (Dy3.42), on flats	Fringing forest (*E. tereticornis*, *Melaleuca* spp.) on channels; *E. populnea* woodland with eastern mid-height grass (*Bothriochloa decipiens*. *Aristida glumaris*) and frontage woodland (*E. polycarpa*, *E. tessellaris*) with frontage grass (*Heteropogon contortus*)	IVp_{3-4}

* Land class downgraded on account of low rainfall in south-west of area.

PORTWINE LAND SYSTEM (720 SQ MILES)

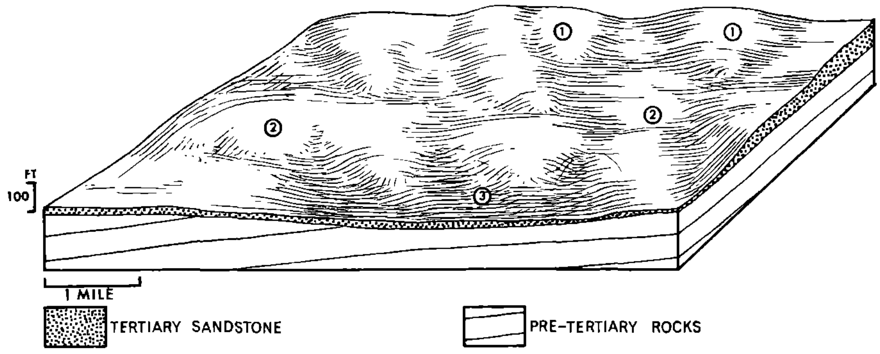
Stony hills with ironbark in groves and texture-contrast soils on Drummond Basin sediments below the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	10% Widespread	Stony hills, cuestas, and strike ridges up to 200 ft high	Mainly shallow rocky soils and shallow texture-contrast soils; minor areas of deeper soils, Luxor (Dy2.22)	Narrow-leaved ironbark woodland (*E. drepanophylla*, *E. polycarpa* sometimes prominent); arenicolous midstorey (*Acacia cunninghamii*); eastern mid-height grass (*Cymbopogon refractus*, *Aristida glumaris*, *Bothriochloa ewartiana*)	$VIIt_7$, r_5
2	65% Widespread	Low hills, strike ridges, and cuestas; intervening lowland pockets; occasional gravel patches; slopes up to 25%; local relief 30–150 ft; gullying and sheet erosion	Mainly shallow texture-contrast soils, Southernwood (Db1.12, Dr2.12) and Medway (Dd1.33, Dy2.43); some moderately deep soils, Luxor (Dy2.32), Broadmeadow (Dy3.23), Springwood (Dy2.23), and Taurus (Dr2.13); minor belts of cracking clay soils, generally shallow, Bruce (Ug5.12) and Teviot (Ug5.22)	*E. melanophloia* woodland, grassy or with argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*, and *Albizia basaltica*); some *E. orgadophila* woodland with argillicolous midstorey; eastern mid-height grass (*Bothriochloa ewartiana*, *B. decipiens*, *Themeda australis*, *Aristida* spp.) woodland often groved with treeless intergroves	IV–VI t_6, e_4, d_4
3	20% Widespread	As unit 2 but rather less relief	Moderately deep texture-contrast soils, Taurus (Dy2.23, Dd1.33), thin sandy surface and strongly alkaline subsoils	*E. melanophloia* woodland with argillicolous midstorey (as unit 1); brigalow, *E. populnea*–brigalow, rarely *E. cambageana*–brigalow scrubs, all with *Eremophila mitchellii* midstorey; eastern mid-height grass (*Bothriochloa decipiens*, *B. ewartiana*, *Cymbopogon refractus*) and scrub grass where upper strata dense	IVp_{3-4}, s_3, e_3
4	5% Widespread	Narrow alluvial flats; levees; channels 3–10 ft deep	One observation—cracking clay soil, Vermont (Ug5.34); probably texture-contrast soils mainly	Fringing forest (*E. tereticornis*, *E. tessellaris*, *Casuarina cunninghamiana*) on channels; *E. populnea* woodland sometimes with argillicolous midstorey, eastern mid-height grass; occasional brigalow scrub with scrub grass	IVw_{3-4}, p_{3-4}

RONLOW LAND SYSTEM (770 SQ MILES)

Plains and gently undulating sandy or loamy country with yellowjack and red and yellow earths on intact Tertiary land surface.

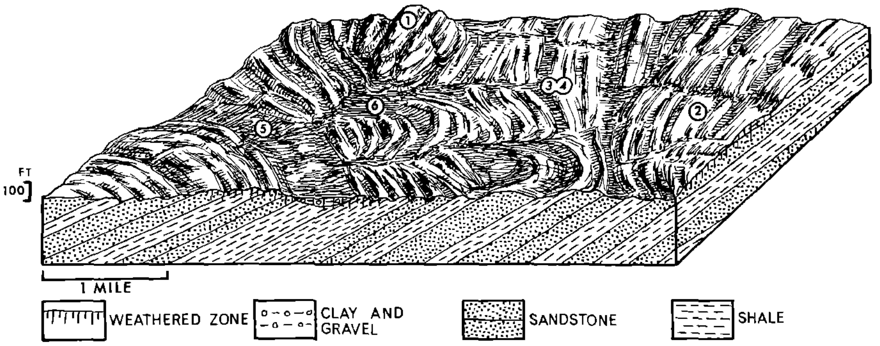


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	70% Widespread	Plains and uplands; very gently undulating; up to 4 miles across; slopes less than 1½%	Mainly loamy red earths, Dunrobin (Gn2.12); sandy red earths, Annandale (Gn2.12, 1.12), extensive in places	Groved *E. similis* woodland, *Acacia leptostachya* midstorey (*A. leptostachya*, *Petalostigma banksii*, *Gastrolobium grandiflorum*) beneath trees, eastern spinifex (*Triodia mitchellii*) alternating with eastern mid-height grass (*Themeda australis*, *Cymbopogon bombycinus*)	VI*n_{3-4}, m_{2-3}
2	20% Widespread	Rises; undulating; up to 1 mile across; local relief 5–50 ft; slopes up to 3%; sheet erosion	Loamy yellow earths, Struan (Gn2.22, 2.62), commonly with mottling and concretionary ironstone in subsoils	*E. melanophloia* woodland, *Acacia coriacea* midstorey (*A. coriacea*, *A. tenuissima*, *A. laccata*), alternating eastern spinifex (*Triodia mitchellii*) and eastern mid-height grass (*Themeda australis*, *Bothriochloa ewartiana*); some *Melaleuca tamariscina* scrub and treeless *Acacia leptostachya* community (*A. leptostachya*, *Melaleuca uncinata*). Sporadic lancewood scrub and *E. normantonensis* woodland	VI*n_{3-4}, m_{2-3}
3	10% Widespread	Plains and lowlands; undulating; slopes less than 2%; minor clay-floored depressions up to 1 mile across	Mainly red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.22); minor very shallow coarse-textured soils, Shotover (Uc1), and cracking clay soils, Vermont (Ug5.24), in depressions, commonly with boulders of massive laterite	*E. melanophloia* woodland with *Acacia coriacea* midstorey or narrow-leaved ironbark (*E. drepanophylla*) woodland without midstorey, alternating eastern spinifex and eastern mid-height grass. *E. tereticornis* woodland in flooded depressions	VI*n_{3-4}, m_{2-3}

* Downgraded on account of low rainfall.

RUTLAND LAND SYSTEM (1250 SQ MILES)

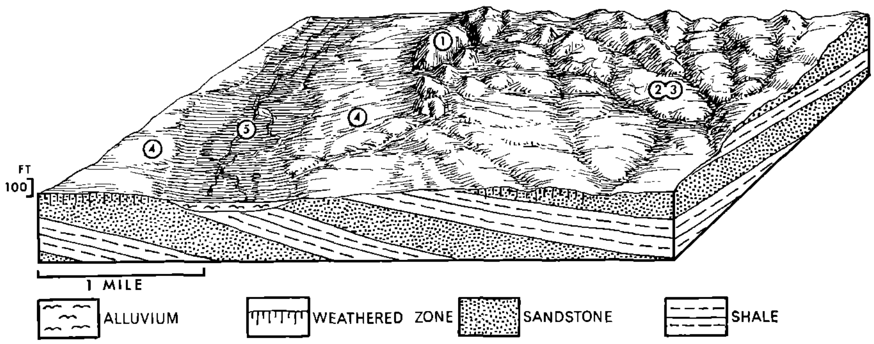
Lowlands and low hills with groved brigalow and ironbark and texture-contrast soils on both weathered and fresh Drummond Basin sediments.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	10% In centre of area	Strike ridges and hills up to 150 ft high; stony with frequent outcrops; slopes 10–30%; gullying and sheet erosion	Mainly shallow texture-contrast soils, Southernwood (Dr2.12); extensive shallow rocky soils, Rugby and Shotover (Um1.2 and Uc1.2)	*E. melanophloia* woodland, sometimes with open argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*), occasional narrow-leaved ironbark (*E. drepanophylla*) woodland with arenicolous midstorey (*Petalostigma pubescens*); eastern mid-height grass (*Bothriochloa ewartiana*, *Aristida* spp.)	VIt_6, e_4, d_4
2	10% Widespread	Low strike ridges and hills up to 100 ft high; slopes up to 15%; locally gravelly; gullying and sheet erosion	Complex distribution governed mainly by lithology and strike of folded parent rocks. Mainly shallow texture-contrast soils, Southernwood (Dd1.12, 1.32) and Medway (Dd1.13), with irregularly distributed areas of deeper soils generally with strongly alkaline subsoils, Taurus (Db1.13), Retro (Dd1.13), and Wyseby (Dd1.32). Minor areas of moderately deep, alkaline cracking clay soils, Teviot (Ug5.12), and shallow rocky soils, Rugby (Um1.2)	Brigalow scrub, rarely eucalypt–brigalow (blackwood in north) scrubs; all with *Eremophila mitchellii* midstorey (*E. mitchellii*, *Ventilago viminalis*, *Carissa ovata*); mosaic of scrub grass (*Paspalidium* spp., *Chloris divaricata*) and eastern mid-height grass (*Bothriochloa ewartiana*)	VIt_6, e_4, d_4
3	25% Widespread	Undulating lowlands; slopes up to 10%; some gullying and sheet erosion; stony in places; minor patches of sand and gravel capping some ridges in the south	Distribution as for unit 2. Mainly shallow texture-contrast soils, Southernwood (Dr2.12); also extensive belts of deep texture-contrast soils, Luxor (Dy3.22), Broadmeadow (Dy2.23), and Taurus (Dr2.13), often with much gravel. Some shallow rocky soils, Rugby and Shotover	*E. melanophloia* woodland, occasional *E. populnea*, *E. orgadophila*, and narrow-leaved ironbark (*E. drepanophylla*) woodlands; moderate argillicolous midstorey (*Eremophila mitchellii*, *Canthium oleifolium*, *Carissa ovata*), rarely arenicolous or no midstorey; occasionally argillicolous community (*Eremophila mitchellii*, *Bursaria incana*, *Canthium oleifolium*, *Ventilago viminalis*) without tree stratum; rarely no woody plants, eastern mid-height grass (*Bothriochloa ewartiana*, *Themeda australis*, *Aristida* spp.), occasional *Tripogon loliiformis* community	IV–VI r_{4-5}, e_4, d_4 p_{3-4}
4	40% Widespread	Undulating lowlands; slopes up to 6%; billy gravel common	Shallow and moderately deep texture-contrast soils with strongly alkaline subsoils, Medway (Dy2.33, Dd1.33), Taurus (Dd1.33), and Retro (Dd1.13), commonly with gravelly surface soils. Minor areas of moderately deep cracking clay soils, Teviot (Ug5.22)	Brigalow scrub (blackwood in north); *Eremophila mitchellii* midstorey (*E. mitchellii*, *Flindersia dissosperma*, *Carissa ovata*); scrub grass (*Paspalidium* spp., *Chloris divaricata*), eastern mid-height grass in open places	IV–VI e_4, p_{3-4}, r_{4-5}
5	10% Sporadic	Patches of gravelly clay; level to undulating	One observation; texture-contrast soil, Retro (Dr2.13)	As unit 2, with eucalypt–brigalow communities more prominent	IV–VI p_{3-4}, e_{3-4}, r_{3-4}
6	5% Widespread	Narrow alluvial flats; single or anastomosing channels 3–10 ft deep; flooded; minor terraces a few feet above flood level	Texture-contrast soils with thin loamy surface soils, Wyseby (Dd1.12) and Retro (Dd1.13); minor dark brown and grey-brown soils, Cheshire (Gn3.13), and alluvial soils, Davy, Clematis, and Warrinilla	*E. microtheca*, occasional *E. tereticornis*, fringing channels; *E. populnea* woodland, usually with argillicolous understorey and eastern mid-height grass; some brigalow scrub with *Eremophila mitchellii* midstorey and scrub grass	IV–V w_{4-5}, p_{3-4}

Skye Land System* (370 sq miles)

Lowlands and low hills predominantly with box and texture-contrast soils on mixed sediments mainly exposed below the Tertiary weathered zone.

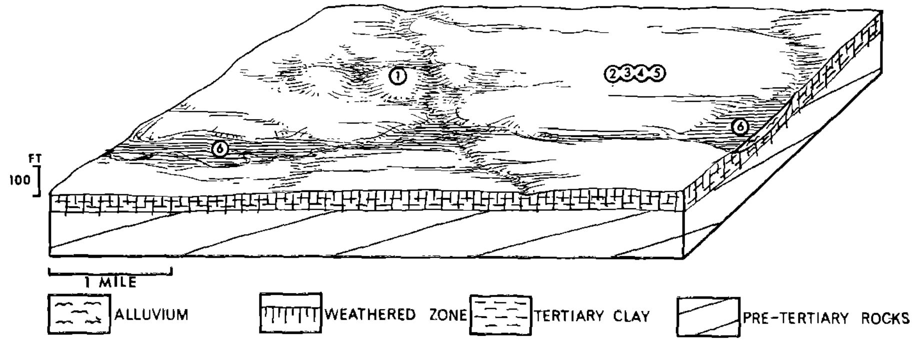


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% Sporadic	Scarps and hills; rocky; local relief probably 10–100 ft; slopes up to 60%; gullying and sheet erosion	No observations; probably shallow rocky soils and shallow red earths	Lancewood scrub, arid scrub grass (*Cleistochloa subjuncea*, *Aristida caput-medusae*)	VII–VIII t_{7-8}
2	20% Widespread	Scarps, rises, ridges; undulating to hilly; local relief probably 10–100 ft; slopes up to 20%; minor outcrops, some sandy areas and gravel patches	Minor areas of red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.24), on rises; uniform coarse-textured soils, Petrona (Uc1.22) and Highmount (Uc4.12), on lower slopes	*E. melanophloia* woodland (high proportion of *E. populnea* and occasionally *E. polycarpa*), occasional *E. populnea* woodland, rarely narrow-leaved ironbark woodland (*E. drepanophylla*, *E. citriodora*); all with arenicolous midstorey (*Callitris columellaris*, *Acacia cunninghamii*, *Dodonaea viscosa*), and eastern mid-height grass (*Bothriochloa decipiens*, *B. ewartiana*, *Aristida ramosa*), and scrub grass where upper layers are dense	VIt_6, n_{3-4}
3	45% Widespread	As unit 2, but less steep with fewer outcrops and more colluvium	Texture-contrast soils, dominantly Taurus (Dr2.13, Dy3.23), minor areas of Luxor, Broadmeadow (Dr2.13), and Retro (Dd1.33)	*E. populnea* woodland with argillicolous midstorey (*Bauhinia carronii*, *Eremophila mitchellii*, high proportion of brigalow); eastern mid-height grass (*Bothriochloa decipiens*, *B. ewartiana*, *Aristida ramosa*) and scrub grass where upper layers are dense	IVp_{3-4}, s_{2-3}, e_3
4	20% Widespread	Plains and lowlands; gently undulating; local relief 5–25 ft; slopes up to 5%; some minor fans and colluvial aprons	Mainly texture-contrast soils, Retro (Db1.13); minor areas of dark brown and grey-brown soils, Cheshire (Gn3.13)	Brigalow, occasional *E. populnea*-brigalow, rare *E. cambageana*-brigalow scrubs; *Geijera parviflora* (shrub wilga) midstorey (*Geijera parviflora*, *Eremophila mitchellii*, *Brachychiton rupestre*); scrub grass (*Paspalidium* spp., *Ancistrachne uncinulata*)	IVp_{3-4}, s_{2-3}, e_3
5	10% Widespread	Alluvial flats; terraced and with well-marked levees; usually sandy; not flooded; single channels up to 30 ft deep	No observations; probably texture-contrast soils mainly	Fringing community (*E. tereticornis*, *Casuarina cunninghamiana*); *E. populnea* woodland with eastern mid-height grass (*Bothriochloa decipiens*); occasional brigalow scrub with *Eremophila mitchellii* midstorey and scrub grass	IVp_{3-4}

* Similar to Woleebee land system in the Dawson–Fitzroy area.

SOMERBY LAND SYSTEM* (680 SQ MILES)

Gilgaied plains with brigalow and cracking clay soils on acid clay exposed within the Tertiary weathered zone.

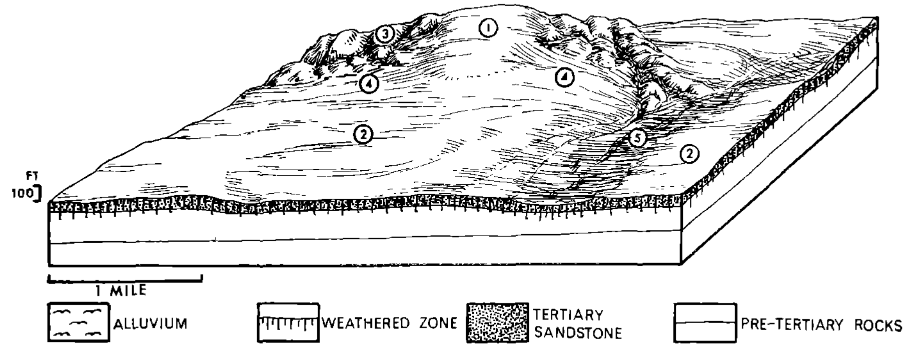


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% Widespread	Rises; low, with local relief up to 15 ft; mainly weathered soft sandstone and clay; minor strike ridges on harder rocks	Mainly texture-contrast soils, Luxor (Dy3.22) and Springwood (Dy2.32); minor areas of loamy yellow earths, Struan (Gn2.22), on upper slopes	*E. populnea* or occasional *E. melanophloia* woodlands; argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*); eastern mid-height grass (*Bothriochloa ewartiana*, *Aristida* spp., *Heteropogon contortus*)	IVp$_{3-4}$, e$_{2-3}$
2	15% Widespread	Plains; weathered clay with some billy and ironstone gravel; occasional knolls on harder rocks	Texture-contrast soils with thin loamy surface and strongly alkaline subsoils, Retro (Db1.13, Dr2.43)	*E. cambageana*– or *E. thozetiana*–brigalow scrub; *Eremophila mitchellii* midstorey (*E. mitchellii*, *Carissa ovata*); scrub grass (*Paspalidium* spp., *Sporobolus* spp.) and eastern mid-height grass (*Bothriochloa ewartiana*) in open places. Rarely lancewood scrub and arid scrub grass	IVp$_{3-4}$, s$_{3}$
3	20% Widespread	As unit 2 but slightly lower in the landscape	Deep cracking clay soils on weathered materials, Rolleston (Ug5.24, 5.15), generally alkaline surface over acid, mottled subsoils	Brigalow (blackwood in north), rarely gidgee or belah, scrub; *Eremophila mitchellii* (*E. mitchellii*, *Heterodendrum oleifolium*, *Bauhinia carronii*, *Carissa ovata*), *Terminalia oblongata* (*T. oblongata*, *Ehretia membranifolia*, *Eremophila mitchellii*, *Carissa ovata*), or rarely no midstorey; scrub grass (*Paspalidium* spp., *Chloris divaricata*, *Sporobolus* spp.)	IIIs$_{3}$,k$_{2-3}$
4	10% Sporadic	As unit 2	Mosaic of gilgaied deep cracking clay soils, Pegunny (Ug5.24, 5.34), and texture-contrast soils, Retro (Db1.13, Dr2.43)	*E. cambageana*–brigalow and brigalow scrubs; *Eremophila mitchellii* midstorey, rarely *Terminalia oblongata* or no midstorey; sparse scrub grass (*Paspalidium* spp.) or eastern mid-height grass (*Bothriochloa ewartiana*) in open places	IVg$_{4}$,s$_{3-4}$, p$_{3-4}$,k$_{2-3}$
5	50% Widespread	As unit 2 but in slightly lower sites; gilgai up to 6 ft deep	Gilgaied, deep cracking clay soils, Pegunny (Ug5.24), generally strongly alkaline surface over acid mottled subsoils	As unit 3	IVg$_{4}$,s$_{3-4}$, k$_{2-3}$
6	<5% Sporadic	Alluvial flats; mainly clay; flooded; small anastomosing channels; limited silty levees above flood level	Cracking clay soils on alluvium, Vermont (Ug5.16, 5.24); minor areas of fine-textured alluvial soils, Clematis (Uf1.4)	Fringing forest (*E. tereticornis*, *E. microtheca*, brigalow, *Melaleuca* spp.) on channels; brigalow scrub as unit 3; occasional grassland–blue grass (*Dichanthium sericeum*, *Thellungia advena*)	Vw$_{6}$

*Similar in part to Highworth land system in the Dawson–Fitzroy area.

Tichbourne Land System (1660 sq miles)

Undulating country with silver-leaved ironbark or melaleuca and red and yellow earths on partially stripped Tertiary land surface.

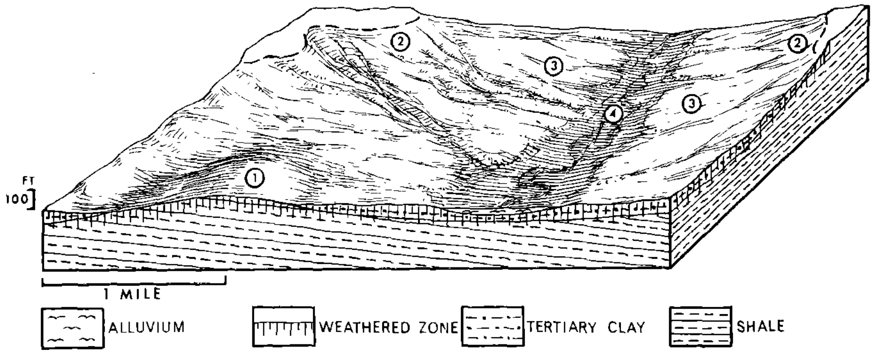


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	15% Widespread	Interfluves; level to gently sloping, undissected and underlain by laterite; up to 1 mile across; slopes 1–3%; ironstone gravel on surface	Loamy and sandy yellow earths, Struan (Gn2.21) and Forrester (Gn1.22), commonly underlain by concretionary or massive laterite at moderately shallow depths; shallow uniform coarse-textured soils, Petrona (Uc1.23), extensive in places	*Melaleuca tamariscina* scrub, treeless *Acacia leptostachya* community (*A. leptostachya, Melaleuca uncinata*), occasional low *E. melanophloia* woodland with *Melaleuca nervosa* midstorey or *Acacia leptostachya* midstorey; sparse eastern spinifex (*Triodia mitchellii*)	VI^*n_{3-4}, m_3
2	60% Widespread	Plains, undulations; level to low hilly; up to 2 miles across; local relief 10–100 ft; slopes up to 5% but usually less than 2%; sandy or loamy surface; some sandy colluvial fans	Mainly loamy red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.22); some sandy yellow earths, Forrester (Gn1.22), on fans	*E. melanophloia* woodland with *Acacia coriacea* midstorey (*A. coriacea, A. tenuissima*), occasional *E. similis* woodland (*E. drepanophylla, E. trachyphloia* sometimes prominent) with *Acacia leptostachya* midstorey, narrow-leaved ironbark woodland (*E. drepanophylla, E. peltata* sometimes alone) with *Melaleuca nervosa* arenicolous midstorey, or *E. polycarpa–E. papuana* woodland with arenicolous midstorey (*Persoonia falcata, Lysicarpus angustifolius*); eastern spinifex (*Triodia mitchellii*) and/or eastern mid-height grass (*Bothriochloa ewartiana, Aristida* spp.)	VI^*n_{3-4}, m_3
3	5% Widespread	Knolls, breakaways, dissected valley heads; cut below unit 1 or rising above unit 2; up to ½ mile across; local relief 10–100 ft; stony with much outcrop	Mainly shallow rocky soils, Shotover (Uc1.23), minor areas of shallow red and yellow earths, Gregory (Gn2.12, 2.22)	Lancewood scrub; sparse scrub grass (*Cleistochloa subjuncea, Scleria* sp.)	$VIIt_7$,r_5,d_6
4	15% Sporadic	Stripped margins of units 1–3; moderately sloping; up to ½ mile across; slopes 2–9%; some outcrop; sheet erosion	Loamy red earths, Dunrobin (Gn2.12), underlain by concretionary ironstone and mottled-zone materials; minor shallow rocky soils, Shotover (Uc1), and shallow texture-contrast soils, Medway (Db1.43), below scarps	*E. normantonensis* woodland, *E. thozetiana* woodland with argillicolous understorey (brigalow, *Eremophila mitchellii*), occasional low *E. polycarpa–E. papuana* woodland; eastern spinifex (*Triodia mitchellii*), eastern mid-height grass (*Aristida* spp., *Eriachne* spp.), rarely scrub grass	VI^*n_{3-4}, m_3,e_{3-4}
5	5% Sporadic	Alluvial flats; up to ¼ mile wide; usually sandy with single meandering channel, sometimes argillaceous with anastomosing channels	Mainly texture-contrast soils, Luxor (Dy2.22) and Taurus (Db1.13); minor areas of medium- to fine-textured alluvial soils, Clematis (Uf1.4)	Fringing woodland (*E. tereticornis*, occasional *E. microtheca*); *E. populnea* woodland usually without understorey; small areas of brigalow and gidgee scrubs and *E. microtheca* woodland; usually eastern mid-height grass	IVp_{3-4}, w_{3-4},s_{2-3}

*Downgraded on account of generally low rainfall.

ULCANBAH LAND SYSTEM (230 SQ MILES)

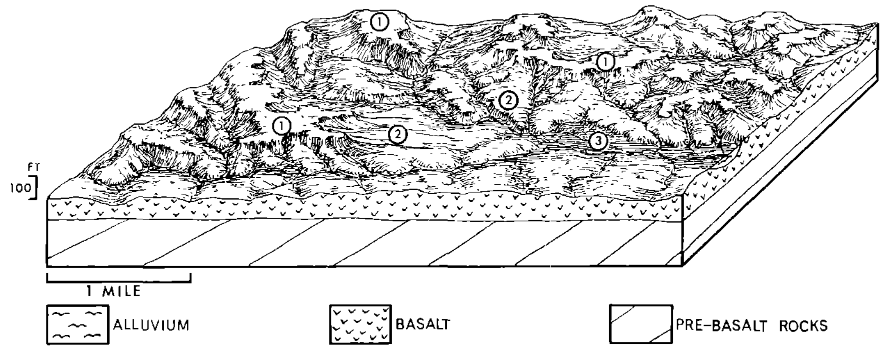
Clay plains with gidgee and cracking clay soils on shales and acid clay exposed within the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% Oakvale	Rises; up to 1 mile wide and 50 ft high but usually smaller, lower, and indefinite; slopes up to 5%; gravelly surface; gullying	Mainly loamy red and yellow earths, Dunrobin (Gn2.12) and Struan (Gn2.22); minor areas of dark brown and grey-brown soils, Gindie (Uf6.31), on calcareous sediments	*E. melanophloia* (*E. melanophloia, E. terminalis*) and *E. populnea* woodlands, eastern mid-height grass	IVn_{3-4}, m_3
2	20% Sporadic	Plains, upper parts of colluvial aprons; level to gently undulating; up to ½ mile across; slopes up to 5%; weathered clay and shale with occasional stones; minor low shaly rises and scarps	Texture-contrast soils, thin loamy surface soils, Wyseby (Dr2.32) and Retro (Dr2.13)	Open brigalow, *E. thozetiana*-brigalow, *E. cambageana*-brigalow, rarely gidgee scrubs, with *Eremophila mitchellii* mid-storey (*E. mitchellii, Carissa ovata, Hakea leucoptera* in the west); sparse scrub grass (*Paspalidium* spp., *Sporobolus* spp.) and eastern mid-height grass in open places	IVp_{3-4}, s_{2-3},e_{2-3}
3	65% Widespread	Plains, lower part of colluvial aprons; up to 3 miles across; slopes up to 2%; weathered clay and shale; minor shallow channels in depressions	Texture-contrast soils with thin loamy surface and alkaline subsoils, Retro (Db1.33, Dr2.13), merging with deep cracking clay soils, Rolleston (Ug5.24); minor areas of gilgaied clay soils, Pegunny (Ug5.24)	Gidgee, rarely brigalow, scrubs, with *Terminalia oblongata* (*T. oblongata, Eremophila mitchellii, Carissa ovata, Heterodendrum diversifolium*), *Eremophila mitchellii* (*E. mitchellii, Carissa ovata, Myoporum deserti*), occasional softwood (*Citriobatus spinescens, Erythroxylum australe, Ehretia membranifolia*), rarely no understorey; scrub grass (*Paspalidium* spp., *Chloris divaricata, Sporobolus* spp., *Atriplex* spp., *Bassia* spp.)	III–IV p_{3-4},s_{3-4}, e_2
4	10% Widespread	Alluvial flats; low levees common but no terraces; up to ½ mile wide; clay and silt; anastomosing narrow channels up to 12 ft deep	No observations; probably texture-contrast and cracking clay soils	Fringing woodland (*E. microtheca, Melaleuca* spp., *Terminalia oblongata*) on channels; *E. populnea* woodland, low stands of *Eremophila mitchellii*, patches of gidgee and brigalow; bare ground, sparse eastern mid-height grass and *Tripogon loliiformis* community	IV–Vw_{4-5}

WATERFORD LAND SYSTEM (900 SQ MILES)

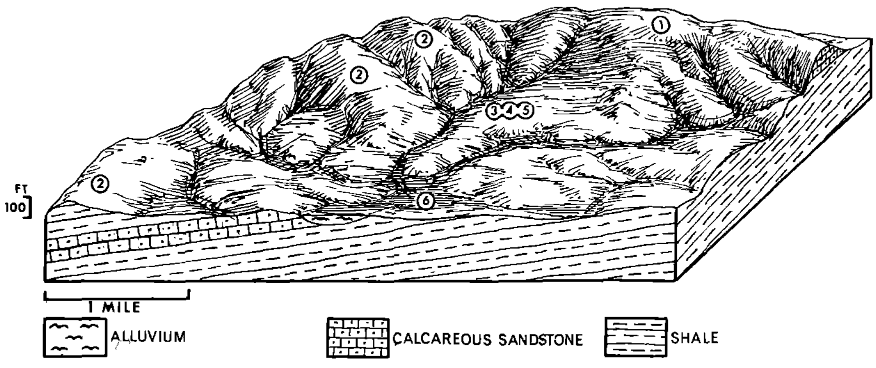
Low hills with open mountain coolibah woodland and shallow cracking clay soils on basalt below the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	55% Widespread	Low mesas, benched slopes, and limited patches of rolling country; outcrops and stony surfaces common; slopes 2–10%, steepening locally to 60% on mesa edges; local relief 30–150 ft; unit includes small plain at Surbiton	Mainly shallow, cracking clay soils, Bruce (Ug5.13, 5.14), generally stony, with shallow rocky soils near outcrops, Rugby (Um1.2), minor areas of reddish brown clay soils, Glenora (Ug5.33); shallow bouldery red earths, Gregory (Gn2.12), at Surbiton	*E. orgadophila* woodland (*E. orgadophila*, *E. dichromophloia*), occasionally *E. melanophloia* woodland; blue grass (*Dichanthium sericeum*) and eastern mid-height grass (*Bothriochloa ewartiana*, *Heteropogon contortus*). Near Surbiton, low, open *E. melanophloia* woodland over eastern mid-height grass (*Bothriochloa ewartiana*)	IVd_4,e_{3-4}
2	40% Widespread	Undulating lowlands and colluvial lower slopes; considerable gullying; slopes up to 10% on steeper parts, usually up to 3%	Reddish brown and shallow cracking clay soils, Glenora (Ug5.37, 5.31) and Arcturus (Ug5.12), sometimes underlain by highly calcareous materials	Grassland, blue grass (*Dichanthium sericeum*, *Thellungia advena*), some eastern mid-height grass (*Heteropogon contortus*, *Bothriochloa ewartiana*) on upper slopes. Occasionally brigalow and gidgee scrubs, with *Terminalia oblongata* midstorey, sometimes in pure stands; very sparse grass	III–IV e_{3-4},d_3,k_{2-3}
3	5% Widespread	Alluvial clay flats up to ½ mile wide with anastomosing channels 3–10 ft deep	Cracking clay soils, Vermont (Ug5.15), and uniform fine-textured alluvial soil, Clematis (Uf1.41)	*E. microtheca* on channels (*E. tereticornis* on larger ones); groves of *Melaleuca bracteata* and *Acacia pendula*, blue grass	Vw_6

Wharton Land System* (830 sq miles)

Lowlands with brigalow and wilga and dark brown and grey-brown soils formed on shales below the Tertiary weathered zone.

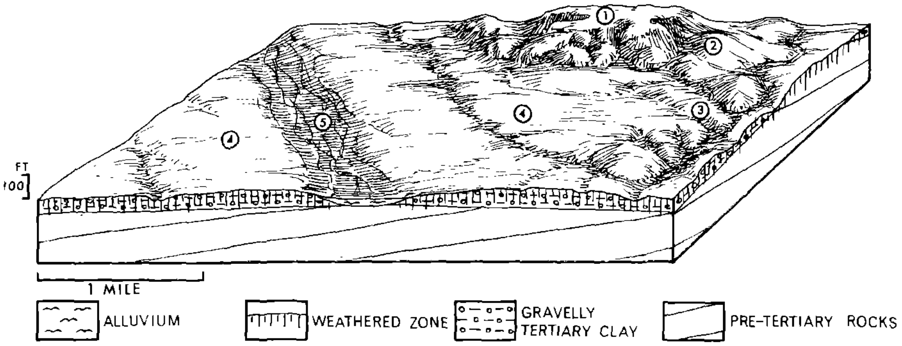


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	5% Sporadic	Crests; undulating; less than 200 yd across; often stony with some outcrop; thin quartz sand cover in places	Mainly texture-contrast soils, Luxor (Dr2.22) and Wyseby (Dr2.22); minor areas of sandy red earths, Annandale (Gn2.12); and shallow rocky soils, Rugby (Uf1.4)	*E. melanophloia* woodland with argillicolous midstorey (*Albizia basaltica, Eremophila mitchellii*), *E. populnea* woodland with argillicolous midstorey (*Eremophila mitchellii, Dodonaea viscosa*), occasionally no midstorey; eastern mid-height grass (*Bothriochloa decipiens, Cymbopogon refractus, Aristida* spp.)	IVp_{3-4}, e_3,s_2
2	10% Sporadic	Low ridges, escarpments, and associated margining slopes; 10–80 ft high; slopes up to 40%; stony with some outcrop in places; sheet erosion common	Dark brown and grey-brown soils, Cheshire (Gn3.24), on slopes; shallow rocky soils, Rugby, on ridges and scarps	Mainly bonewood (*Macropteranthes leichhardtii*) scrub with sparse scrub grass (*Eragrostis megalosperma*); occasional lancewood scrub with arid scrub grass (*Aristida caput-medusae*)	VI–VII t_{6-7},e_4
3	20% Widespread	Lowlands, slopes below units 1 and 2, low mesas; undulating with occasional low scarps; local relief 10–80 ft; slopes up to 9% locally steeper round mesas; often gravelly with outcrops on steeper portions; some sheet and gully erosion	Texture-contrast soils with strongly alkaline subsoils, mainly Retro (Dy2.13), some Broadmeadow (Dr2.13) and Taurus (Dr2.23); on lower slopes, dark brown and grey-brown soils, Cheshire (Gn3.43), and cracking clay soils, Rolleston (Ug5.16)	*E. cambageana*–brigalow, rarely brigalow, scrub; *Geijera parviflora* (shrub wilga) midstorey (*Brachychiton rupestre, Eremophila mitchellii, Geijera parviflora*); scrub grass (*Paspalidium* spp., *Cymbopogon refractus*)	IVp_{3-4}, e_{3-4}
4	50% Widespread	As unit 3 but possibly slightly lower	Dark brown and grey-brown soils, Cheshire (Gn3.93, 3.23), and cracking clay soils, Rolleston (Ug5.15); minor areas of texture-contrast soils, Springwood (Dy3.12) and Retro (Dr2.13)	Brigalow scrub; *Geijera parviflora* (shrub wilga) midstorey (*G. parviflora, Eremophila mitchellii, Brachychiton rupestre*), rarely *Eremophila mitchellii* midstorey; scrub grass (*Paspalidium* spp., *Chloris divaricata, Cymbopogon refractus*)	III–IV e_{3-4},s_3, k_{2-3}
5	10% Widespread	As unit 3 but severe sheet erosion	Truncated dark brown and grey-brown soils, Cheshire (Gn3.23)	Stands of *Eremophila mitchellii* with *Tripogon loliiformis* community and much bare ground; occasional open brigalow scrub	IVe_4
6	5% Widespread	Alluvial flats; levees and sandy surface where derived from adjacent sandstone; silt to clay elsewhere with less microrelief and marked scalding; generally anastomosing channels	No observations; probably texture-contrast and cracking clay soils	*E. populnea* woodland with argillicolous midstorey (*Eremophila mitchellii*), brigalow and *E. populnea*–brigalow scrubs with *Geijera parviflora* (shrub wilga) understorey, bare areas and areas with sparse *Tripogon loliiformis* community only	IVp_{3-4}

*Similar to Arcadia land system in the Isaac–Comet area.

WILLOWS LAND SYSTEM (160 SQ MILES)

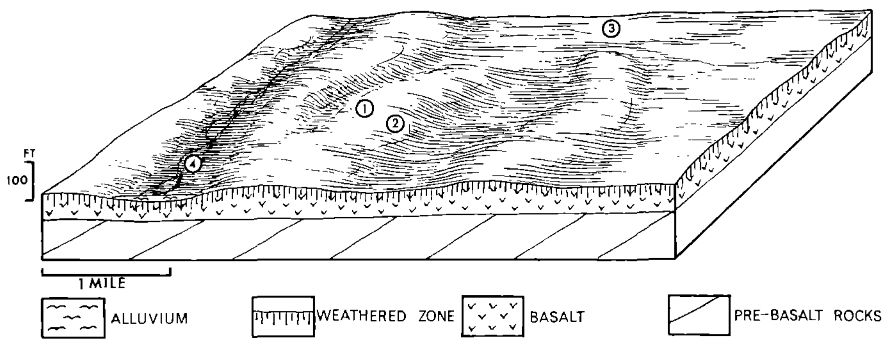
Gravelly lowlands with brigalow and cracking clay soils on weathered gravel exposed within the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	<5% Sporadic	Small mesas and rises	Loamy red earths commonly with gravel, Dunrobin (Gn2.12)	Low *E. melanophloia* or *E. polycarpa–E. papuana* woodlands, eastern mid-height grass (*Bothriochloa ewartiana*, *Aristida* spp.)	IVn_{3-4},m_3
2	10% Widespread	Rises, hills; rarely more than ½ mile across; local relief 10–80 ft; slopes up to 15%; very gravelly	Shallow and deep texture-contrast soils, Southernwood (Dd1.12) and Luxor (Dy2.32), generally with gravelly surface horizons; minor areas of uniform coarse-textured soils, Highmount (Uc1.21), gravelly phase	*E. melanophloia*, occasional *E. populnea* or *E. orgadophila* woodlands, usually argillicolous (*Eremophila mitchellii*, *Carissa ovata*), rarely *Acacia rhodoxylon* midstorey with *E. melanophloia*; eastern mid-height grass (*Bothriochloa ewartiana*)	$IV–VIt_6,$ $e_{3-4},d_4,$ r_{3-4}
3	25% Widespread	Rises, lower slopes of undulating terrain, plains; level to low hilly; local relief 5–30 ft; slopes up to 5%; generally gravelly; limited occurrences of steeper gravelly hills	Deep texture-contrast soils, mainly Retro (Dd1.13), minor Taurus (Dy3.13) and Wyseby (Dy2.12), generally with gravelly surface soils; minor areas of very stony dark brown and grey-brown soils, Cheshire (Gn3.93)	*E. thozetiana*–brigalow or *E. cambageana*–brigalow scrubs (brigalow layer sometimes open); *Eremophila mitchellii* (*E. mitchellii*, *Carissa ovata*), rarely *Terminalia oblongata* (*T. oblongata*, *Eremophila mitchellii*) midstorey; scrub grass (*Paspalidium* spp., *Chloris acicularis*), rarely eastern mid-height grass	$IV–Vr_{4-5},$ p_{3-4},e_{2-3}
4	60% Widespread	Plains, interfluves; gently undulating to level; slopes up to 3%; usually weathered gravelly clay; gullying	Mainly deep alkaline/acid cracking clay soils, Rolleston (Ug5.16, 5.24), minor areas of gilgaied clay soils, Pegunny (Ug5.16, 5.24); commonly with much coarse billy gravel on surface	Brigalow scrub; *Eremophila mitchellii* (*E. mitchellii*, *Carissa ovata*), rarely *Terminalia oblongata*, or no midstorey; scrub grass (*Paspalidium* spp., *Chloris divaricata*) or eastern mid-height grass (*Bothriochloa ewartiana*) in open places	$IV–VIr_{4-5}$ s_3,k_{2-3}
5	5% Widespread	Alluvial flats; complex of clay pockets and silty and sandy levees; small anastomosing channels 3–8 ft deep; probably flooded	Texture-contrast soils, Retro (Dy2.23), on levees; cracking clay soils, Vermont (Ug5.24), and uniform alluvial soils, Clematis (Um5.4), on plains	Brigalow, *E. microtheca*, *Terminalia oblongata* on channels; brigalow scrub (as unit 4) or *E. populnea* woodland with argillicolous midstorey (*Eremophila mitchellii*, *Carissa ovata*) and eastern mid-height grass (*Bothriochloa decipiens*)	$IV–V$ w_{4-5},p_{3-4}

WONDABAH LAND SYSTEM (190 SQ MILES)

Plains and lowlands with gidgee scrub and cracking clay soils formed on basalt within the Tertiary weathered zone.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation	Land Class
1	10% Widespread	Gently undulating low interfluves rising a few feet above other units; often stony	Cracking self-mulching clay soils, May Downs (Ug5.12)	Grassland, blue grass (*Dichanthium sericeum*, *Panicum* spp.); occasionally *E. orgadophila* woodland (*E. orgadophila*, *E. dichromophloia*) with blue grass and eastern mid-height grass	IIe$_2$,k$_2$
2	15% Widespread	Gentle slopes on margins of unit 1; slopes up to 3%	Reddish brown cracking clay soils, Glenora (Ug5.37)	Sometimes brigalow scrub with *Terminalia oblongata* midstorey, usually *Terminalia oblongata* community (*T. oblongata*, *Eremophila mitchellii*, *Geijera parviflora*, *Carissa ovata*) without taller trees; sparse scrub grass (*Paspalidium* spp., *Chloris divaricata*) with blue grass and rarely eastern mid-height grass in open places	IIIe$_{2-3}$, k$_{2-3}$
3	70% Widespread	Plains, shallow depressions, and colluvial foot slopes; slopes less than 2%; limited areas on steeper slopes up to 6% with occasional outcrops	Mainly reddish brown, alkaline cracking clay soils, Glenora (Ug5.32, 5.13); minor dark brown and grey-brown soils, Cheshire (Uf6.31)	Gidgee scrub, usually with *Eremophila mitchellii* and *Terminalia oblongata* midstorey communities, rarely with softwood midstorey; sparse scrub grass	IIIe$_{2-3}$, k$_{2-3}$
4	5% Sporadic	Narrow alluvial clay flats; anastomosing channels 3–10 ft deep; flooded	No observations; probably cracking clay soils and uniform fine-textured alluvial soils	*E. microtheca* on channels, blue grass on flats	Vw$_5$

PART IV. CLIMATE OF THE NOGOA–BELYANDO AREA

By E. A. FITZPATRICK*

I. INTRODUCTION

(a) Principal Climatic Features

Broad transition rather than clearly defined climatic zonation is characteristic within the area. The principal transitions are toward increasing aridity westward and increasing temperature northward. The climate is thus difficult to characterize in any single climatic "type", but it can be described generally as ranging from tropical to subtropical and from subhumid to semi-arid (Köppen 1931; Thornthwaite 1931; Meigs 1953).

Approximately three-quarters of the mean annual rainfall occurs during the six summer months. By comparison with areas of similar mean annual rainfall in southern and northern Australia, the variability of rainfall is high (Loewe 1948).

Day temperatures are high throughout the year, but minimum temperatures are low enough to create an appreciable frost risk over the southern half of the area.

(b) Principal Climatic Controls

In its latitudinal situation, the area is marginal with respect to the major meteorological controls that bring more dependable rainfall to the north (in summer) and to the south (in winter). In general, the climate of the area is strongly controlled by anticyclonic and trade wind influences.

Between May and August, winds are generally south-easterly to south-westerly. Over this period the centres of the migratory subtropical anticyclones are well to the north, and the intertropical convergence zone is far beyond the northern extremities of the continent. The extratropical cyclonic systems which pass in an easterly direction along the southern margins of the continent, and which strongly control the character of winter weather over all of south-eastern Australia, have no pronounced influence within the area. These systems usually produce no more than the passage of weak troughs across central Queensland, giving only a few days of somewhat cloudier weather with light falls of rain at times, and followed by spells of cooler weather as air masses from the south move into the area. The prevailing pattern of fine, sunny weather, with mild days and cool nights, returns quickly with the re-establishment of stable, anticyclonic controls.

Between September and December the dominance of winds having a southerly component weakens, and there is an increasing proportion of winds from the north and north-east. With increasing radiation intensities and longer days, and with prevailing dry weather at this time, daytime temperatures increase rapidly over this

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period. This is accompanied by active localized convection and increasing cumuliform cloud. Scattered thunderstorms become more frequent throughout central and south-eastern Queensland; these generally occur with the inland penetration of air that has had an extended passage over the warm waters of the Coral Sea. Spells of very hot, dry weather may also occur at this time whenever the broad synoptic patterns bring in air that has had long trajectories over inland and northern Australia.

With the southward advance of the intertropical convergence zone in January and February, the area has its most favourable conditions for the influx of maritime air masses with moist conditions throughout considerable depth. The centres of anti-cyclonic cells are at this time displaced well to the south, and the possibility of convergent air streams over central and northern Australia is greatly improved; but even so, the area is clearly less favourably situated for sustained, heavy rainfall at this time than areas to the north and east. This is due not only to its greater distance from sources of moist air, but also to its situation in the lee of ranges to the east and north-east which tend to concentrate rainfall along the Queensland coast. Thus, although January through March is distinctly the rainiest part of the year, these rains are highly erratic in their temporal incidence and amount.

Tropical cyclones which approach the Queensland coast from the Coral Sea area are also most frequent from January to March, and are another useful rain-producing mechanism. Normally, these cyclones either remain at sea or merely skirt the Queensland coast, confining heavy falls to the coastal zone and adjacent ranges. However, at times tropical cyclones do move inland, and degenerate there as large rain depressions, producing heavy falls of rain inland (Fitzpatrick 1960). Unfortunately these occurrences are highly erratic, and this further adds to the high variability of summer rainfall in this area.

In April, with the northward return of anticyclonic controls, and less frequent intrusions of air masses from tropical seas, cloudiness and rainfall are markedly reduced and the characteristic pattern of fine, mild weather of the winter months sets in.

II. General Climatic Characteristics

(*a*) *Rainfall*

Mean annual and seasonal (six-monthly) rainfall with standard deviations, coefficients of variation, and the percentage of the mean annual rainfall occurring during the summer months are given in Table 3. These data have been obtained from all stations within or close to the area having records over the 35-year period 1926–60. This period has been taken here as a standard reference to facilitate a valid comparison between stations. Selected data from Table 3 are shown in Figures 3–5.

Mean annual rainfall ranges generally between 20 and 27 in. Although rainfall gradients are generally weak, a distinct trend toward lower rainfall from east to west is evident, particularly in the southern half of the area (Fig. 3). A zone of comparatively low rainfall (less than 24 in.) extends from the extreme south along the Nogoa River north-eastward to Emerald.

The coefficients of variation of annual rainfall (standard deviation as percentage of mean) range from 37 to 52%. Figure 4 shows that an area of high variability

TABLE 3

MEAN ANNUAL AND SEASONAL RAINFALL WITH STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION*

Station	Annual			Summer (November–April)			Winter (May–October)			Mean Summer Rainfall as Percentage of Mean Annual
	Mean	S.D.	C.V.	Mean	S.D.	C.V.	Mean	S.D.	C.V.	
Alpha	21·29	±11·12	52	15·14	±8·15	54	6·15	±3·93	64	71
Anakie	26·54	±12·31	46	20·24	±9·50	47	6·30	±5·37	85	76
Banchory Downs	21·05	± 8·93	42	15·68	±6·91	44	5·37	±3·74	70	74
Bulliwallah	24·05	±10·02	42	18·96	±8·18	43	5·09	±3·64	72	79
Bundabaroo	21·49	± 9·00	42	16·99	±8·82	52	4·50	±3·09	69	79
Capella	23·84	± 8·79	37	17·64	±7·41	42	6·17	±3·58	58	74
Clermont	25·27	±10·20	40	19·11	±7·70	40	6·16	±4·50	73	76
Elgin Downs	21·82	±10·48	48	17·22	±8·78	51	4·60	±3·69	80	79
Emerald	24·68	± 9·05	37	18·23	±6·95	38	6·46	±4·04	62	74
Gordon Downs	23·08	± 9·70	42	17·19	±7·99	47	6·66	±5·82	87	72
Harden Park	18·72	± 7·93	42	13·12	±5·60	43	5·60	±3·58	64	70
Jericho	20·33	± 9·60	47	14·46	±6·15	43	5·87	±3·78	64	71
Logan Downs	23·71	± 8·77	37	17·95	±7·66	43	5·77	±4·94	86	76
Mantuan Downs	24·35	±11·64	48	17·46	±7·56	43	6·89	±4·14	60	72
Mirtna	23·35	± 9·94	43	19·02	±7·92	42	4·33	±2·74	63	81
Mt. Coolon	21·70	± 8·31	38	17·21	±6·82	40	4·49	±3·03	67	79
Mt. McConnel	27·62	±10·45	38	22·98	±9·52	41	4·64	±2·52	54	83
Rainworth	27·57	±11·91	43	19·65	±7·95	40	7·92	±5·92	75	71
Sapphire	25·50	±10·56	41	19·04	±7·65	40	6·46	±4·20	65	75
Springsure	27·76	±11·48	41	21·01	±7·33	35	7·77	±4·35	56	76
Surbiton	19·60	±10·06	51	14·42	±7·11	49	5·39	±2·97	55	74
Tambo	20·04	± 7·59	38	14·08	±5·90	42	5·96	±3·70	62	70
Twin Hills	24·53	±10·65	43	18·78	±8·11	43	5·75	±3·61	63	76
Yacamunda	22·84	± 8·68	38	17·67	±6·81	39	5·17	±3·09	60	77

* From annual and monthly rainfall records over period 1926–60 inclusive supplied by Bureau of Meteorology.

occurs in the vicinity of Alpha and Surbiton and that somewhat less variable rainfall occurs along the eastern margin of the area, northward from Emerald. Even in the most favoured situations, however, annual rainfall is very variable in amount by comparison with areas to the north, east, and south (Dick 1958). From the 35-year period adopted here, no clearly recognizable regional trends are evident in the coefficients of variation of the six-monthly seasonal rainfalls.

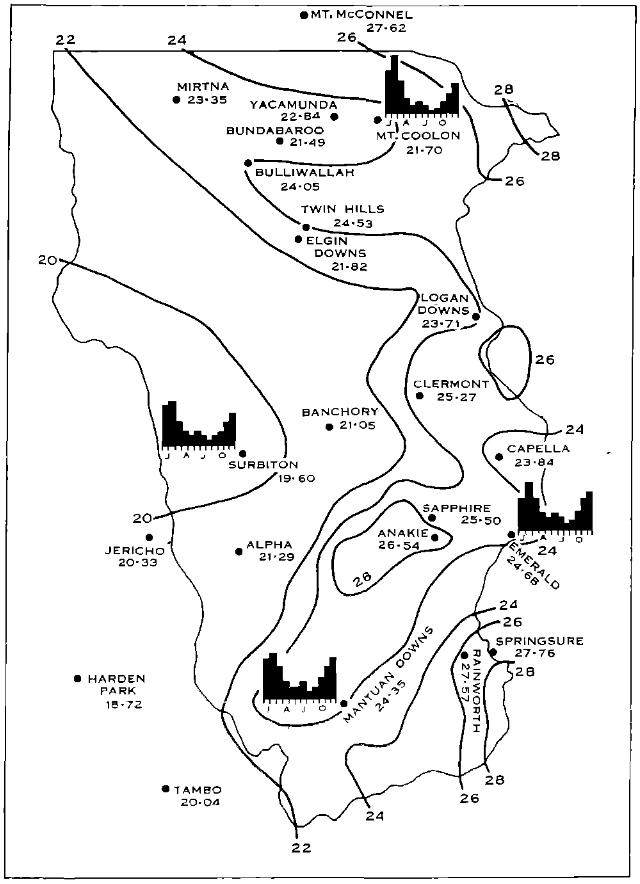

Fig. 3.—Mean annual rainfall (in.).

As may be expected from known controls, the proportion of the mean annual rainfall occurring during the summer months increases from south to north (Fig. 5). Approximately 70% of the annual rainfall occurs between November and April inclusive in the extreme south, whereas over 80% occurs over this interval in the extreme north.

Mean monthly rainfalls are summarized in Table 4. February is the wettest month throughout the area, with an average of at least 3·5 in. at all stations except Alpha (and three stations, Jericho, Harden Park, and Tambo, situated outside the area to the south-west). However, unlike areas closer to the coast, the difference between February rainfall and that of December or January is generally small. The effect of late spring and early summer convectional rains is clearly seen from these data, particularly for stations in the south-eastern portion of the area. Emerald, Springsure, Rainworth, and Mantuan Downs all have monthly averages over 2·5 in. between November and January inclusive. Unfortunately for agricultural prospects,

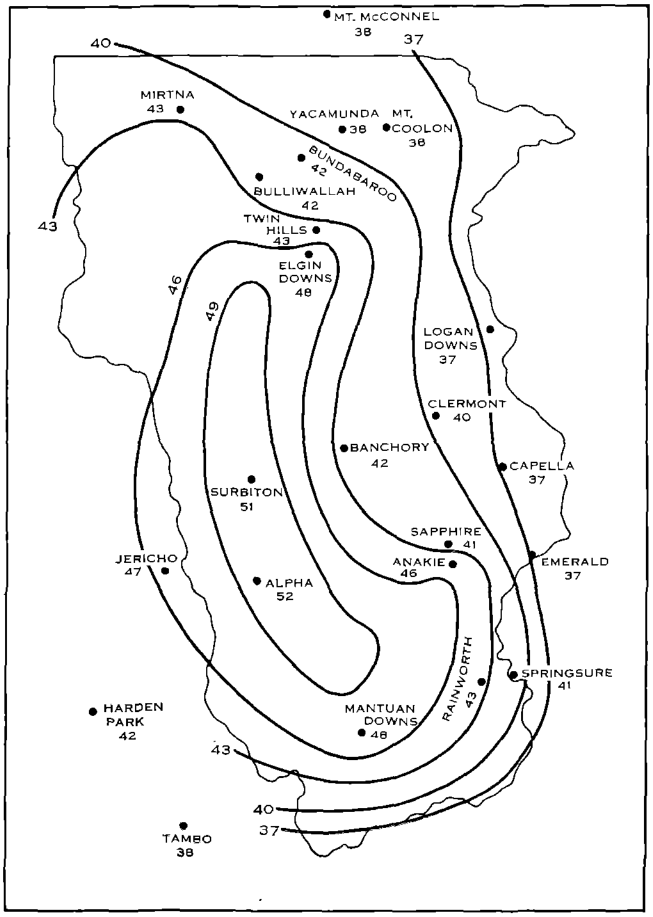

Fig. 4.—Coefficient of variation of annual rainfall (%).

these rains are erratic and generally of short duration and high intensity. A marked reduction of rainfall occurs in April; between April and July the average rainfall is generally within the range of 1·0 to 1·5 in. per month, with some tendency for increased rainfall in June, especially in the south-east (e.g. Anakie, Emerald, Rainworth, and Springsure). August and September are even drier, with means generally within the range 0·3 to 0·8 in.

Because the area occasionally receives very high falls, the annual and monthly means give an exaggerated impression of what might be regarded as "normal" expectancy. In Table 5 are shown the monthly amounts of rain exceeded in 10, 50, and 90% of all years for selected stations having long records. Also shown for comparison are the means from the 35-year standard period as given in Table 4. It is notable that by comparison with the annual means, the annual median values (i.e. 50% criterion) are remarkably uniform between stations. Thus, spatial differences in annual rainfall within the area are even smaller if the effect of occasional very heavy falls is

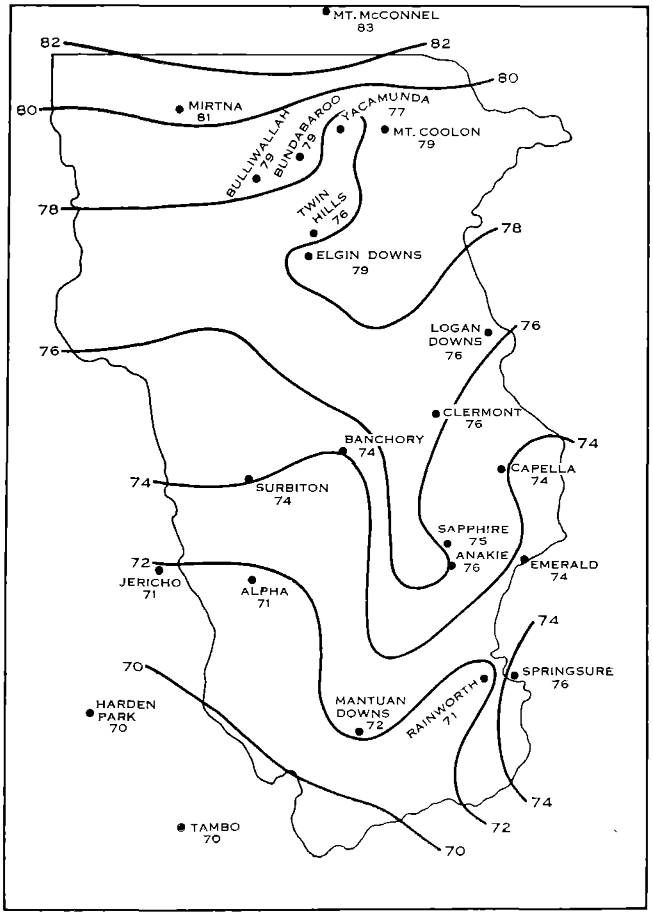

Fig. 5.—Percentage of mean annual rainfall during the six summer months, November to April inclusive.

ignored. In virtually all cases the monthly medians are lower than the means, often by as much as one-third. From December to March, monthly totals of 6 in. or higher occur with a mean frequency of at least once in 10 years, and in fact during February there is over most of the area better than a 10% chance that the monthly total will exceed 10·0 in. The possibility of very low monthly totals at any time of year is evident from the values given with the 90% criterion. Even during January and February, 10% of all years have monthly totals less than amounts generally not exceeding 0·8 in. per month. Between April and October, individual months are not infrequently rainless. In terms of minimal expectancy (i.e. with the 90% criterion),

TABLE 4

MEAN MONTHLY RAINFALL* (IN.)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Alpha	3·27	3·36	2·28	1·30	1·19	1·17	1·09	0·54	0·68	1·40	1·91	3·12
Anakie	4·20	5·30	2·81	1·54	1·19	1·84	1·30	0·58	0·61	1·73	2·43	3·54
Banchory Downs	3·80	4·07	1·93	1·23	0·97	1·15	0·97	0·41	0·62	1·38	1·94	2·65
Bulliwallah	4·08	5·23	3·32	1·46	0·98	1·07	1·04	0·42	0·50	1·16	1·76	3·01
Bundabaroo	4·06	4·66	2·63	1·54	0·89	0·91	0·86	0·32	0·34	1·03	1·85	2·39
Capella	3·74	4·26	2·96	1·11	1·16	1·23	1·16	0·38	0·55	1·64	2·39	3·25
Clermont	4·63	4·80	2·99	1·27	1·30	1·27	1·24	0·51	0·62	1·41	2·09	3·14
Elgin Downs	3·56	4·65	2·44	1·65	0·78	1·14	0·96	0·32	0·51	1·36	2·01	2·37
Emerald	3·64	4·49	2·78	1·33	1·08	1·28	1·23	0·54	0·69	1·64	2·79	3·20
Gordon Downs	3·58	4·18	2·75	1·05	1·14	1·26	1·19	0·49	0·65	1·46	2·36	3·02
Harden Park	3·49	2·61	2·11	1·26	1·08	1·07	1·18	0·47	0·59	1·30	1·27	2·29
Jericho	3·09	3·31	2·08	1·52	1·07	1·11	1·11	0·51	0·65	1·46	1·92	2·50
Logan Downs	3·69	4·82	2·56	1·30	1·04	1·25	1·07	0·43	0·61	1·37	2·00	3·51
Mantuan Downs	3·61	3·80	2·67	1·32	1·28	1·21	1·31	0·57	0·77	1·81	2·68	3·31
Mirtna	4·26	5·47	3·42	1·08	0·82	1·00	0·83	0·30	0·44	1·11	1·96	2·69
Mt. Coolon	4·02	4·79	2·72	1·48	0·78	1·08	0·88	0·39	0·54	1·13	1·64	2·13
Mt. McConnel	4·92	7·61	3·48	1·89	0·88	1·22	0·85	0·36	0·43	0·98	1·97	3·04
Rainworth	3·83	4·73	2·64	1·73	1·20	1·59	1·32	0·67	0·94	1·88	3·04	4·00
Sapphire	3·95	5·09	2·65	1·54	1·18	1·39	1·29	0·56	0·69	1·56	2·34	3·26
Springsure	4·21	4·46	2·80	1·67	1·16	1·61	1·33	0·69	0·98	2·00	3·21	3·66
Surbiton	3·48	3·59	1·85	1·14	0·87	1·07	0·98	0·40	0·57	1·13	1·80	2·71
Tambo	2·78	2·94	2·03	1·71	1·13	1·03	1·23	0·55	0·62	1·40	1·80	2·81
Twin Hills	3·95	5·25	2·83	1·74	1·13	1·21	1·05	0·38	0·66	1·33	2·23	2·76
Yacamunda	3·83	5·32	2·79	1·46	1·01	1·17	0·93	0·38	0·39	1·14	1·84	2·58

* From records over the period 1926–60 inclusive supplied by Bureau of Meteorology.

TABLE 5

MONTHLY AND ANNUAL RAINFALLS EXCEEDED IN 10, 50, AND 90% OF ALL YEARS*

Criterion	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Clermont (87 yr of records)												
10%	10·30	11·20	7·70	3·60	3·40	3·80	2·30	1·90	2·70	3·30	4·60	7·00	42·20
50%	4·20	3·60	2·10	1·10	0·70	1·00	0·50	0·40	0·40	1·10	1·80	2·60	24·90
Mean	4·63	4·80	2·99	1·27	1·30	1·27	1·24	0·51	0·62	1·41	2·09	3·14	25·27
90%	0·70	0·50	0·30	0·10	nil	0·10	nil	nil	nil	0·10	0·30	0·80	15·60
	Emerald (75 yr of records)												
10%	8·70	8·80	6·30	3·70	3·30	3·90	3·20	2·10	2·80	3·60	4·60	6·70	35·60
50%	3·20	2·90	2·40	0·80	0·60	1·00	0·60	0·50	0·40	1·20	1·60	2·70	24·80
Mean	3·64	4·49	2·78	1·33	1·08	1·28	1·23	0·54	0·69	1·64	2·79	3·20	24·69
90%	0·60	0·40	0·30	nil	nil	0·10	nil	nil	nil	0·10	0·20	0·40	14·80
	Springsure (89 yr of records)												
10%	8·10	10·00	7·00	4·20	3·40	4·10	3·30	2·50	3·00	4·00	5·40	6·60	39·90
50%	3·40	3·00	2·20	0·80	0·90	1·00	0·70	1·00	0·80	1·60	1·80	2·80	24·90
Mean	4·21	4·46	2·80	1·67	1·16	1·61	1·33	0·69	0·98	2·00	3·21	3·66	27·78
90%	0·80	0·50	0·20	0·10	0·10	nil	nil	nil	0·10	0·20	0·40	0·50	15·30
	Twin Hills (66 yr of records)												
10%	11·50	11·00	5·70	3·70	2·70	3·80	2·70	2·00	2·80	3·20	5·00	6·00	37·10
50%	3·40	3·30	2·30	0·60	0·50	1·10	0·20	0·40	0·20	0·90	1·40	2·10	24·30
Mean	3·95	5·25	2·83	1·74	1·13	1·21	1·05	0·38	0·66	1·33	2·23	2·76	24·52
90%	0·70	0·50	0·20	nil	nil	0·30	nil	0·10	nil	0·10	0·10	0·30	12·00

* Data supplied by Department of National Development from records of the Bureau of Meteorology.

rainfall during December and January appears to be as good as, or even better than, that of February.

Table 6 indicates the frequency of daily rainfalls of varying amounts at Emerald and Alpha. Generally, over 40% of all days on which rain is observed have falls of less than 0·25 in. throughout the year. Between 10% (in August–September) and 6% (in February–March) of all rain days have falls exceeding 2·0 in. In June at Emerald there is a larger proportion of rain days with falls greater than 1·0 in. than during April and May. The prevalence of convectional rainfall during December is evidenced by the comparatively large proportion of falls within the range 0·25 to 1·0 in. and a low proportion of falls less than 0·25 in. at both stations.

TABLE 6

PERCENTAGE OF RAIN DAYS* WITH TOTAL FALLS WITHIN SPECIFIED LIMITS FOR EMERALD AND ALPHA

Range (in.)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Emerald (77 yr of records)											
0·01–0·24	50	49	57	59	68	61	62	61	61	62	52	47
0·25–0·99	33	33	30	31	23	25	29	32	30	30	37	41
1·00–1·99	13	11	8	8	7	10	7	6	8	7	8	9
2·00–3·99	3	5	4	2	2	4	2	1	1	1	2	2
⩾4·00	1	1	1	—	—	—	—	—	—	—	—	1
Mean no. of rain days	8·3	6·8	5·7	3·7	3·4	3·3	3·2	2·6	2·9	4·4	5·5	7·2
	Alpha (68 yr of records)											
0·01–0·24	42	47	47	46	54	44	52	54	55	53	53	37
0·25–0·99	42	37	37	43	34	43	34	37	37	39	37	45
1·00–1·99	11	11	10	8	9	9	10	9	7	6	8	12
2·00–3·99	4	4	5	2	3	3	4	1	1	2	2	6
⩾4·00	1	1	1	—	—	1	—	—	—	—	—	—
Mean no. of rain days	6·2	6·0	4·6	2·5	2·4	2·8	2·4	1·9	2·0	3·1	4·2	4·3

* Rain day defined as a day with 0·01 in. or more of rain. Tabulations made from daily rainfall records of the Bureau of Meteorology.

(b) *Temperature*

The only temperature data from within the area are for Clermont and Emerald, but additional data are available for the nearby stations Springsure, Tambo, and Charters Towers to the south-east, south-west, and north respectively. Mean conditions for all these stations are summarized in Table 7, and data showing the frequency of temperature above and below selected thresholds are given for Clermont, Emerald, and Springsure in Table 8.

Mean maximum temperature ranges from approximately 70°F in July to 95°F in December and January (Table 7). The frequency of temperatures above the 90°F and 100°F thresholds increases rapidly during October (Table 8). On the average, temperatures over 90°F occur on about 65 to 75% of all days during December and January, and daily maxima above 100°F occur about 15 to 30% of the time during

TABLE 7

AVERAGE MEAN MAXIMUM, MEAN, AND MEAN MINIMUM TEMPERATURES FOR FIVE STATIONS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Charters Towers (elev. 1019 ft)												
Maximum (°F)	92·9	90·5	88·6	86·0	81·3	76·4	76·0	79·6	84·9	90·2	93·1	94·7	86·2
Mean (°F)	82·1	80·5	78·5	74·8	69·8	65·3	63·7	66·6	71·7	76·8	60·3	82·2	74·4
Minimum (°F)	71·3	70·6	68·5	63·6	58·3	54·2	51·6	53·6	58·4	63·4	67·6	69·7	62·6
	Clermont (elev. 870 ft)												
Maximum (°F)	94·3	91·5	89·4	84·8	78·7	73·1	72·8	76·9	83·3	90·1	93·7	95·2	85·2
Mean (°F)	82·4	80·3	77·6	71·8	64·9	59·7	57·8	61·0	67·8	75·2	79·7	82·1	71·7
Minimum (°F)	70·5	69·0	65·7	58·7	51·0	46·3	42·8	45·1	52·3	60·3	65·8	69·1	58·1
	Emerald (elev. 588 ft)												
Maximum (°F)	95·1	93·1	90·5	85·8	79·2	73·5	72·9	77·1	83·2	89·8	93·5	95·3	85·8
Mean (°F)	82·9	81·8	78·7	72·6	65·6	60·5	58·5	61·3	68·2	75·1	79·8	82·2	72·3
Minimum (°F)	70·7	70·1	66·8	59·3	51·9	47·5	44·3	45·5	53·3	60·5	66·0	69·0	58·7
	Springsure (elev. 1057 ft)												
Maximum (°F)	93·3	91·7	89·2	84·3	77·6	71·5	70·7	74·9	81·2	87·6	91·4	93·1	83·4
Mean (°F)	81·4	80·1	77·2	71·3	64·2	58·6	56·9	59·9	66·8	73·4	78·0	80·5	70·7
Minimum (°F)	69·4	68·6	65·3	58·5	50·8	45·6	43·1	45·0	52·3	59·2	64·5	67·9	57·5
	Tambo (elev. 1293 ft)												
Maximum (°F)	96·2	94·3	91·1	85·5	77·8	71·4	70·6	74·9	81·9	88·8	92·9	95·4	85·1
Mean (°F)	82·6	80·9	77·1	69·8	61·7	56·5	54·7	57·9	65·0	72·7	77·8	81·0	69·8
Minimum (°F)	68·9	67·5	63·0	54·1	45·7	41·7	38·7	40·8	48·1	56·6	62·9	66·5	54·5

* Data of the Bureau of Meteorology (1962).

TABLE 8

MEAN NUMBER OF DAYS WITH TEMPERATURES ABOVE AND BELOW SELECTED THRESHOLDS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
						Clermont							
Maximum ≥90°F	25·0	18·0	19·7	6·9	0·4	—	—	1·0	5·3	15·9	24·5	25·7	142·4
Maximum ≥100°F	9·1	3·0	1·9	0·2	—	—	—	—	0·2	0·6	3·4	9·5	27·9
Minimum ≤36°F	—	—	—	—	0·7	4·6	8·1	4·4	0·1	—	—	—	17·9
Minimum ≤32°F	—	—	—	—	0·1	0·8	2·0	0·9	—	—	—	—	3·8
						Emerald							
Maximum ≥90°F	23·4	17·4	16·1	4·7	0·2	—	—	0·3	3·2	12·5	21·5	26·1	125·4
Maximum ≥100°F	6·4	2·4	1·0	0·1	—	—	—	—	—	1·4	2·5	5·3	19·1
Minimum ≤36°F	—	—	—	—	0·3	3·9	5·9	3·4	0·1	—	—	—	13·6
Minimum ≤32°F	—	—	—	—	—	0·5	1·5	0·6	—	—	—	—	2·6
						Springsure							
Maximum ≥90°F	21·2	17·4	14·6	4·2	0·1	—	—	0·2	2·2	11·0	18·7	22·5	112·1
Maximum ≥100°F	4·9	3·1	0·9	—	—	—	—	—	—	0·9	2·6	4·7	17·1
Minimum ≤36°F	—	—	—	—	1·3	5·1	8·5	4·7	0·6	0·1	—	—	20·3
Minimum ≤32°F	—	—	—	—	0·1	1·8	3·5	1·6	—	—	—	—	7·0

* Data supplied by Bureau of Meteorology.

these two months. The frequency of very high maximum temperatures decreases considerably in February with increased cloudiness and rainfall. From an analysis of 25 years' data for Clermont, Skerman (1958) has found that "heatwaves" of 5 consecutive days or longer with temperatures over 100°F have occurred 3 times during November, 15 times during December, 26 times during January, and only 4 times during February.

Mean minimum temperatures range from about 40 or 45°F in July to about 70°F in January (Table 7). Although day temperatures are high throughout the winter, night-time temperatures are low owing to the inland situation of the area and the prevailing stable anticyclonic controls with intense nocturnal radiational cooling under prevailing clear skies. Frosts have occurred at all stations, and the risk of frost is appreciable between June and August over the southern half of the area (Table 8). Screen temperatures below 36°F have occurred as early as May and as late as September at both Clermont and Emerald. Such occurrences may be regarded as generally coincident with at least light frosts in the vicinity of the station (Foley 1945).

The mean length of the period between the first and last occurrences of screen temperatures below 36°F is 56 days at Clermont (June 14 to August 9) and 52 days at Emerald (June 21 to August 11). Screen temperatures below 32°F can be taken to represent widespread severe frost. These occur most often in July, but can be expected also during June and August. Minimum-temperature data for Charters Towers suggest that there is little risk of frost in the extreme northern portion of the area. The frequency and severity of frosts are closely related to the extent to which local terrain promotes a concentration of cold air within surface depressions. Hence the risk of frost is apt to be highly variable even within short distances, and areal variations in this risk cannot be assessed quantitatively in any detail from the limited macroclimatic data available.

(*c*) *Humidity*

Data included in Table 9 show the mean monthly humidity conditions at Charters Towers, Clermont, and Tambo. Data are also available for Emerald, but these are very similar to those for Clermont.

Mean monthly 9 a.m. vapour pressure data are of interest as an indication of seasonal trends in actual atmospheric water vapour content. The annual regime of this element follows closely that of mean rainfall, being highest in February and lowest in either July or August. As might be expected, vapour pressures decrease from east to west and from north to south.

There is only small seasonal variation in either the mean index of relative humidity (calculated from 9 a.m. vapour pressure and saturation vapour pressure at mean air temperature) or the mean 3 p.m. levels. During February and March the mean index of relative humidity ranges from nearly 70% in the extreme north to about 55% in the south-west. Lowest values occur during October and November when vapour pressures are comparatively low and temperatures are high; at this time the mean index of relative humidity ranges from about 58% in the north to about 48% in the south-west. The 3 p.m. relative humidities are approximately 20% lower throughout the year.

TABLE 9

MEAN MONTHLY DATA* FOR ELEMENTS OTHER THAN RAINFALL AND TEMPERATURE AT THREE STATIONS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Charters Towers							
9 a.m. vapour pressure (inHg)	0·718	0·724	0·668	0·574	0·477	0·428	0·380	0·408	0·470	0·539	0·604	0·665	0·555
Average index of mean relative humidity (%)	65	69	68	66	65	68	64	62	60	58	58	60	63
3 p.m. relative humidity (%)	46	50	49	46	48	52	47	44	38	35	37	39	44
Evaporation (in.)	7·73	6·13	5·55	5·15	4·30	3·53	4·01	4·94	6·09	9·44	9·39	8·08	74·34
						Clermont							
9 a.m. vapour pressure (inHg)	0·647	0·656	0·601	0·479	0·378	0·335	0·294	0·308	0·377	0·458	0·531	0·575	0·470
Average index of mean relative humidity (%)	58	63	63	61	61	65	61	57	55	52	52	54	59
Saturation deficit (inHg)	0·405	0·336	0·331	0·290	0·215	0·141	0·153	0·214	0·322	0·436	0·483	0·468	0·316
9 a.m. cloudiness (tenths)	3·5	3·9	3·2	2·2	2·2	2·6	1·8	1·5	1·8	1·9	2·5	3·0	2·5
Evaporation (in.)	8·27	6·62	5·73	5·08	4·27	3·41	3·86	4·70	6·01	7·73	9·00	9·38	74·06
						Tambo							
9 a.m. vapour pressure (inHg)	0·562	0·595	0·525	0·418	0·338	0·299	0·267	0·266	0·305	0·364	0·462	0·512	0·409
Average index of mean relative humidity (%)	50	56	56	57	61	65	62	55	49	45	48	48	53
3 p.m. relative humidity (%)	30	36	35	32	35	39	35	29	25	25	27	28	31
Evaporation (in.)	10·10	8·27	7·13	5·81	4·33	3·38	3·68	4·65	6·33	8·38	9·52	10·41	81·99

* Evaporation estimated by method of Fitzpatrick (1963) from mean maximum temperature, vapour pressure, and day length. Other data extracted or derived from data published by the Bureau of Meteorology (1962).

The mean monthly saturation deficits for Clermont give a general indication of the seasonal trends in the drying power of the air. High values occur between October and January. Saturation deficit is conspicuously lower in February and thereafter declines steadily to the low levels of June and July.

(*d*) *Cloudiness, Sunshine, and Radiation*

Cloudiness decreases from east to west throughout the year, and also varies from north to south in accordance with the seasonal rain influences. Between December and March, mean cloudiness at Clermont is over three-tenths, reaching a maximum of four-tenths in February. Between April and November, mean cloudiness is generally less than 2·5-tenths, increasing slightly in June and remaining less than two-tenths over the interval July to October.

Maps of duration of sunshine prepared by the Bureau of Meteorology (1954) show the mean duration of sunshine to be at a maximum in November (approx. 9 to 10 hr) and at a minimum in June (approx. 7·5 hr). Day length varies by about 3 hr during the year, being about 10·5 hr in June and about 13·5 hr in December.

No radiation data are available, but estimated mean total radiation (Bureau of Meteorology 1964) ranges from approximately 325 cal cm^{-2} day^{-1} in June to 635 cal cm^{-2} day^{-1} in November. Because of increased cloudiness, estimated mean total radiation decreases steadily from November onwards, with February, the cloudiest month, having averages ranging between 525 and 550 cal cm^{-2} day^{-1}.

(*e*) *Evaporation*

Evaporation measurements have not been made within the area, but estimates of evaporation from the Australian tank evaporimeter based upon mean maximum temperature and vapour pressure (Fitzpatrick 1963) have been made for the stations included in Table 7. Monthly and annual estimates for Charters Towers, Clermont, and Tambo are included in Table 9.

Areal differences in annual evaporation are small, the values ranging between about 71 in. at Springsure and 82 in. at Tambo. As well as a trend throughout the year toward higher estimated evaporation from east to west, there is a general increase in estimated evaporation southward during the summer months; this is in accord with the decrease in cloudiness and vapour pressure toward the south. Between December and March inclusive, the total estimated evaporation at Charters Towers is approximately 27 in., whereas at Tambo it is nearly 36 in. over this period. For all other months the estimated evaporation is remarkably uniform between stations. During June and July the estimates range between 3·5 and 4·0 in.; a rapid increase occurs during August, and the rates for September are everywhere greater than 6 in. per month. High evaporation rates prevail between November and January, and there is a marked reduction in February and March due to increased cloudiness and vapour pressure.

III. Acknowledgments

The author is grateful for the generous cooperation given by the Bureau of Meteorology and the Department of National Development in providing data, and to Mrs. A. Komarowski for assistance in carrying out computations.

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PART V. GEOLOGY OF THE NOGOA–BELYANDO AREA

By R. W. Galloway*

I. Introduction

In recent years the geology of this part of central Queensland has become much better known, thanks mainly to an extensive programme of geologic mapping at a scale of 1 : 250,000 undertaken jointly by the Commonwealth Bureau of Mineral Resources, Geology, and Geophysics and the Geological Survey of Queensland. Readers requiring fuller details of the area are referred to the maps and publications of the Commonwealth Bureau of Mineral Resources (Dickens, Malone, and Jensen 1964; Malone, Corbett, and Jensen 1964; Mollan, Exon, and Kirkegaard (unpublished data)†; Veevers *et al.* 1964*a*, 1964*b*) and to Hill and Denmead (1960), who summarize previous work.

The following outline of the geology is largely based on these sources. No detailed maps were available for the western one-third of the area and here the geology has been inferred from scattered observations and from air photographs. Formation names generally follow the 1: 500,000 geological map of the Bowen Basin (Preliminary Edition, 1965) published by the Commonwealth Bureau of Mineral Resources, Geology, and Geophysics.

II. General Geology

The survey area extends over six major structural units ranging in age from Precambrian to Mesozoic (Fig. 6). Each of these units has rocks of characteristic lithology, structure, and age, and consequently they form a convenient framework for describing the geology. These six units are the Anakie Inlier, the Drummond Basin, the Bulgonunna Block, the Bowen Basin, the Springsure Shelf, and the Great Artesian Basin. In addition the eastern half of the area forms part of the Tertiary Volcanic Province of eastern Australia and a wide range of Tertiary continental sediments and post-Tertiary alluvium occurs over much of the area (see geologic–geomorphic map). The stratigraphy is summarized in Table 10.

(*a*) *The Anakie Inlier*

The Anakie Inlier crops out as an elongated mass of metamorphic and granitic rocks which extends north by west for 180 miles from the vicinity of Anakie to the northern border of the survey area. The width of the inlier ranges from 10 to 40 miles. The rocks are the oldest in the area, ranging from possibly Precambrian to Middle Devonian. Both high-grade and low-grade metamorphics are present and the commonest

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† Mollan, R. G., Exon, N. F., and Kirkegaard, A. G.—The geology of the Springsure 1: 250,000 Sheet area, Queensland. Bur. Miner. Resour. Geol. Geophys. Aust. Rec. 1964/27 (unpublished).

lithologies include quartz greywacke, slate, phyllite, mica schist, quartz sandstone, and abundant quartz veins; there are also minor occurrences of volcanic rocks. As a rule, the metasediments are closely folded and strike north by west, parallel to the axis of the inlier as a whole.

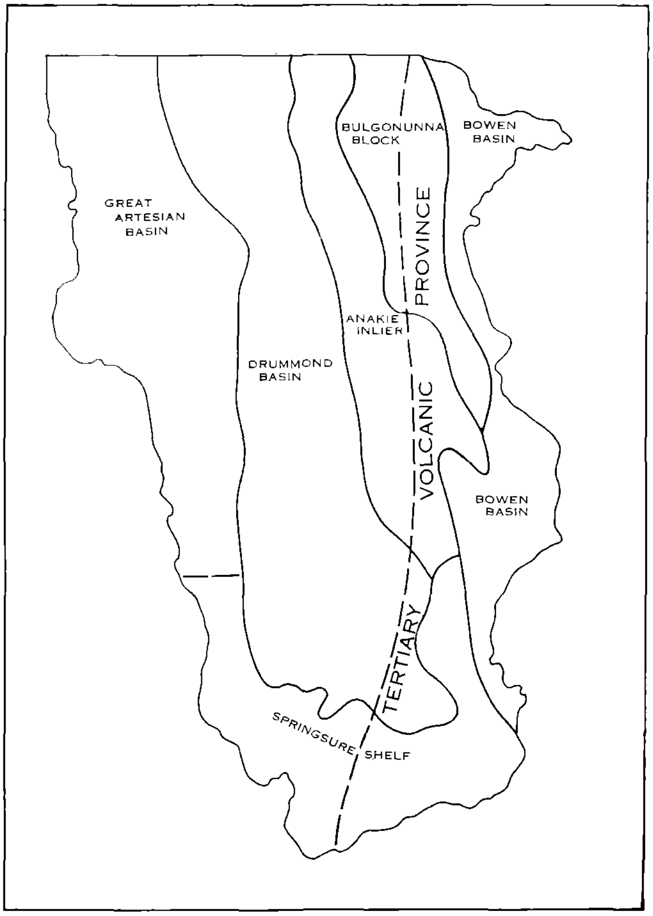

Fig. 6.—Major structural units.

West of Emerald, the metamorphics have been intruded by the extensive mass of the Retreat Granite which crops out over 600 sq miles. Granite is also associated with the Anakie Inlier in the extreme north. Smaller occurrences of granite and metamorphic rocks are exposed near Silver Hills and west of Springsure. Also west of Emerald, granite, metamorphic rocks, volcanics, and sandstones are exposed in the heart of two denuded anticlines and are correlated with the Anakie Inlier.

(*b*) *The Drummond Basin*

The Drummond Basin extends in a north–south direction for nearly 250 miles through practically the entire length of the area; the width exposed ranges from 20

TABLE 10

STRATIGRAPHY

Age	Location with Reference to Major Structural Units of Figure 6	Rock Units
Quaternary	Throughout the area	Younger alluvium Wind-blown sand Older alluvium
Tertiary	Throughout the area Tertiary Volcanic Province	Tertiary clay Tertiary sandstone Acid intrusives and extrusives Basalt plugs Basalt flows
Cretaceous	Springsure Shelf	Blythesdale Formation (?)
Jurassic	Springsure Shelf	Precipice Sandstone
Triassic	Springsure Shelf and Great Artesian Basin Springsure Shelf and Great Artesian Basin	Moolayember Formation Clematis Sandstone
Permian	Springsure Shelf Bowen Basin	Rewan Formation Black Alley Shale Peawaddy Formation Colinlea Sandstone Upper Bowen Coal Measures Middle Bowen Beds
	Unconformity	
Permian to Carboniferous	Drummond Basin	Joe Joe Formation
	Unconformity	
Carboniferous	Bulgonunna Block Drummond Basin	Bulgonunna Volcanics Ducabrook Formation Raymond Sandstone Mt. Hall Conglomerate
Upper Devonian	Drummond Basin	Telemon Formation Silver Hills Volcanics
	Unconformity	
Pre-Middle Devonian	Anakie Inlier	Retreat Granite Anakie Metamorphics

to 60 miles. It is occupied by a largely conformable sequence of sedimentary and volcanic rocks extending in age from Middle or Upper Devonian to Lower Carboniferous and attaining a maximum thickness in excess of 15,000 ft. The western and southern margins of the basin are concealed under younger rocks while to the east it laps over, or is faulted against the Anakie Inlier. Within the major basins are a number of subparallel folds striking broadly north–south and forming fairly narrow, steeply dipping, breached anticlines and wide shallow synclines.

The lower part of the Drummond Basin sequence in the area is largely made up of four units: all are relatively insignificant in terms of extent of outcrop. At the base are the Silver Hills Volcanics which crop out in a narrow belt on the south-western edge of the Anakie Inlier and in breached anticlines west of Springsure. These rocks comprise rhyolite, trachyte, agglomerate, tuff, conglomerate, sandstone, and shale. The overlying Telemon Formation is composed of conglomerate, lithic quartz sandstone, tuffaceous sandstone, claystone, and minor limestone. Similar rocks occur in a small area south of Clermont on the other side of the Anakie Inlier. Overlying the Telemon Formation is the quartzose Mount Hall Conglomerate of variable thickness, exposed in some of the anticlines within the Drummond Basin. It is in turn overlain by the finer-textured but still rather quartzose Raymond Sandstone.

Over these four relatively minor rock units lies the Ducabrook Formation which is the major unit of the Drummond Basin. The Ducabrook Formation crops out over some 4200 sq miles of the survey area, mainly on the western half of the Emerald and Springsure 1: 250,000 map sheets, and is up to 7000 ft thick. It consists of thick flaggy sandstones, mudstones, and tuff, generally moderately folded along north-north-west to south-east axes with dips up to 15°. The rocks tend to be softer and shalier in the south and on the western and eastern margins of the Drummond Basin while more-resistant sandstones predominate in the centre. In the north, dips are steeper and the sequence contains a higher proportion of quartzitic rocks, often further silicified by Tertiary weathering, as well as beds of resistant lavas.

Unconformably or disconformably overlying the Ducabrook Formation is the Joe Joe Formation of Upper Carboniferous to Permian age. This formation was deposited over the site of the Drummond Basin after a period of folding. It consists of a gently dipping sequence of lithic conglomerate, quartz–lithic crumbly yellow sandstone, siltstone, and minor shale; it is believed to be in part glacigene. The Joe Joe Formation crops out fairly extensively at the southern end of the exposed Drummond Basin. It is believed to extend well north of the railway line east of Alpha, but the exact extent of this formation, difficult at times to distinguish on the air photographs from the underlying Ducabrook Formation, is not known.

(*c*) *The Bulgonunna Block*

Volcanic rocks are exposed over an area of some 700 sq miles on the north-eastern side of the Anakie Inlier. They include intermediate to acid volcanics of Carboniferous age comprising rhyolite, andesite, tuff, and agglomerate, together with some intrusive rocks, greywacke, and siltstone. These are deeply weathered and poorly exposed in the western half of their occurrence and towards the south they are not readily distinguished from limited areas of Devonian to Carboniferous tuffs, porphyritic lavas, and conglomerates which crop out sporadically north of Clermont, and which are included in the Bulgonunna Block. Exposures are better in the eastern half where they form a distinctive area of extremely rocky low hills. The volcanics are folded and faulted, with well-developed joints and fractures. A few small occurrences of granitic rocks north-east of Mt. Coolon are included in this unit.

(*d*) *The Bowen Basin*

The western edge of the Bowen Basin occupies the eastern margin of the survey area. The rocks are Permian sediments, for the most part poorly exposed. From Capella southwards the rocks are mainly quartzose and include pebbly sandstone, sandstone, and siltstone with some minor shale. North of Capella the Bowen Basin rocks are even more poorly exposed but lithologically more variable and include lithic sandstone, lithic siltstone, greywacke, and shale. A small outlying area of sandstone, shale, and coal forms the Blair Athol coalfield near Clermont. The Bowen Basin rocks in the survey area are either gently folded or undisturbed.

(*e*) *The Springsure Shelf*

The Springsure Shelf is an area of Permo–Triassic sediments which loops round the southern end of the Drummond Basin with gentle dips to the south, south-west, and west. Cross folding and possibly faulting occur in the Fairview area.

At the base of the sequence is a thin shaly formation unconformably overlying the uppermost (Joe Joe) formation of the Drummond Basin. Above the shale is the thick Colinlea Sandstone, which is quartzose with a kaolinitic matrix. This resistant formation forms high, rugged country. Above the Colinlea Sandstone is the rather weak Peawaddy Formation, comprising lithic quartz sandstone, carbonaceous siltstone, and lenticular coquinite. The overlying Black Alley Shale is of terrestrial origin and is partly tuffaceous. Over it is the Rewan Formation which forms the basal unit of the Triassic sequence; it consists of multi-coloured, lithic, silty sandstone, mudstone, and shale and becomes increasingly sandy westwards. This is in turn overlain by the Clematis Sandstone, which is generally quartzose and resistant but which south of Mantuan Downs is rather weaker with a finer texture and a good deal of mica. Next is the Moolayember Formation which consists of weak carbonaceous shales with occasional beds of calcareous sandstone and some quartzose sediments towards the base. It forms a lowland overlooked by the prominent scarp developed in the overlying Jurassic quartz Precipice Sandstone. The Precipice Sandstone forms the south-western boundary of the survey area except at Mt. Playfair in the extreme south-west where a small area of still younger Cretaceous sandstone, probably part of the Blythesdale Formation, is included.

(*f*) *The Great Artesian Basin*

The limits of this structural unit have not been clearly defined in the survey area, particularly vis-à-vis the Springsure Shelf. For the present purpose it is taken to comprise the Permian to Jurassic sediments which unconformably overlie the western edge of the Drummond Basin north of the central railway line. Here exposures are poor on account of an extensive cover of younger Cainozoic sediments and the effects of deep weathering. It is clear, however, that there is a more or less conformable sequence of sediments dipping very gently westwards. The rocks are apparently continuous with the better-exposed Springsure Shelf sequence to the south-east. The quartzose Colinlea Sandstone and Clematis Sandstone form low interfluves while broad vales, largely filled with Cainozoic sediments, are most probably developed along the strike of shaly rocks corresponding to the Peawaddy Formation, Black Alley Shale, and Rewan Formation. Gentle cross-warping may have been responsible for the formation of the closed basins occupied by Lakes Galilee and Buchanan, although other explanations are possible (see Part VI).

(*g*) *Tertiary Volcanics*

Tertiary volcanic rocks, both intrusive and extrusive, are widely distributed in the eastern half of the area, with an outlying occurrence at Surbiton about 40 miles north of Alpha.

The extrusive rocks are dominantly olivine basalt which still forms extensive sheets but which was formerly much more widespread. Small surviving outliers indicate it may once have covered fully half the entire area. The maximum thickness exceeds 1000 ft on the Buckland Tableland in the south-east but generally the surviving flows are much thinner, averaging perhaps 50 ft. The original thickness of the basalt was probably very much greater. The age of the basalt is probably Lower to Middle Tertiary, but there were at least two phases of basalt extrusion separated by an interval of weathering and erosion which may have been prolonged. The character of the country on both fresh and weathered Tertiary basalt, as expressed in vegetation and soils, is so distinctive that it is represented by special categories on the geologic–geomorphic map.

The Tertiary intrusive rocks fall into three main groups.

(i) In the north-east, on the divide between the Belyando and Isaac Rivers, a series of acid intrusive plugs rise steeply as much as 1000 ft above the surrounding country to form the Peak Range. A trachyte flow capping Lords Table Mountain is probably associated with the same volcanic activity.

(ii) North-west of Emerald a considerable number of steep basalt plugs rise from the generally undulating surface of the Retreat Granite.

(iii) Just north of Springsure is a complex of Tertiary acid plugs, domes, and dykes. A trachyte flow capping Mt. Zamia just north of the town is probably associated with this volcanism.

(*h*) *Tertiary Sediments*

The Tertiary rocks comprise quartz sandstone and conglomerate, argillaceous quartz sandstone, sandy claystone, gravelly clay, clay, laterite, secondary limestone, and billy quartzite. These rocks have been produced by weathering, erosion, and deposition acting largely within the confines of the area. At one time they extended over practically the entire area and although later erosion has largely removed them in the south they still form the most extensive group of rocks, as can be seen from the geologic–geomorphic map.

Quartz sandstone with marked current bedding occurs in the north-east round the Bulgonunna Volcanics. The argillaceous quartz sandstone and sandy claystone cover about 8000 sq miles (nearly one-quarter of the entire area) chiefly in the western half of the area. Associated with these rocks in the north-west are extensive, very gently sloping, outwash fans of sand, silt, and clay.

The Tertiary clays are often hard to distinguish from deeply weathered older rocks, from which they are in fact derived, but they probably cover between 2000 and 3000 sq miles and are widely distributed in lowland sites throughout the area except in the south. They are usually mottled and acid at depth and contain minor amounts of quartz gravel and ironstone fragments. The clays between Pinehill and Craven are particularly gravelly and possibly derive in part from the break-down *in situ* of Joe Joe conglomerate or originated as gravelly fans laid down at the foot of high sandstone ranges to the south-east. Corresponding gravelly Tertiary deposits are found in the Willows area on the other side of these ranges. In the Diamond Downs–Avon Downs area between Clermont and Mt. Coolon, the clays were laid down by streams dissecting deeply weathered basalt, are usually less acid, and usually contain abundant gypsum. Undulating, practically stone-free clay sheets around Natal Downs are lithologically similar but of uncertain age and origin.

Laterite, often consisting of a cemented ferruginous rubble, is widespread, particularly in the west. At one time it probably occurred over most of the area but it has been extensively removed by erosion.

Secondary limestone occurs on deeply weathered basalt east of Clermont. Silicification of older rocks is common under the basalt and in deep weathered profiles. The silicified horizons when exposed by later erosion have broken down to form spreads of billy gravel.

Over most of the area the Tertiary sediments are only from 10 to 50 ft thick. In the west, however, they reach greater thicknesses in vales developed along the shales in the Permian, Triassic, and Jurassic rocks. Here depths of 200 ft or more have been revealed by later dissection and in bores.

(*i*) *Post-Tertiary Alluvium*

Riverine alluvium is extremely widespread, particularly along the major streams such as the Belyando and Mistake Creek where it is up to 10 miles wide. The alluvium shows the normal variations in texture according to the position in relation to levees, channels, terraces, and back swamps. Older and younger alluvia are present. Stabilized dunes and wind-blown sand sheets are associated with the sandy older alluvium in the west of the area.

III. Geologic History

At some time previous to the Devonian, possibly long before, sediments were laid down, then folded, intruded, and metamorphosed. In the Lower and Middle Devonian, sediments were deposited adjacent to the older rocks, and were folded with them and intruded by the Retreat Granite to form the Anakie Inlier. After a brief period of erosion Devonian to Carboniferous rocks were deposited in the Drummond Basin west of the Anakie Inlier and to the east of the Inlier as well. In the north-east the volcanics of the Bulgonunna Block, and in the west the Joe Joe Formation, were deposited somewhat later. The latter part of the deposition in the Drummond Basin was accompanied and followed by moderate folding along broadly meridional lines.

After deposition of the Drummond Basin rocks a further period of erosion was followed by deposition of the Permian Bowen beds in the east and the Permian to Jurassic sediments of the Springsure Shelf and the Great Artesian Basin in the south and west. These rocks were thrown into gentle, approximately meridional folds in the east and tilted very gently to west and south elsewhere. Some folding and possibly faulting along a north-east axis occurred in the Fairview area.

Prolonged erosion in later Mesozoic times was followed in the Tertiary by a complex series of events in which depositional phases alternated with erosional phases. The basalt was probably poured out early in the Tertiary, followed by the Tertiary intrusions, then by deposition of the sandy and argillaceous terrestrial sediments, deep weathering and the development of laterite, dissection, and further deposition of detrital sediments. There was undoubtedly much overlapping between these various stages, which are discussed more fully in Part VI. Tectonic activity in the Tertiary was probably limited to some regional uplift of the Buckland Tableland in the extreme south-east, and localized disturbance in the immediate vicinity of the Tertiary intrusions.

In post-Tertiary times alluvium accumulated along the rivers, interrupted by a phase or phases of dune and wind-blown sand formation.

IV. Lithology and the Land Systems

It is, of course, obvious that the nature of the underlying rock is a prime factor in determining the character of the land. In this respect it is lithology rather than stratigraphy that is important and consequently rocks of widely differing age can be regarded as similar when considering land systems in relation to geology. Furthermore, as pointed out in Parts III and VI, Tertiary deep weathering can effectively alter the lithology and has gone far towards imposing a unity on diverse rocks. It is therefore necessary to divide many lithologic groups into two types: fresh, or little weathered, and weathered. It should be noted that the fresh rocks have been exposed by removal of the overlying weathered profile and/or Tertiary sediments and that traces of the basal part of the weathering zone or patches of Tertiary sediments often survive.

Seven broad geologic categories have been recognized and these are listed in the first column of Table 11 and utilized in the key to the geologic–geomorphic map. These broad categories can be further divided into 15 lithologic types listed in the second column of Table 11 and described below. These 15 types are generally associated with groups of related land systems. However, some land systems contain more than one lithologic type either because a particularly dominant soil or vegetation imposes a unity transgressing geologic boundaries (e.g. lancewood) or because the occurrences of each lithology are too small to be mapped individually (e.g. most of

Disney land system). In the latter case, variations in lithology are usually reflected in the breakdown into land units within the land system rather than in distinctions between land systems.

(*a*) *Pre-Tertiary Rocks* (*Little Weathered*)

(i) *Metamorphics of the Anakie Inlier.*—Close dissection with short, fairly steep slopes, shallow soils, and abundant angular surface gravel derived from quartz veins characterize Copperfield land system which is developed on this rock.

(ii) *Retreat Granite.*—Rolling country with occasional low rocky tors and patches of weathered rock on the divides and rather narrow valleys typifies the Peak Vale land system developed on this rock. The soils are deeper than on the metamorphics of the Anakie Inlier but some vein quartz gravel occurs on the surface in places. Part of Hope land system is on granite associated with the Anakie Inlier in the north.

(iii) *Bulgonunna, Silver Hills, and Related Volcanics and Tertiary Intrusives.*—The volcanics have proved remarkably resistant to deep weathering and often rise above much more weathered lowlands. Extremely rocky low hills characterize the Borilla land system which is found on these rocks. Part of Percy land system occurs on the Tertiary intrusives and is likewise extremely rocky but with a greater range of relief.

(iv) *Drummond Basin Sediments.*—A considerable variety of land systems exists on these rocks. Where the more resistant sandstones crop out there are rocky, steep hills and mountains with skeletal soils, forming Bogantungan, Hope, and parts of Portwine and Carborough land systems. Where the sediments are more shaly, the country is lower and forms Rutland and Craven land systems and lower parts of Portwine land system. Throughout, benches and weakly developed scarps have formed in response to structural variations within the dipping strata. The tree vegetation is often in groves and glades parallel to the strike and reflecting variations in the lithology of the underlying folded sedimentary rocks.

(v) *Mixed Sediments.*—A wide range of rocks is found in this rather ill-defined lithologic type which includes formations of Late Carboniferous (Joe Joe) to Late Triassic (Moolayember) age. Generally the rocks are neither highly quartzitic nor especially rich in readily weatherable minerals. Lowlands and plains with a considerable range of vegetation and moderately deep soils characterize this lithologic unit. The major land systems on this lithologic unit are Wharton, Skye, Cungelella, Hillalong, some Hope, and a little Craven and Monteagle. A close correspondence has been noted between the presence of the Moolayember and Rewan formations and the occurrence of brigalow–wilga scrubs.

(vi) *Permian Shales.*—These shales are thicker, more extensive, and generally give rise to better soils than other shales in the area and consequently form a distinct group.

The soft, carbonaceous or calcareous nature of the Black Alley Shale and part of the Peawaddy Formation which comprise this lithologic unit gives rise to the rolling downs and deep soils that characterize the Mantuan land system. Parts of the softwood scrub of Kareela and Cungelella land systems are also found on this lithologic unit.

TABLE 11

GEOLOGY AND THE LAND SYSTEMS

Broad Geologic Category	Lithologic Type and Weathering Status	Formation and Age	Land Systems Solely or Dominantly on this Lithology	Land Systems Partially on this Lithology
Pre-Tertiary rocks (little weathered)	Metamorphics (little weathered): quartz greywacke, slate, phyllite, mica schist, vein quartz	Anakie Metamorphics: ?Pre-Cambrian to Middle Devonian	Copperfield	
	Granite (little weathered)	Retreat Granite: Devonian	Peak Vale	Hope
	Volcanics (little weathered): rhyolite, andesite, tuff, agglomerate, trachyte	Silver Hills Volcanics: Devonian Bulgonunna Block: Carboniferous Intrusives: Tertiary	Borilla	Percy
	Drummond Basin sediments (little weathered): sandstone, mudstone, tuff, conglomerate	Telemon Formation: Devonian Raymond Sandstone: Carboniferous Ducabrook Formation: Carboniferous	Rutland, Hope, Portwine, Bogantungan, Craven	Carborough
	Mixed sediments (little weathered): lithic sandstone, shale, tuff, carbonaceous shale, mudstone	Joe Joe Formation: Carboniferous to Permian Bowen Basin sediments: Permian Rewan Formation: Triassic Moolayember Formation: Triassic	Wharton, Skye, Cungelella, Hillalong	Hope, Craven, Monteagle
	Permian shales (little weathered): tuffaceous and carbonaceous shale, coquinite	Black Alley Shale: Permian Peawaddy Formation (part): Permian	Mantuan	Kareela, Cungelella
	Quartz sandstone (little weathered)	Mt. Hall Conglomerate: Carboniferous Colinlea Sandstone: Permian Peawaddy Formation (part): Permian Clematis Sandstone: Triassic Precipice Sandstone: Jurassic Blythesdale Formation: Cretaceous	Playfair, Carborough	Durrandella

Pre-Tertiary rocks (weathered)	Pre-Tertiary rocks (weathered)	Part of all pre-Tertiary formations	Loudon	Hope, Ulcanbah, Disney, Humboldt, Durrandella, Monteagle
Tertiary basalt (little weathered) Tertiary basalt (weathered)	Tertiary basalt (little weathered) Tertiary basalt (weathered)	Basalt (no formation name): Tertiary Basalt (no formation name): Tertiary	Oxford, Waterford, Percy Kinsale, Wondabah	Kareela
Tertiary sandstone (weathered)	Tertiary sandstone (weathered): quartz sandstone, conglomerate, sandy claystone	Conglomerate, sandstone, and claystone (no formation name): Tertiary	Lennox, Ronlow, Tichbourne, Degulla	Durrandella, Monteagle, Pinehill
Tertiary clay	Tertiary acid clay (weathered) Tertiary gypseous clay (weathered?) Tertiary gravel (weathered)	Clay (no formation name): Tertiary Clay (no formation name): late Tertiary Gravelly clay (no formation name): Tertiary	Islay, Humboldt, Blackwater, Somerby Moray, Avon Willows	Ulcanbah Disney, Humboldt, Pinehill
Post-Tertiary alluvium	Alluvium	Sand, silt, and clay (no formation name): post-Tertiary	Comet, Banchory, Funnel, Alpha, Galilee	Mantuan

(vii) *Quartz Sandstone*.—This extremely resistant lithologic unit naturally gives rise to rugged terrain with shallow soils. Benches, cliffs, and deep, narrow valleys are characteristic of Carborough land system on this lithology. In the south-west of the survey area erosion has in places stripped off a softer overlying formation but has not deeply bitten into the quartz sandstone, and consequently undulating terrain with shallow sandy soils has resulted (part of Playfair land system). Less resistant sandstones in the extreme south-west give rise to deeper sandy soils in the same land system.

(*b*) *Pre-Tertiary Rocks* (*Weathered*)

A great variety of rocks exists in this category but deep weathering has imposed a uniformity of soils and vegetation, as pointed out in Part III. Relief is generally gently undulating but both plains and hills are included. Most of Loudon land system and parts of Humboldt, Durrandella, Disney, Hope, Ulcanbah, and Monteagle land systems occur on this lithologic unit.

(*c*) *Tertiary Basalt* (*Little Weathered*)

Rolling downs and low, flat-topped hills with benched slopes predominate on Oxford and Waterford land systems. Some traces of a former cover of deeply weathered basalt are still preserved and the soils are consequently reddish rather than the black colour associated with completely fresh basalt. Nodules, veins, and irregular masses of carbonate, gypsum, and silica are common in the subsoil and in the underlying bed-rock. Rather similar country is developed in the volcanic Dunstable Formation which crops out in two small areas west of Springsure. In the extreme south-east, uplift of the Buckland Tableland has enabled dissection to cut deeply into, and through, a thick basalt layer which now forms irregular plateaux bounded by cliffs and steep slopes making up most of Percy land system. The lower part of these slopes where erosion has cut through the basalt into the underlying shales comprises slumped areas mantled with basalt debris which form the major part of Kareela land system.

(*d*) *Tertiary Basalt* (*Weathered*)

Although this lithologic category is much more weathered than the little-weathered basalt, the originally basic nature of the rock still has an effect and soils and vegetation differ markedly from those on other deeply weathered rocks. Lowlands and plains with brigalow, gidgee, and softwood scrub are characteristic (Kinsale and Wondabah land systems).

(*e*) *Tertiary Sandstone* (*Weathered*)

This very extensive lithologic type ranges from quartz sandstone to sandy or gravelly claystone. It is mostly associated with laterite which is exposed in depressions and at breakaways. Relief is level to gently undulating with low knolls where harder rocks protrude through the Tertiary cover. Locally, where dissection is active, steeper slopes and scarps are found. Sandy or loamy soils predominate. Lennox, Ronlow, and Tichbourne land systems are almost exclusively developed on this lithologic type. Degulla land system consists of similar country on extensive, very gently sloping fans derived from the Tertiary sandstone. Monteagle and Pinehill land systems are mainly on a rather argillaceous facies of the Tertiary sandstone while the relevant portions of Durrandella land system are associated with the steeper scarps and breakaways.

(*f*) *Tertiary Clay*

(i) *Tertiary Acid Clay.*—This very extensive lithologic category is associated with plains and lowlands with deep soils and dense scrubs of brigalow or gidgee. Gravel is common in this material and gilgai microrelief occurs in the lower sites. Islay, Blackwater, and Somerby land systems and much of Ulcanbah land system are mainly on this clay.

(ii) *Tertiary Gypseous Clay.*—This practically stoneless clay generally underlies the rolling grassland and scrubs of gidgee and brigalow which make up Moray and Avon land systems. It probably owes its frequently alkaline nature to the extremely base-rich rocks (basalt and possibly shale) from which it has been derived. Some of the bases seem to persist despite Tertiary weathering and the subsequent vicissitudes of erosion and deposition.

(iii) *Tertiary Gravelly Clay.*—This small lithologic unit consists of billy and quartz gravel in a matrix of clay or sand. The undulating Willows land system with its extremely gravelly soils is restricted to this category which also forms stony parts of Disney, Humboldt, and Pinehill land systems.

(*g*) *Post-Tertiary Alluvium*

Extensive spreads of alluvium accompany the major streams. Fine-textured alluvium forms Comet, Banchory, and Funnel land systems while Alpha land system is on somewhat coarser material including wind-blown sand derived from old levees. This lithologic unit includes playa clay plains and silty or sandy shore-line features at Lakes Galilee and Buchanan (Galilee land system). Of course, small areas of alluvium occur in all other land systems.

V. Structure and the Land Systems

Structural variations within the lithologic types have not proved significant in defining the land systems but they are responsible for many landscape features of a lower order of significance. Flat or nearly flat-bedded rocks such as the Tertiary sandstone, Tertiary basalt, and the Ducabrook sediments north of Bogantungan give rise to plateaux and hills with benched slopes. Moderately dipping sediments of contrasted resistance produce scarps, particularly well developed round the anticlines west of Springsure, while steeply dipping Ducabrook sediments north of Mt. Douglas give rise to linear strike ridges and vales. The highly folded nature of the metamorphic rocks in the Anakie Inlier, however, is not significantly reflected in the relief and these rocks tend to behave as a homogeneous mass. Abundant faults and fractures in the Bulgonunna Block, on the other hand, contribute to the marked irregularity of the relief on these rocks by favouring a close network of dissecting valleys.

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PART VI. GEOMORPHOLOGY OF THE NOGOA–BELYANDO AREA

By R. W. GALLOWAY*

I. PHYSICAL REGIONS

Eight physical regions may be distinguished on the bases of relief and geology (Frontispiece and Fig. 7). Each of these regions is, of course, a complex of subregions and only the major features are here described. It should be emphasized that the names used for these regions refer only to the area covered by this report and are not to be regarded as proper names.

(*a*) *Western Plains and Tablelands*

This region occupies the western portion of the area and extends from the northern border to a few miles south of Alpha. It coincides with the Great Artesian Basin structural unit discussed in Part V. Most of the region consists of plains and gently undulating low tablelands covered by Tertiary detrital rocks and laterite. Where harder formations occur in the underlying Permian, Triassic, and Jurassic sediments low ranges rise a few score to a few hundred feet, usually with very gentle slopes but locally with extremely dissected, broken forms where erosion has pierced the widespread Cainozoic cover. Below these ranges are extensive, confluent, low-gradient fans several miles across with shallow, inactive, anastomosing channels. Some patches of deeply weathered clays and shales are exposed and give rise to dense scrub on heavy soils. In the north-west, Lakes Galilee and Buchanan lie in extensive, shallow, closed basins. At present they hold water only in wet seasons but they are fringed by shore-lines formed at times when the water level was 10 to 40 ft higher than now; their beds are occupied by saline clay flats inundated in wet seasons. Major streams within this physical region tend to have fairly wide alluvial flats with clearly developed levees.

(*b*) *Northern Hills*

This area has broken relief and a variety of topographic types reflecting the complex geology and the varying extent of Cainozoic erosion, sedimentation, and deep weathering. In the west is a series of steep, parallel ridges 20 to 200 ft high, running more or less north–south, which have been exposed by removal of a former cover of Tertiary sediments and which are separated by strike vales up to a mile wide. Also in the western part is a group of dissected hills on Ducabrook Sandstone north of Bulliwallah. In the centre is a belt of lower undulating country on little-weathered granite and rather more weathered metamorphics with occasional hills coinciding with more resistant outcrops. To the east, this gives way to extremely rocky low hills on the Bulgonunna Volcanics with local relief from 50 to 300 ft. The fringes of the Bulgonunna Volcanics are covered by remnants of a formerly extensive sheet of Ter-

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tiary sandstone. These remnants form low to high mesas, particularly well developed on the north-west side of the Bulgonunna Volcanics (Rottenstone Range) and on the north-east (part of Leichhardt Range). In the extreme east relics of the Tertiary mesas overlook weathered basalt on which undulating country has been cut subsequent to the removal of the Tertiary sandstones.

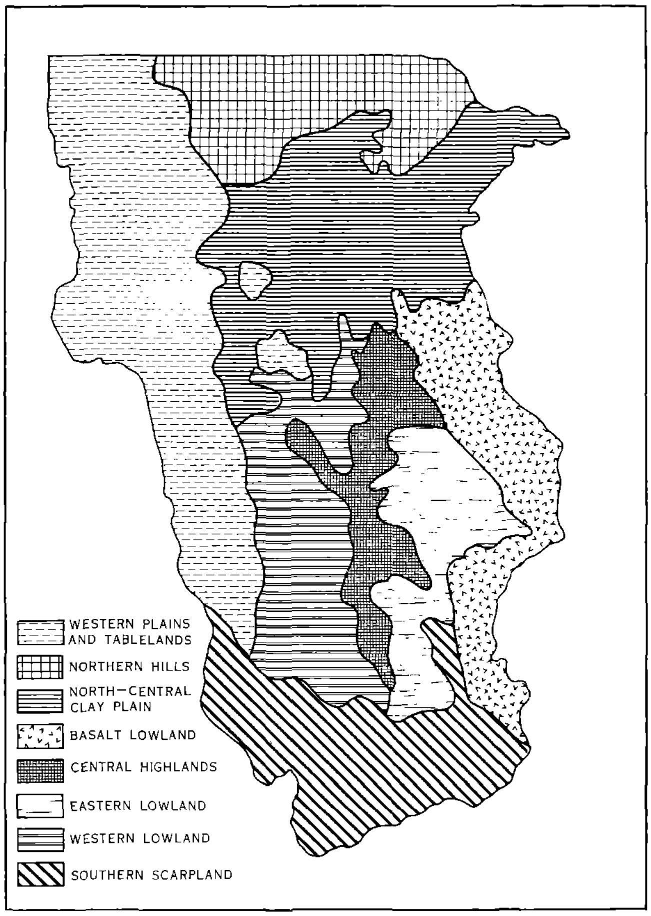

Fig. 7.—Physical regions.

(c) *North-central Clay Plain*

Clay plains and lowlands are widespread from the latitude of Clermont north to the northern hills. Much of the clay is associated with deep weathering profiles on Tertiary claystone and older rocks and tends to be acid at depth. More alkaline clay spreads are formed by extensive fans around Diamond Downs derived from weathered basalt. Extensive clay sheets of uncertain origin, generally alkaline, also occur near Natal Downs and Moray Downs. Major rivers have broad alluvial flats up to 10 miles wide, and flood extensively.

(*d*) *Basalt Lowland*

Along the eastern margin of the area, erosion has formed an extensive rolling lowland in Tertiary basalt. Isolated mesas of basalt and volcanic plugs rise steeply 100 to 1500 ft above the lowlands. Fine-textured alluvial flats margin most streams.

(*e*) *Central Highlands*

A block of higher country, ranging from low hills to low mountains, with local relief from 100 to 1500 ft extends nearly north–south from the vicinity of Cairo homestead to just south of Mt. Portwine. The height and form of these highlands vary considerably according to the geology. In the north, they consist of undulations and low hills on the Anakie Inlier and on a partial cover of Tertiary sediments. In the centre, the Anakie rocks are less weathered, much more closely dissected, and form steeper country with local relief up to 500 ft such as occurs west of Clermont. In the south, the highland is formed by resistant elements in the Drummond Basin rocks together with some granite. The highest point of the central highlands—Mt. Tabletop, rising to 2700 ft—lies in this southern sector. The surviving effects of Tertiary deep weathering decrease from north to south and are hardly apparent in the southern sector. For much of their length the central highlands coincide with the Drummond Range, which is the divide between the Nogoa and the Belyando Rivers.

(*f*) *Eastern Lowland*

This lowland belt lies on the eastern side of the central highlands and extends from Clermont south to the Nogoa River. It is developed on a variety of rocks and includes rolling country on granite and basalt, and undulating to low hilly country on Permian quartzose sediments. Extensive remnants of Tertiary deep weathering profiles and Tertiary sediments survive around Anakie. On the moderately dipping Ducabrook rocks low, ill-defined scarps have developed. Quartz gravel, derived from the Anakie Inlier and Retreat Granite, is common. Limited areas of much steeper country lie west of Springsure where anticlines have brought up resistant quartz sandstone and volcanic rocks on which steep strike ridges have developed. Fairly wide alluvial flats extend along the major streams.

(*g*) *Western Lowland*

This lowland belt extends from Narrien south to Joe Joe homestead where it coalesces with the southern end of the eastern lowland. It is characterized by low undulating relief for the most part, with weakly developed scarps and strike ridges formed on the moderately dipping sedimentary rocks of the Drummond Basin. A number of rugged ranges coincide with anticlines which bring up the underlying more resistant rocks, and consist of steep strike ridges and cuestas with local relief up to 1200 ft. The central part of this lowland north-east of Alpha is characterized by spreads of gravelly clay. Considerable portions of this region are occupied by gently undulating surfaces on Tertiary sandstone. Some of the major rivers crossing this area have very wide alluvial flats, but others are somewhat incised and their alluvium is not extensive.

(*h*) *Southern Scarpland*

The southern scarpland loops in an arc around the southern end of the survey area from Alpha to Vandyke and coincides with the structural division known as the Springsure Shelf (Part V) in which conformable sedimentary strata dip gently west or south. Over most of this physical region the major products of Tertiary deposition and deep weathering have been stripped off and the lithology of the underlying rocks consequently largely determines the character of the country.

There is an alternation of broken, dissected hills on the resistant sandstone formations and undulating lowlands on the weaker shaly formations. Only moderately extensive alluvial flats are present on the softer rocks while on the harder the streams flow in defiles with very narrow sandy alluvial flats.

The eastern end of the scarpland is overlain by thick Tertiary basalt part of which forms the Buckland Tableland, the highest ground in the survey area, rising to about 3500 ft. Deep valleys dissecting the tableland are fringed by enormous slumps.

II. Drainage

The Nogoa River draining the south-eastern third of the area flows from south-west to north-east; its most notable tributaries are Theresa Creek, draining an extensive area south-west of Clermont, and Vandyke Creek, which flows north from the high Buckland Tableland in the extreme south. The Nogoa is part of the Fitzroy drainage system which reaches the sea at Rockhampton to the east. The Belyando River, which drains the remaining two-thirds of the area, receives several large tributaries: Alpha Creek from the south, Mistake Creek from the south-east, and the Suttor River from the east. The Belyando flows northwards to join the Burdekin River system, which debouches at Townsville to the north of the survey area. In the north-west of the area are two basins of internal drainage centring on Lakes Galilee and Buchanan. The western boundary of the area is part of the continental divide separating areas that drain to the Pacific Ocean from areas draining towards the Lake Eyre basin.

III. Geomorphic History

The decipherable history of the landscape extends from late Mesozoic times to the present day. Eight major stages can be discerned, though the earlier are poorly known and there was probably considerable overlap between events treated here, for clarity, as discrete.

(*a*) *Pre-basalt Erosion*

A prolonged period of erosion extended through late Mesozoic and early Tertiary times until terminated by great outpourings of basalt. During this period hundreds or even thousands of feet of rock were removed. Some of that ancient landscape was preserved under the basalt and its general form can be reconstructed where thin, scattered patches of the protective basalt cover survive, notably in the south and east. It appears that the pre-basalt landscape was mainly gently undulating. The southern scarpland physical region was a lowland from which rose only low scarps on the harder rocks. Possibly the scarps had not been worn back to their present position and lay further to the north and east. The eastern lowland physical region consisted of undulating country similar to its present form. Relics of a valley system resembling the present one in scale and depth are detectable in the Emerald area. Scraps of basalt in the western lowland physical region at Surbiton and high on the central highlands suggest that these two major features already existed, though the possibility of post-basalt tectonic disturbance, or that the Surbiton basalt is much younger, cannot be ruled out. Overall, it appears that a broad valley drained northwards more or less along the line of the present Belyando but that it extended farther south than it does today over what is now the upper Nogoa catchment. East of the Anakie Inlier the land probably drained eastwards, while in the extreme west drainage was probably westwards towards the Great Artesian Basin.

(b) Basalt Flows

The next major phase in the history of the landscape was the outpouring of great basalt flows in lower to middle Tertiary time. At their maximum extent they covered at least the eastern half of the area, possibly to an average depth of several hundred feet. The presence of intervening sediments suggests that the extrusion of the flows took place during at least two periods, separated by an interval of erosion and deposition which was perhaps prolonged.

(c) Post-basalt Erosion

The phase of basalt flows was followed by a prolonged period of erosion in middle Tertiary times. At first the rivers removed the products of weathering and erosion completely, and the overall surface was significantly lowered. Much of the basalt was stripped off or reduced to relatively thin sheets such as those east of Clermont. Only on the Buckland Tableland in the extreme south was the basalt extensively preserved, suggesting that this area was not yet uplifted to its present altitude. On the pre-basalt rocks erosion was largely controlled by contrasts in lithology. On the gently dipping sediments of the Great Artesian Basin and Springsure Shelf the softer beds were excavated to form vales, leaving the harder to survive as scarps. In the northern hills physical region strike vales were excavated along relatively unresistant, steeply dipping beds of the Ducabrook Formation while harder beds stood up several score to several hundred feet as steep strike ridges.

(d) Post-basalt Deposition

Erosion continued to operate during this phase but its effect on the landscape changed significantly in that the resulting debris was no longer exported from the area but largely accumulated on the lowlands to form the varied Tertiary sediments while only the higher areas continued to be worn down. The scarplands to the south and west, having been previously accentuated, were now diminished as detritus from the scarps filled vales at their feet: this process went so far that some scarps were drowned in their own debris. It is possible that the detritus accumulated rapidly enough to block the valleys draining what are now the sites of Lakes Galilee and Buchanan and so created the closed depressions without the intervention of earth movements (cf. Part V). In the north-eastern hills the ridge-and-vale topography formed in the previous phase was bevelled off with debris choking the valleys while erosion lowered the ridges. The central highlands shed gravel and finer detritus onto adjacent parts of the eastern and western lowlands. It is possible that the clay sheets at Natal Downs and Moray Downs were deposited at this time and represent material derived from shales which were then exposed below the sandstone scarp to the west and which are now largely concealed by later detritus. Alternatively, the Moray Downs–Natal Downs clay sheets may actually be these shales *in situ* but extensively altered by deep weathering.

While the Tertiary sediments accumulated to a depth of several hundred feet below steep scarps in the west and south, as a rule their thickness is of the order of 10 to 50 ft. As indicated in Part V there is a wide variety of lithologies in the Tertiary rocks which can be correlated in part with the source area. Sandstones tended to furnish sandy or loamy sediments, conglomerates formed gravelly sediments, while shales and basalt supplied clay. At many localities, however, there is an upward succession from clay-rich to sand-rich material implying some change in the nature of the sediment supply, possibly related to changes in weathering of the source area. It is reasonable to believe that the change from clayey to sandy detritus and the change from export to retention within the area of eroded material were related to a common cause in a reduced or changed incidence of precipitation at some time during the second half of the Tertiary. Gravel is particularly common in the Tertiary rocks near present-day major rivers, suggesting that the latter already existed at this time and were capable of transporting larger material than they can today when bed loads coarser than sand are rare. There may have been violent, if brief, seasonal periods of run-off. As is to be expected, the finer sediments were carried further than the coarser and consequently the Tertiary clays are more widespread and are often found without a cover of the later sandier material, e.g. in the north-central clay plain physical region. However, it is not known to what extent these clay areas did formerly have a cover of sandier Tertiary rocks.

The result of the post-basalt erosion and deposition was a gently undulating landscape which was depositional over extensive lowland areas and erosional on limited higher areas. Its present extent is therefore approximately coterminous with that of the Tertiary sandstone (see Part V). Slopes rarely exceeded one degree and valleys were both shallow and widely spaced; the total range of relief, however, was not much less than at present. Higher areas, then as now, corresponded to more-resistant rocks such as the volcanics at Bulgonunna Peak and quartz sandstone in the south and west. Only in such situations did the underlying bed-rock show through the enveloping Tertiary cover. Escarpments were more or less emasculated and marked only by slight steepening of the land surface (Fig. 8(*a*)). The drainage system was broadly analogous to the present, though in the north-east, streams that now flow to the Burdekin or to the Isaac flowed into the Belyando and in the south-west some streams that are now part of the Belyando system still flowed westwards towards the Great Artesian Basin. This gently undulating landscape is here termed the *Tertiary land surface*.

(*e*) *Tertiary Deep Weathering*

Deep weathering was intimately associated with the gently undulating Tertiary landscape just described. It penetrated deeply below the surface, possibly to several hundred feet in places, and extensively altered the nature of the rocks by mobilizing bases and by kaolinization. Silica was also mobilized and redeposited in the weathering profile as horizons and masses of billy quartzite. Lateritic profiles consisting of a ferruginous zone over mottled and pallid zones developed widely and must have covered most, if not all, of the area. This deep weathering profile is here termed the *Tertiary weathered zone*.

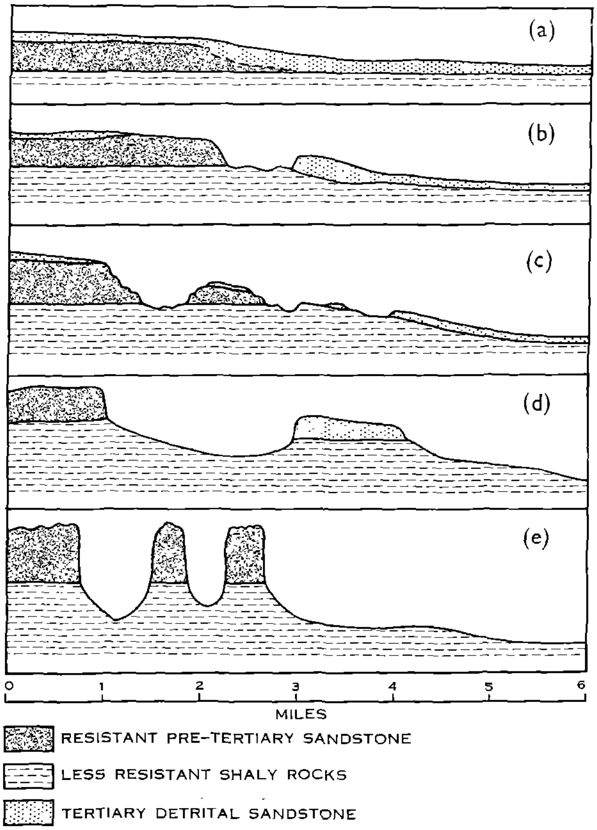

Fig. 8.—Scarp profiles in relation to removal of the Tertiary sediments and land surface. Vertical exaggeration $\times 10 \cdot 6$.
(*a*) No removal (closed basin, west of Lake Galilee).
(*b*) Incipient removal (closed basin, west of Lake Buchanan).
(*c*) Partial removal (Belyando catchment).
(*d*) Partial removal (Belyando catchment).
(*e*) Complete removal (Nogoa catchment).

It is, however, far from clear to what extent the weathering preceded, accompanied, or followed completion of the Tertiary surface, and it is extremely difficult to separate its effects from those of inherent variations in the Tertiary sediments. On the one hand, the argillaceous nature of the lower part of many of the Tertiary rocks suggests chemical weathering *prior to* their deposition and the inclusion of billy pebbles in the Tertiary conglomerates points to the same conclusion. Even the widespread ferruginous zone of the lateritic profile commonly found just below the Tertiary land surface does not necessarily imply severe post-depositional weathering since it is often clearly a detrital deposit in its own right and a facies of the Tertiary sediments rather than the product of subsequent weathering. On the other hand, the Tertiary sediments themselves often have well-developed pallid zones implying intense weathering *after* their deposition.

Where weathering has affected rocks older than the Tertiary sediments its effects have varied to some extent with the lithology. Shales were intensely affected while quartzose sandstone, understandably, was influenced very much less. Surprisingly, the Anakie Inlier was only moderately weathered over most of its extent, despite the presence of weatherable minerals. It is deeply weathered north of Cairo homestead. Basalt was severely affected and bases were leached out to be re-deposited at great depth as carbonate and gypsum.

Weathering was also affected by situation, being more severe in low-lying sites than on rises. For example the higher, central, part of the Bulgonunna Block was not deeply weathered while the lower margins were severely affected. Hills of Ducabrook sandstone between Mt. Douglas and Natal Downs were far less affected than adjacent lowlands of similar lithology. Thus the base of the weathering profile followed the Tertiary land surface but with more marked undulations, reflecting the deeper, more intense weathering on lowland sites.

Despite these variations according to situation and lithology, and despite the uncertainties involved by possible confusion with Tertiary sedimentation, deep weathering clearly went far towards imposing a unity on the landscape. Where subsequent erosion has partially dissected the weathered zone a catena of soils and vegetation has developed which is the key to understanding many of the land systems (see Section II of Part III). If the Tertiary weathered zone has been sharply dissected with the production of steep slopes, the upper elements of the catena, or even the entire catena, can be concentrated into a narrow belt only a few hundred yards wide. On the other hand, if the Tertiary weathered zone has been only gently bevelled, the various elements of the catena can form irregular belts of country up to several miles wide.

(f) Late Tertiary Erosion

Renewed erosion took place after the deep weathering and formation of the undulating Tertiary land surface. This erosion carved out the landscape to more or less its present form and is still actively in progress. Final adjustments to the drainage pattern took place during this phase. There was a loss of one or two small streams in the north-east by capture to the Isaac River system and a compensating gain in the extreme south-west where the headwaters of Goodliffe Creek, which formerly flowed south-westwards to the inland, were diverted to the Nogoa.

The manner and extent to which this phase of erosion removed the Tertiary land surface, sediments, and deep weathered zone largely determine the present character of the country. Areas of little removal, partial removal, and complete removal can be distinguished.

(i) *Areas of Little Removal.*—The western plains and tablelands have inherited the gently undulating to level form of the Tertiary land surface with little modification.

This is particularly true in the closed basins of Lake Buchanan and Lake Galilee, which were cut off from the rejuvenating influence of incision by the major streams. The very gentle slope of the Tertiary land surface in this area was a major factor in the preservation of the surface, and whatever erosion has occurred has been concentrated on the steeper sites.

West of Lake Galilee the Tertiary surface and Tertiary sandstone have been preserved practically intact and a buried scarp is betrayed by no more than a gentle inflexion of the surface (Fig. 8(*a*)). Around Lake Buchanan, on the other hand, the old post-basalt landscape was not quite so completely smoothed off by the Tertiary erosion and sediments, and here incipient re-excavation of the relief has commenced with the opening of a narrow valley between an old, buried scarp and the consolidated Tertiary detrital apron formed against it (Fig. 8(*b*)). Gently undulating broad interfluves on the western plains and tablelands have been subjected to stripping by sheet erosion. Sandy and loamy material has been stripped off the rises and deposited on adjacent lower slopes and depressions, where it probably becomes re-cemented into sandstone.

(ii) *Areas of Partial Removal*.—Later Tertiary erosion has partially removed the Tertiary weathered zone, sediments, and land surface in most of the Belyando catchment, the Anakie–Clermont area of the Nogoa catchment, and steeper parts of the Lake Buchanan basin. Usually relics of the old surface are preserved on the major interfluves and occasionally near the valley floors, intermediate slopes are cut in weathered Tertiary or older rocks, while low ground is occupied by Tertiary clay. Under these circumstances, the catenary sequence of vegetation and soils outlined in Part III is well expressed.

Round the margins of the Bulgonunna Block the weathered zone has been only partially removed and relics of the Tertiary land surface with ironbark or box are preserved above slopes cut on weathered volcanics and supporting lancewood while the valley floors are under blackbutt, brigalow, or gidgee. On folded Drummond Basin sediments north of Mt. Douglas late Tertiary erosion has re-excavated old strike vales which had been buried by Tertiary sediments. In the north-central clay plain the low relief has inhibited deep erosion and extensive areas of Tertiary clay and Tertiary weathered zone on older rocks have been preserved.

Erosion affected the flanks of interfluves of the western plains and tablelands physical region, cutting through the thin Tertiary cover and intricately dissecting the underlying pre-Tertiary weathered rocks: the less steeply sloping Tertiary land surface on the crests of the interfluves and on the adjacent valley floors was hardly affected (Fig. 8(*b*) and (*c*)). A similar situation exists in the valley of Alpha Creek south of the railway line. This valley already existed as a broad depression on the Tertiary land surface, which survives on the interfluves and down near the valley floor but has been largely removed from the steeper slopes between where erosion has bitten deeply into the underlying weathered rocks.

That part of the southern scarpland physical region which lies within the Belyando catchment experienced rejuvenation in this phase, with removal of much of the Tertiary detritus that had accumulated in the vales during the preceding phases of post-basalt deposition and Tertiary weathering. Erosion has now re-excavated the old scarps from their mantle of debris, of which relics still survive as mesas in front of the scarps. Mt. Paddy, south of Avoca homestead, for instance, is an isolated relic of a formerly continuous Tertiary fill, perhaps 200 ft thick, which once extended up to, and possibly over, the scarp of the Colinlea Formation (Fig. 8(*d*)). The position of these Tertiary mesas indicates that the adjacent scarps on the older rocks have retreated no more than a mile or two since having been re-exposed, and probably much less.

(iii) *Areas of Complete Removal.*—Complete removal has occurred in most of the Nogoa catchment and on much of the higher, steeper country of the central highlands and northern hills where the Tertiary land surface had a steeper gradient than normal. The extensive removal in the Nogoa catchment is partly a result of late-Tertiary uplift. The effect of this uplift can be seen on the Buckland Tableland where the streams have been able to cut deeply below the base of the basalt whereas elsewhere erosion has hardly penetrated below this ancient level. Furthermore, the Nogoa river system as a whole seems to have been a more active agent of erosion than the Belyando system, since at most points there is an abrupt rise ranging from several tens to several hundreds of feet on passing across the divide from the former to the latter catchments. Only between Anakie and Clermont is this asymmetry of the divide not apparent and it is significant that here the Tertiary sediments and weathered zone have not been completely removed from the Nogoa catchment.

Where removal has been complete the underlying pre-Tertiary rocks largely determine the relief, soil, and vegetation patterns. Variations in the lithology of the Ducabrook Formation are reflected in banding of trees and soil parallel to the strike. On the metamorphics of the Anakie Inlier an intricately dissected relief has developed with shallow, stony soils while rolling country with moderately deep texture-contrast soils developed on the granite. The varied strata of those parts of the Springsure Shelf structural unit which lie in the Nogoa catchment are clearly expressed in contrasted belts of country ranging from downs to steep scarps (Fig. 8(*e*)). The fractured volcanics of the central, higher part of the Bulgonunna Block now form rocky low hills with very thin soils and stunted ironbark trees. On the basalt country in the east of the area the reddish, highly alkaline soils with secondary carbonate, gypsum, and silica indicate that removal was not quite completed.

(*g*) *Late Tertiary Deposition*

The erosion that has just been discussed was naturally associated with some deposition within the survey area, even though the greater part of the eroded material must have been removed. In the Nogoa valley this phase of deposition was marked by the formation of billy gravel terraces along the major rivers and by extensive detrital cones also containing billy gravel, built up below the scarps marking the edge of the Buckland Tableland. The source of this billy is probably a silicified horizon which occurs widely under the Tertiary basalt.

In the Belyando catchment there appears to have been further deposition of weathered clay on the north-central clay plains, and in particular very extensive clay fans, derived from erosion of weathered basalt, were formed in the Diamond Downs–Avon Downs area. Despite the weathering, some of the alkalinity of the parent rocks persists in these clays. Patches of quartz gravel near the major streams in the north-eastern hills likewise indicate a fairly important period of deposition long after the major Tertiary sediments were formed but before the post-Tertiary alluviation. In parts of the western plains and tablelands physical region, notably around Lake Buchanan and west of Natal Downs, very extensive colluvial and alluvial fans were laid down. These fans are up to 5 miles long and must be relatively young in geological terms since the distributaries that built them can still be traced on air photographs. They represent a relatively young phase of sedimentation similar to that which laid down the Tertiary sandstone.

It should be pointed out that the effects of this period of deposition are not easily differentiated from those of the preceding post-basalt deposition and the succeeding Quaternary alluviation.

This late Cainozoic deposition was followed or accompanied by a further, minor, phase of deep weathering. Weathering to a depth of 10 ft has been recorded in the extreme south-west but cannot have been very intense since calcareous sandstone members in the Moolayember Formation have been leached only to a depth of a few inches.

(*h*) *Post-Tertiary Alluviation*

Alluvial spreads accompany all streams in the area except those flowing in minor gullies or draining steep hill country. The width of the alluvial tracts ranges from a few yards to several miles, and there is a great variety of materials, microrelief, and degree of flooding. At least two periods of alluviation can be detected, separated by a time when wind action was important (Fig. 9). These periods probably reflect climatic changes during the Quaternary.

The first period of alluviation was associated with wide shallow channels and large meanders on the major streams. Along those streams which drain predominantly sandstone country this phase of alluviation was marked by the formation of large, sandy levees. In places these levees were remarkably steep, with back slopes up to 2° and heights of 10 to 20 ft above the finer-textured flood-plains. In these sandy areas the old channels are not subject to flooding and their floors can be as much as 25 ft above the present stream beds. In the lower reaches of the main rivers where argillaceous rocks have contributed more to the alluvium, the channels of this period are still sometimes flooded and the levees are much less steep. Probably it was at this time that Lakes Galilee and Buchanan held much more water than they do today and an older set of beaches was formed up to 40 ft above the lake floors. The beaches testify to a period or periods when the evaporation : precipitation ratio was much lower than it is today.

In a succeeding phase of presumably drier climate the sandy levees were subject to wind action which reduced their height and increased their width, sand being in places blown up out of the alluvial flats onto adjacent higher country. Locally, near Bygana for instance, small dunes were formed, while the old channels were partially filled with drifted sand. In a few places the filling of the channels went so far as to eradicate them completely, leaving only a single low sand ridge to mark the site of a former channel flanked by steep levees. This phase of wind action appears to have affected sandier parts of the undulating Tertiary land surface causing the development of thin sheets of loose fine sand. The old beaches around Lake Buchanan and to a lesser extent those at Lake Galilee were likewise affected by wind action and both sand sheets and shallow deflation hollows were created. The effects of this phase of wind action are more apparent in the drier west of the survey area than in the east.

Finally, renewed alluviation set in with a swing back to somewhat more humid conditions and it is still continuing today. In this current phase two main types of alluvial land forms have developed. Single, fairly deep, meandering channels flanked by well-developed levees are characteristic of fairly coarse alluvium (silt and sand) derived from sandstone, granite, or volcanics. These channels tend to be about half as wide and at least twice as deep as the earlier generation of channels with sandy

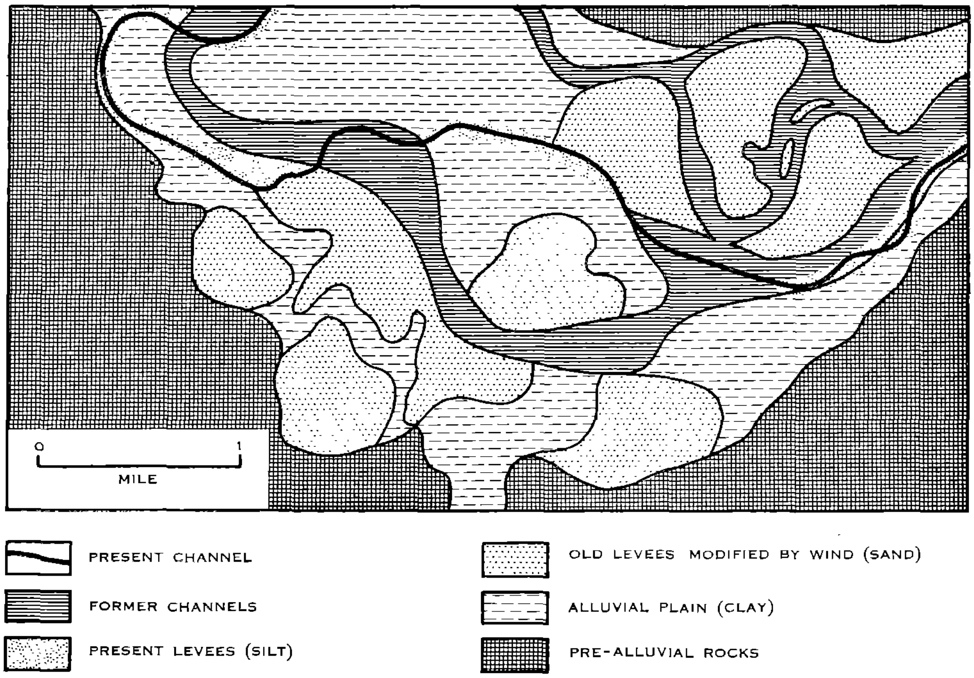

Fig. 9.—Alluvial features on Native Companion Creek.

levees found in the same area. The other type of recent alluvium is finer-grained (silt and clay) and is derived generally from shale and basalt or occupies flood-out areas of major rivers. It is associated with braided channels rarely more than 10 ft deep and less well-defined levees.

At Lakes Galilee and Buchanan a lower, younger generation of shore-line features was formed, extending up to about 15 ft above lake bottom and still evolving spasmodically under present conditions.

While alluvial clays occur in back-swamp situations in the modern alluvium, in many cases it appears that clay flats near the larger rivers are in fact part of the old

Tertiary weathered clay rather than a recent fluviatile deposit. Deep gilgais and the occasional occurrence of blackbutt (*E. cambageana*) on the valley floors are related to these old clays and not to the present alluvium, which is often no more than a thin, patchy cover.

IV. Geomorphology and the Land Systems

In classifying the land systems from the geomorphic point of view two orders of classification, corresponding to the first two columns of Table 12, have been used. Where a land system extends significantly onto more than one of the geomorphic units so defined, this is indicated in the table. The resulting arrangement of the land systems is close to, but not identical with, that adopted in the account of the soils (Part VII).

In the first order of classification, five categories have been recognized corresponding to the relationship of the land systems to the Tertiary rocks, Tertiary land surface, and Tertiary weathered zone. Land systems can be on the stable or moderately stripped surface, can be erosional or depositional landscapes within the dissected weathered zone, can be on older rocks from which the Tertiary weathered zone has been largely stripped, or can be on post-Tertiary alluvium. These five categories are also utilized in the reference to the geologic–geomorphic map, where it has been possible to indicate some transitional areas that do not fall clearly into any one geomorphic category.

In the second order of classification, four simple relief categories have been distinguished: mountainous, hilly, undulating, and level. These simple categories can include a wide range of individual land forms: e.g. "hilly" includes scarps, mesas, granitic domes, dissected uplands, and some lower volcanic plugs. Like the land systems themselves, these relief categories have been identified from air photographs supplemented by field observations. Terrain was regarded as level if practically no relief was perceptible on the photographs under the stereoscope. In the field this corresponded to slopes less than $\frac{1}{2}$–1% and maximum local relief from valley floors to interfluve crests of 10–20 ft. Terrain was regarded as undulating if it had visible relief on the air photographs but if both main roads and farm tracks could cross at least 80% of it in any direction with little or no deviation necessary on account of steep slopes: this category corresponded in the field to maximum slopes up to 7–10% and local relief of 10–150 ft. Hilly terrain was that which roads could cross only by the most favourable routes and corresponded to maximum slopes up to 20% and local relief of 100–300 ft. Limited areas, up to 20% of the whole, could be significantly steeper. Mountainous terrain was that which roads could not cross except perhaps along the major valleys. Slopes were up to 100% and local relief generally well over 300 ft. These four relief categories have been used in the reference to the geologic–geomorphic map.

Land systems within each relief type have been listed in the third column of Table 12 in approximate order of lithology with the most quartzose first and the most basic last. Land systems on basalt have been distinguished from those on other rocks on the geologic–geomorphic map.

(*a*) *Land Systems on Stable or Moderately Stripped Tertiary Land Surface and Tertiary Sandstone*

These areas have inherited the gently undulating form and sandy to loamy surface texture of the old surface. Laterite is commonly exposed where stripping and dissection have been active. Characteristic slopes are less than 1·5% and much of the surface can be regarded as stable. However, surficial stripping is quite active where slopes exceed about 2%. The soils tend to be extremely poor in accord with the

TABLE 12

GEOMORPHOLOGY AND THE LAND SYSTEMS

Relationship to Tertiary Rocks, Land Surface, and Weathered Zone	Relief Category	Land Systems in Order of Lithology—Quartzose to Basic
Land systems on stable or moderately stripped Tertiary land surface	Hilly to undulating	Tichbourne
	Undulating to level	Ronlow, Lennox, Degulla, Monteagle, Pinehill, Disney (part)
Erosional land systems within the Tertiary weathered zone	Hilly	Durrandella, Loudon, Humboldt (part)
	Undulating	Disney (part), Humboldt (part), Wondabah, Kinsale, Rutland (part)
Depositional land systems within the Tertiary weathered zone	Undulating and level	Willows, Blackwater, Somerby, Disney (part), Humboldt (part), Islay, Ulcanbah, Avon, Moray
Erosional land systems largely below the Tertiary weathered zone	Mountainous	Carborough, Bogantungan, Percy
	Hilly	Portwine, Hope, Copperfield, Borilla, Waterford, Kareela
	Undulating	Playfair, Craven, Rutland (part), Skye, Cungelella, Wharton, Peak Vale, Hillalong, Mantuan, Oxford
Post-Tertiary alluvial land systems	Higher alluvial plains	Alpha
	Lower alluvial plains	Banchory, Comet, Funnel
	Lacustrine plains	Galilee

prolonged weathering they have undergone. As the geologic–geomorphic map shows, these land systems are the dominant feature of the western plains and tablelands, particularly around Lake Galilee where there has been little or no dissection of the Tertiary surface. On the other hand, these land systems are largely absent from the Nogoa catchment and the central highlands, where late Tertiary erosion has been most effective.

(i) *Hilly to Undulating*.—Tichbourne land system includes low knolls of resistant rock peeping through the Tertiary sandstone, stripped surfaces round these knolls and near breakaways, low breakaways, and shallow valley heads dissecting the Tertiary surface.

(ii) *Undulating to Level*.—Lennox and Ronlow land systems are practically intact survivals of the Tertiary surface with minor sheet erosion and possibly some minor wind-blown sand sheets in a few places. Lennox is characterized by silver-leaved ironbark and Ronlow by bloodwoods and yellowjacks.

Monteagle land system, with a vegetation dominated by box, is formed on partially stripped portions of the Tertiary surface.

Pinehill land system, also partially stripped, is mainly associated with a gravelly facies of the Tertiary around the upper Belyando River.

Degulla land system comprises extensive fans in the north-west of the area, derived from dissection of the Tertiary sandstone and older arenaceous rocks. In source material, soil, vegetation, and location this land system is closer to those associated with the intact Tertiary land surface than to the various depositional land systems with which, strictly speaking, it belongs. Shallow, disused distributaries extend over much of the surface. The profile of the fans steepens from about 0·25% in the lower parts to 0·75% in the upper parts.

(*b*) *Erosional Land Systems within the Tertiary Weathered Zone*

In these land systems the original Tertiary surface has been reduced to small remnants on the interfluves, or entirely removed, and the surface is mainly formed on older rocks deeply affected by the Tertiary weathering. Pockets of acid Tertiary clay may be found in the lowest parts. The characteristic vegetation of steeper, rockier areas such as breakaways and strike ridges on resistant rocks is bendee or lancewood, while on lower slopes box and blackbutt are found and in depressions brigalow or gidgee. The geologic–geomorphic map shows how these land systems are largely concentrated in the northern hills physical region, the upper Belyando catchment south of Alpha, and the northern end of the central highlands. These are all areas where the original Tertiary surface has been extensively dissected but not completely removed.

(i) *Hilly*.—Durrandella land system consists of breakaways, dissected scarp zones, and dissected hills on Tertiary sandstone and the quartzose Colinlea and Clematis Sandstones. It is found mainly in the south-west quarter of the survey area. Loudon land system is largely concentrated in the north-east quarter and includes strike ridges on silicified, steeply dipping beds of the Ducabrook Formation with intervening vales on softer beds often floored by a thin cover of Tertiary clay. The weathered parts of the Bulgonunna Volcanics are included in this land system.

A small part of Humboldt land system, occupying the lower part of breakaways, is found in this category.

(ii) *Undulating*.—Disney land system is mostly a mosaic of small remnants of Tertiary rocks capping undulating terrain on weathered older rocks. Most, if not all, of the elements of the catena (Table 2) occur here, giving rise to a wide range of soils and vegetation.

That part of Humboldt land system which occurs in this geomorphic category is mostly gently undulating and, in places, stony.

Kinsale and Wondabah land systems occur on weathered basalt which is frequently enriched by gypsum and secondary carbonate: gently undulating, stone-free areas under brigalow or gidgee are the rule.

(c) *Depositional Land Systems within the Tertiary Weathered Zone*

These land systems are mainly in the Belyando catchment where the Tertiary land surface and weathered zone have been partially removed. They are associated with the acid and alkaline Tertiary clays discussed in Part V, the origin of which is not always clear. It is also not certain to what extent these landscapes are erosional and cut into the softer parts of the Tertiary deposits, rather than depositional, although there are indications that deposition has been dominant in forming at least the surface layers. The land systems occur mainly on the north-central clay plain and on the eastern and western lowlands. Some occurrences are found in the Nogoa catchment but are largely confined to the Anakie–Clermont–Emerald triangle where, as noted earlier in this Part, remnants of the Tertiary deposits and weathered zone have been preserved. As is to be expected in such soft material, plains and lowlands predominate.

(i) *Undulating to Level.*—The stony Willow land system consists of relics of a former extensive Tertiary gravelly cover now preserved only on interfluves and subject to dissection working back from lower adjacent areas. It generally occurs on the eastern flank of the central highland, from which the gravel was probably derived.

Avon and Moray land systems are undulating to level grassland and gidgee scrub on stone-free gypseous clay.

(ii) *Level.*—Most of the land systems in this category (Blackwater, Somerby, Islay, and much of Humboldt and Ulcanbah) are clay plains on acid weathered clay with varying amounts of billy and quartz gravel. Strong gilgai is usual in the lowest sites. Limited undulating areas occur within these plains.

(d) *Erosional Land Systems largely below the Tertiary Weathered Zone*

Nineteen land systems, ranging from mountainous to undulating, occur in this category. They are situated mainly in the Nogoa catchment and in the central highlands, i.e. in those areas where dissection of the Tertiary surface and weathered zone has been most effective. Even here, however, removal of the old weathered zone has often not been complete and traces of a basal zone of carbonate and gypsum enrichment are common, particularly on the basalt. Furthermore, late Tertiary weathering subsequent to most of the dissection has had some effect.

(i) *Mountainous.*—Carborough land system is extremely rocky country on quartz sandstone. Structurally controlled small-scale features such as benches and cliffs are universal while the major land forms are those of deeply dissected plateaux. In fact much of this land system was subjected to Tertiary deep weathering, which, however, had little effect on account of the resistant nature of the rock.

Bogantungan land system is similar but is developed on the more resistant elements of the Ducabrook Formation; it lacks the distinctive sandstone shrub vegetation of Carborough land system.

Percy land system consists of deeply dissected basalt tablelands and steep volcanic plugs.

(ii) *Hilly*.—Portwine and Hope land systems consist mainly of rather low hills, often transitional to undulating terrain and partly shown as such on the geologic–geomorphic map. There is marked banding of the vegetation in response to variations in lithology of the underlying sedimentary rocks. Stony surfaces and low, weakly developed cuestas characterize the harder beds while the softer beds tend to form vales with deeper soils.

Copperfield land system comprises closely dissected terrain on the metamorphic rocks of the Anakie Inlier; short, steep slopes, and abundant vein quartz gravel on the surface are characteristic. Over limited areas the presence of volcanic rocks provides deeper soils with a higher clay content.

Borilla land system is found mainly on the igneous rocks of the Bulgonunna Block and Silver Hills Volcanics and on the volcanic plugs of the Peak Range. Extreme rockiness and remarkably little sign of deep weathering are features of this land system.

Waterford and Kareela land systems are on basalt which often shows signs of former deep weathering. Most of Kareela land system occurs on the great slump features along the northern margin of the Buckland Tableland.

(iii) *Undulating*.—Playfair land system is formed partly on resistant quartz sandstone, which has suffered little dissection but supports only shallow soils with some outcrop, and partly on much weaker sandstones giving deeper soils.

Craven and Rutland are both undulating land systems mainly on folded sandstones and shales of the Ducabrook Formation. They both show the groves and glades typical of land systems on this rock and the difference in tree species between the two systems appears to reflect slightly greater preservation of Tertiary weathering effects on Rutland (brigalow) as compared with Craven (ironbark). Skye, Cungelella, Wharton, and Hillalong land systems are mainly lowlands on shales, diversified by low ridges on sandstone. Parts of these systems seem particularly susceptible to sheet and gully soil erosion, giving a "scarred" pattern on the air photographs. Cungelella has much gravel on the surface apparently derived from the Buckland Tableland immediately to the south.

Peak Vale land system comprises rolling country on granite with moderately deep soils but diversified by occasional rocky tors up to 50 ft high and basalt plugs up to 500 ft.

Mantuan land system consists of rolling downs on Permian shales and some extensive alluvial spreads derived from the basalt of the Blackdown Tableland.

Oxford land system also consists of rolling downs, but on basalt, not shales. Some outcrop occurs near the crests of broad rises but as a rule the soils are moderately deep. In a few areas, notably at Surbiton, extreme stoniness occurs, with pieces of basalt up to 1 ft across littered over the surface. Elsewhere Oxford land system is marked by much carbonate and gypsum and some silica masses, presumably representing the remains of accumulations near the base of the Tertiary weathered zone. A reddish tinge in the soil probably is also related to a former overlying deep weathered zone.

(e) *Post-Tertiary Alluvial Land Systems*

Five land systems are included in this category. All are regarded as level, even though considerable relief, up to 40 ft, can exist on limited parts. However, there are significant differences in land form, soil, and vegetation between the higher and lower alluvial plains and between them and the lacustrine plains. Consequently a modification of the simple relief categories must be introduced here to express these differences.

(i) *Higher Alluvial Plains.*—Alpha land system is found on alluvium generally associated with the earlier alluvial phase discussed previously under post-Tertiary alluviation. This land system is generally not subject to flooding except in the north-east and has mature soils consonant with its considerable age. It includes alluvial plains, terraces, levees, abandoned channels, and sand sheets derived by wind action from old levees. It occurs mainly where alluvium has been derived from Tertiary sandstone in the west or from the sand-producing central highlands or northern hills and is absent from basaltic or shaly areas. A single deep meandering present-day channel is usual and relics of wide, shallow, old channels are common.

(ii) *Lower Alluvial Plains.*—Banchory, Funnel, and Comet land systems are lower alluvial clay plains, mostly subject to flooding. Braided, shallow, present-day channels are usual in these land systems. Small areas of weathered Tertiary clay with gilgais are included.

(iii) *Lacustrine Plains.*—Galilee is the single lacustrine land system and consists essentially of saline clay lake floors seasonally flooded, and complex beach features round the margins. The shore-line features at Lake Buchanan are sandy while those at Lake Galilee are loamy.

PART VII. SOILS OF THE NOGOA–BELYANDO AREA

By R. H. Gunn*

I. Introduction

The nature and distribution of soils in the area are intimately related to the lithology of parent rocks and the past history of weathering, erosion, and deposition. Denudation of deeply weathered lateritic profiles formed mainly in sedimentary rocks during the Tertiary has resulted in the development of a specific range of soils in catenary sequence on the exposed weathering zones. Red and yellow earths are the dominant soils on more or less intact Tertiary surfaces, while soils with abrupt textural contrasts (mainly solonetzic and solodic) and cracking clay soils have developed on depositional and erosional landscapes within the weathered zone (Table 2).

Over wide areas erosion has completely removed the Tertiary deposits and weathered zone and has exposed the underlying relatively fresh rocks. In these parts soil formation has been controlled mainly by the lithology and stratigraphy of the parent rocks and by more recent climatic conditions. The general trend has been the formation of texture-contrast soils on parent materials derived from moderately quartzose rocks, and cracking clays on materials derived from shales, mudstones, and basalt.

Morphological and chemical properties of many of the soils in the area indicate that halomorphic influences have been active during their formation. The widespread occurrence of soils with marked textural differentiation often with well-developed columnar structure and a preponderance of sodium and magnesium ions in the exchange complex supports this view. Moderate to high contents of soluble salts and a high proportion of sodium chloride in some cracking clay soils are a further noteworthy feature.

Most of the soils that occur in the area have been previously studied and described in Queensland, notably by Hubble (1961) and Isbell (1957, 1962).

II. Soil Groups and Families

The soils of the area have been arranged in 7 major groups and 34 families. The major groups are generally broader than great soil groups. The cracking clay soils, for example, include the Australian black earths and grey and brown soils of heavy texture, and the texture-contrast soils include solodized solonetz and solodic soils as well as polygenetic soils with similar characteristics. The families within each major group have been defined according to differences in properties considered to be of importance to land use. The differentiae vary from group to group. In the cracking clay families parent material, microrelief, depth, and reaction are the main properties. The families of texture-contrast soils are differentiated on the basis of the texture and

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TABLE 13

SOIL GROUPS AND FAMILIES IN THE NOGOA–BELYANDO AREA

Major Group	Family	Brief Description	Appropriate or Approximate Equivalent Names	Principal Profile Form (Northcote 1965)
Alluvial soils	Davy	Uniform coarse textures	Alluvial soils (Stephens 1962)	Uc1·22, 1·23
	Clematis	Uniform medium to fine textures		Um1·21, Uf1·41
	Warrinilla	Medium- to fine-textured soils on coarse-textured substrata		Um1·2, 5·5, Uf6·33
	Moolayember	Coarse- to medium-textured soils on fine-textured substrata		Um5·5
Cracking clay soils	Tertiary weathered zone parent materials			
	Pegunny	Gilgaied deep clay soils, mainly dark grey-brown strongly alkaline surface over mottled, acid subsoils	Grey and brown soils of heavy texture (Stephens 1962)	Ug5·24
	Rolleston	Deep clay soils, not gilgaied	Grey and brown soils of heavy texture (Stephens 1962)	Ug5·24, 5·15
	Transported Tertiary weathered zone parent materials			
	Natal	Dark brown to grey-brown self-mulching clay soils, moderately to strongly alkaline throughout, deep	Brown soil of heavy texture	Ug5·24, 5·16
	Logan	Dark brown to grey-brown self-mulching clay soils, neutral to strongly alkaline at or near the surface, slightly to strongly acid at depth, gypseous, deep	Brown soil of heavy texture	Ug5·24, 5·16
	Sedentary on basalt and other volcanic rocks			
	Arcturus	Dark grey-brown to black self-mulching clay soils, moderately shallow (24–36 in.)	Black earth (Stephens 1962)	Ug5·12
	May Downs	Dark grey-brown to black self-mulching clay soils, deep (> 36 in.)	Black earth	Ug5·12, 5·16
	Glenora	Dark brown to reddish brown clay soils, deep	Brown soil of heavy texture	Ug5·34, 5·37
	Sedentary on various sedimentary rocks			
	Teviot	Dark grey, self-mulching clay soils, moderately deep to deep	Black earth	Ug5·12, 5·14
	On alluvial parent materials			
	Vermont	Dark brown to dark grey clay soils, deep	Grey and brown soils of heavy texture	Ug5·16, 5·24
	Shallow clay soils on various rocks			
	Bruce	Shallow clay soils		Ug5·12

Texture-contrast soils	Shallow soils (< 24 in.)			
	Southernwood	Sandy or loamy surface soils, acid to mildly alkaline subsoils	Solod (Stephens 1962)	Dr2·12, Dy2·22
	Medway	Sandy or loamy surface soils, strongly alkaline subsoils	Solodized solonetz and solodic (Stephens 1962)	Dr2·13, Db1·13, Dy2·23
	Deep soils (> 36 in.)			
	Thick sandy surface soils (> 15 in.)			
	Luxor	Acid to mildly alkaline subsoils	Sandy solodic soils (Downes and Sleeman 1955), sandy solod	Dy3·42, 3·22
	Broadmeadow	Strongly alkaline subsoils, generally mottled	Solodic, and solodized solonetz (Isbell 1957)	Dy2·23, 3·23
	Thin sandy surface soils (< 15 in.)			
	Springwood	Acid to mildly alkaline subsoils	Solod	Dr2·12, Dy3·12
	Taurus	Strongly alkaline subsoils	Solodized solonetz and solodic	Dr2·13, Dy2·23
	Loamy surface soils (generally < 15 in.)			
	Wyseby	Acid to mildly alkaline subsoils	Solod	Dy2·22, Db1·32
	Retro	Strongly alkaline subsoils	Solodized solonetz and solodic	Db1·13, 1·33, Dy2·13, Dd1·13
Red and yellow earths	Dunrobin	Loamy red earths	Lateritic red earths (Stephens 1962)	Gn2·12
	Struan	Loamy yellow earths	Yellow earths (Stewart 1959; Stephens 1962)	Gn2·22, 2·62, 2·82
	Annandale	Sandy red earths		Gn2·12, 1·12
	Forrester	Sandy yellow earths		Gn2·22
	Gregory	Shallow red and yellow earths (24 in. or less)		Gn2·11, 2·12
	Wilpeena	Red and yellow earths on alluvial materials		Gn2·12
Dark brown and grey-brown soils	Gindie	Shallow, uniform medium- to fine-textured soils on highly calcareous materials		Uf6·31
	Cheshire	Gradational or uniform, medium- to fine-textured soils, moderately deep to deep		Gn3·93, 3·43, Uf6·31
Uniform coarse-textured soils	Petrona	Shallow to moderately shallow sandy soils (< 36 in.)		Uc1·21, 4·12
	Highmount	Moderately deep to deep sandy soils (> 36 in.)		Uc1·23, 4·11
Shallow rocky soils	Rugby	Very shallow, uniform medium- to fine-textured soils	Skeletal soils (Stephens 1962)	Um1·21
	Shotover	Very shallow, uniform coarse-textured soils		Uc1·21
Miscellaneous land		Saline mud flats		Uf1·4

thickness of surface soils, effective depth, and subsoil reaction. Soils that are common to the three survey areas in the Fitzroy region have been given the same group and family names.

The soil groups and families are shown in Table 13 together with brief descriptions of their main characteristics. Correlations between families and the dominant principal profile forms (Northcote 1965) are given in the table. It will be noted that a particular family may be equated with more than one P.P.F. and *vice versa* for the reason that different criteria are used in grouping the soils.

III. Descriptions of the Soil Groups and Families

The following descriptions of the soils are based on the examination of approximately 800 profiles. Examination was carried out by means of auger borings but numerous small pits were dug in order to examine the upper soil horizons *in situ*. The standard terminology suggested by the United States Department of Agriculture (1951) has been used to describe the soils. Some of the more important soil properties that influence land use are discussed in Part X.

(*a*) *Alluvial Soils*

The soils of this group occur on recent alluvia and show little or no profile differentiation apart from slight accumulation of organic matter at the surface or lime in the deeper layers. They are deep and textures range from sands to clays depending on the source material and mode of deposition. They occur throughout the area and are most extensive on alluvial flats adjacent to major streams in the central and north-eastern parts of the area. They are subject to inundation of varying depth and duration in the wet season. Four families are distinguished according to differences in texture.

Davy.—These soils are structureless, uniform dark brown sands or loamy sands with slightly acid reaction throughout. They occur generally on levees and support a woodland of Moreton Bay ash, bloodwood, or ghost gum.

Clematis.—These soils have uniform textures ranging from loams to silty clay loams generally with a high proportion of silt. Colours are dark brown to grey-brown at the surface, gradually becoming lighter at depth. Soil reaction is slightly acid at or near the surface, grading to moderately or strongly alkaline at depth. Traces of soft carbonate accumulations are sometimes present. Typical vegetation is an open woodland of silver-leaved ironbark, blue gum, coolibah, or poplar box.

Warrinilla.—The soils of this family are dark grey-brown sandy or silty clay loams in the upper 1–2 ft and are underlain by brown sand or loamy sand. The surface layers have weak structure and underlying layers are massive. Soil reaction is slightly acid at the surface, becoming moderately alkaline at depths of 3–4 ft. Woodlands of poplar box or ghost gum are typical.

Moolayember.—These soils have either depositional layers or coarse- to medium-textured materials on older clayey soils. Soil reaction is slightly to moderately acid in the surface layers, becoming moderately alkaline beneath. Poplar box woodland is typical.

(*b*) *Cracking Clay Soils*

The main characteristics of these soils are their uniform medium to high clay contents and pronounced swelling and shrinking properties. Gilgai microrelief is an important feature in some soils of this group. They are widespread and extensive throughout the area and have formed on parent materials derived from basalt and other basic volcanic rocks, various sedimentary rocks, alluvium, and unconsolidated clays of the Tertiary weathered zone.

Most of these soils may be classified broadly as grumusols (Oakes and Thorp 1950) and as grey and brown soils of heavy texture or black earths (Stephens 1962). Isbell (1962) classified and mapped certain of these soils in his study of the brigalow lands of eastern Australia. On the basis of 200 observations, the soils have been arranged in 6 subgroups, according to parent material differences, and 10 families, generally according to differences in depth, reaction, and colour.

(i) *Tertiary Weathered Zone Parent Materials*

Pegunny.—These soils have been described in detail by Isbell (1962) and Reeve, Isbell, and Hubble (1963). They are very deep medium to heavy clays and have strongly developed gilgai microrelief with vertical intervals between mounds and depressions ranging between 1 and 4 ft. They occur generally in low-lying areas with very gently undulating to nearly level relief and are believed to have developed on the lower zones of truncated deep-weathering profiles (Table 2). Gravelly and stony phases are included.

Surface soil colours are predominantly dark grey-brown, but dark grey, brown, or reddish brown colours also occur. The colours generally become gradually lighter with depth and prominent, coarse, red, yellow, or brown mottles are common below 4 ft. Occasionally colours are uniform throughout. Dark brown or black manganiferous staining frequently occurs at a depth of about 3 ft. The surface soils on the mounds generally have a thin, massive crust underlain by medium to coarse blocky structure. When these soils are dry, large cracks form in the depressions and there is a thin granular self-mulching layer at the surface and blocky structure beneath.

Of the 36 profiles examined during the survey 25 were moderately to strongly alkaline at or near the surface, becoming slightly to strongly acid at depths below 3 ft; 9 profiles were neutral or mildly alkaline at the surface, grading to strongly alkaline at depth; and 2 were neutral or slightly acid at the surface, becoming moderately to strongly acid at depth. The alkaline/acid profiles have been described by Isbell (1957, 1962) and Hubble and Isbell (1958).

The soils commonly contain low to moderate amounts of soft carbonate in the upper 3 ft and gypsum was noted in a few profiles at the same depth or slightly deeper. Surface and internal drainage are poor and water may be retained in the depressions for considerable periods after the wet season. These soils invariably support a brigalow and/or gidgee scrub, generally with a sparse understorey of false sandalwood and currant bush.

Analytical data on samples from seven mound profiles are similar to those reported by Isbell (1962) and Reeve, Isbell, and Hubble (1963). Soluble salt contents determined by conductivity measurements on saturation extracts range from 0·15% at a depth of 1–2 ft to 0·46% at 4–6 ft. Chloride expressed as per cent sodium chloride is negligible at the surface but gradually increases to 0·25% or occasionally higher at depths below 3 ft. The exchangeable sodium percentage is also low in the upper 3 ft but is generally more than 15 at depths below 3–4 ft. Exchange capacities range between 20 and 30 m-equiv./100 g soil; there is usually a slight increase with depth. Base saturation exceeds 80% even in the strongly acid horizons. Calcium is the dominant metal ion at or near the surface but magnesium commonly increases with depth and dominates the lower profiles. Moderate amounts of exchangeable potassium are present and there is commonly a decrease with depth. The average total nitrogen and organic carbon contents are 0·07 and 0·63% respectively, giving an average C : N ratio of 9. The available P_2O_5 content ranged from 19 to 64 p.p.m. with an average value of 36 p.p.m.

Clay mineral identifications in samples from five profiles indicate that montmorillonite is generally either dominant or co-dominant with kaolin. In the lower part of one profile kaolin was dominant with montmorillonite subdominant. Quartz was an accessory mineral in all profiles and illite was subdominant or accessory in two profiles.

Rolleston.—These soils are very similar to those of Pegunny family but gilgais are absent or weakly developed. They form a transitional belt between solodic soils at higher levels and the gilgaied clays in lower situations. They have formed on unconsolidated clays in the lower parts of deep weathering profiles developed in a variety of parent rocks. Depths usually exceed 5 ft but indurated mottled- or pallid-zone materials sometimes occur below 4 ft. These soils correspond generally with the miscellaneous deep clay soils described by Isbell (1962).

Textures are uniform medium to heavy clays throughout and a surface strew of coarse billy gravel is a common feature. Colours are predominantly dark brown or grey-brown, and manganiferous staining and prominent grey and red mottling frequently occur in the lower profiles. At the surface there is either a thin, granular self-mulching layer or a platy crust below which the structure is medium to coarse blocky.

Reaction at the surface is usually slightly acid and there is a rapid change to moderate or strong alkalinity at depths of 2–3 ft. Below this depth, reaction becomes moderately to strongly acid. Small amounts of soft carbonate are generally present in the upper 3 ft and sometimes gypsum. No analytical data are available in respect of these soils but chemical properties are probably similar to those of Pegunny family. The characteristic vegetation is brigalow and gidgee scrub usually with an understorey of false sandalwood and currant bush.

(ii) *Transported Tertiary Weathered Zone Parent Materials*.—The soils of the following two families, Natal and Logan, occur only in the north of the area and are believed to have formed on transported parent materials derived mainly from weathered basaltic and other basic volcanic materials, or possibly shales in some areas. They occur in association in gently undulating areas with distinctive photographic patterns resulting from their characteristic open grassland and dense gidgee scrub vegetation.

Natal.—These soils are very deep, dark brown to grey-brown, medium to heavy clays that are moderately to strongly alkaline throughout the profiles to depths of 5–6 ft. The surface colour is dark brown or dark grey-brown and generally grades into brown or yellowish brown with slight mottling and manganiferous staining at depth in some profiles. There is a thin (1–2 in.), friable, fine granular, self-mulching surface layer when the soils are dry and this grades to a fine to medium, subangular blocky structure of moderate grade. Small to moderate amounts of carbonate and finely crystalline gypsum are generally present and the soils are slightly to moderately calcareous.

Analytical data on two profiles indicate that the soils have high exchange capacities (45–60 m-equiv./100 g soil) and are 80–90% base-saturated. Exchangeable calcium and magnesium are the principal metal ions, with calcium dominant in the upper profiles and magnesium at depth. Exchangeable potassium is high (0·6–1·9 m-equiv./100 g soil). The soils are salt-free to depths of about 3 ft but are moderately affected below this depth with 0·3–0·4% sodium chloride. The exchangeable sodium percentage is very low near the surface but increases to above 10 at about 4 ft. In the two profiles sampled, one under gidgee scrub and the other under grassland, the contents of total nitrogen and organic carbon were 0·17 and 1·76% and 0·05 and 0·66% respectively. The available P_2O_5 content under gidgee was 67 p.p.m. and under grassland 9 p.p.m.

Clay mineral determinations in respect of two profiles indicated that montmorillonite was dominant in one profile with accessory kaolin and quartz. In the other profile montmorillonite was dominant between 12 and 24 in. but was co-dominant with kaolin between 42 and 78 in. Illite and quartz were accessory minerals in both horizons.

The vegetation in areas of these soils is either grassland or gidgee scrub, predominantly the latter.

Logan.—These medium to heavy clay soils occur in similar situations to those of Natal family but are characterized by neutral to strongly alkaline reactions at the surface, becoming slightly to very strongly acid at a depth of about 3 ft. They are more than 6 ft in depth. Surface soil colours are dark brown to grey-brown, and subsoils are reddish brown, brown, or grey generally with prominent, coarse, red or yellow mottles at depth. Grassland is the characteristic vegetation but gidgee or brigalow scrub occurs in some areas of these soils.

Moderate amounts of crystalline gypsum below the surface 12 in. are characteristic, and layers of almost pure gypsum separated by clay layers occur in some profiles. The content of total soluble salts is moderate to high (0·35 to more than 0·65%) below the surface foot and the sodium chloride content ranges from 0·20 to 0·65%. The exchangeable sodium percentage commonly exceeds 10 at depths below 5 ft.

Cation exchange capacities range from about 30 to 75 m-equiv./100 g soil, the higher values occurring invariably in the lower profiles at about 6 ft. Calcium is the dominant exchangeable cation in surface horizons but magnesium increases gradually down the profile and becomes dominant at depth. Exchangeable potassium in the three profiles sampled is very much lower (0·1–0·4 m-equiv./100 g soil) than in the soils of the Natal family. The total nitrogen and organic carbon contents in three surface soil samples averaged 0·03 and 0·38% respectively and the range in C : N ratio was from 10 to 13. The available P_2O_5 content is uniformly very low and averaged 7 p.p.m. in the three profiles (range 6–9 p.p.m.).

Clay mineral analysis in respect of three profiles indicates that montmorillonite is dominant with kaolin and quartz either subdominant or accessory.

(iii) *Sedentary Soils on Basalt and Other Volcanic Rocks*.—The soils of the following families, Arcturus, May Downs, and Glenora, have formed *in situ* on fresh basalt or other basic volcanic materials. In some areas they appear to have been affected directly by deep weathering or indirectly, in other places, by the leaching of weathering profiles that at one time lay above them, leading to the accumulation of masses of secondary carbonate. Stony phases occur in the three families.

Arcturus.—The medium to heavy clay soils of this family occur mainly on the upper slopes of low rises in gently undulating areas on Tertiary basalt, often in association with shallow clay soils on the crests. Shallow linear gilgais sometimes occur. They are medium to heavy clays 25 to 36 in. deep, and are generally dark brown or grey-brown, occasionally black, in colour. The surface soils have a thin, friable, granular self-mulching layer when dry, and are underlain by medium to coarse subangular blocky peds with firm to hard consistence. Surface and internal drainage are judged to be moderate, and mottling is absent. Soil reaction is neutral to mildly alkaline at the surface, becoming strongly alkaline in the subsoils. Occasionally the profiles are strongly alkaline throughout. Small to moderate amounts of carbonate concretions are generally present. The characteristic vegetation is grassland or grassy woodland of mountain coolibah or bloodwood.

Cation exchange capacities in samples from two profiles ranged from 65 to 85 m-equiv./100 g soil, the higher values occurring in the surface soils. Calcium is the dominant metal ion and magnesium is second in importance. Moderate amounts of exchangeable potassium are present and exchangeable sodium is low throughout. Total nitrogen in the surface soils was 0·07% and the C : N ratio was 12. The analyses indicate high contents of available P_2O_5 (800 and 3820 p.p.m.).

May Downs.—These soils are similar to those of Arcturus family but depths range from 3 ft to more than 5 ft and they generally occur on lower, colluvial slopes under grassland. These soils receive run-off from upper slopes and are somewhat less well drained.

Glenora.—The soils of this family generally occur on crests or upper slopes of low rises in gently undulating areas. They have formed on materials derived from basalt or other basic volcanic rocks which have probably been subjected to more intense weathering than those of May Downs family. Depth to bed-rock is usually more than 4 ft. Colours are dark brown to reddish brown at the surface and dark reddish brown in the subsoils. There is a fine, granular, self-mulching layer an inch or two thick at the surface, with medium to coarse subangular blocky structure beneath. Reaction is neutral to mildly alkaline at the surface, becoming strongly alkaline at depth, or the soils are strongly alkaline and calcareous throughout. Small amounts of carbonate concretions are usually present in the lower profiles. The soils are moderately well drained but may be saturated for a few days after heavy rainfall. Grassland is characteristic but open mountain coolibah woodland occurs in some areas.

(iv) *Sedentary Soils on Various Sedimentary Rocks*

Teviot.—These medium to heavy clay soils have formed on materials derived from shales and siltstones of various ages mainly in the south of the area. Relief is gently undulating and slopes rarely exceed 5%. Shallow linear gilgais occur frequently. The soils are generally more than 3 ft deep but may be somewhat shallower on ridge crests and upper slopes. Colours are predominantly uniform dark or very dark grey, sometimes brown or yellowish brown. They are mildly alkaline at the surface, becoming very strongly alkaline below the upper 12 in. or strongly alkaline and calcareous throughout. Small to moderate amounts of soft concretionary carbonate are invariably present. Grassland is the characteristic vegetation.

Analytical data from one profile on upper Permian Bandanna Shale near Mantuan Downs indicate a high exchange capacity (57–64 m-equiv./100 g soil) and 80–90% base saturation. Exchangeable calcium comprises about 80% of the total cations present and magnesium is low in comparison with similar soils on basalt. Exchangeable potassium values range from 0·8 to 1·6 m-equiv./100 g soil, the higher value occurring in the surface horizon. Exchangeable sodium increases with depth but does not exceed 7% of the cation exchange capacity. Values for total nitrogen and organic carbon in the surface soil were 0·09 and 1·17% respectively, giving a C : N ratio of 13. Available P_2O_5 in the surface soil was 49 p.p.m. Conductivity values on saturation extracts indicate that the soil is free of soluble salts.

(v) *Alluvial Parent Materials*

Vermont.—The soils of this family are widespread and occupy fairly extensive areas in alluvial flats near major streams. The macrorelief is very gently sloping to nearly level, but dissection by numerous braided stream channels occurs in some areas. Melon-hole gilgais occur in places, possibly where a relatively thin cover of clayey alluvium is underlain by the lower parts of denuded, deep-weathering profiles.

These soils are very deep, dark brown to very dark grey, medium to heavy clays, generally with slightly acid to neutral reaction at the surface becoming moderately to strongly alkaline below about 2 ft. In some areas they are strongly alkaline throughout. Small to moderate amounts of carbonate are usually present and gypsum occurs infrequently. There is a weak, platy structure in the surface 1–2 in. when dry, and the underlying soil has a medium to coarse subangular blocky structure. The soils are very sticky and plastic when wet. Internal drainage is slow to very slow and these soils are liable to periodic or seasonal inundation to considerable depths. The characteristic vegetation is an open woodland of coolibah, gidgee, or brigalow scrub.

The chemical properties probably vary according to the origin of the parent materials. Analytical data from one profile on basaltic alluvium in the south of the area indicate strong to very strong alkalinity throughout, a cation exchange capacity of 44 to 62 m-equiv./100 g soil, the lower value at depth, and 80–100% base saturation. Calcium is the dominant metal ion in the upper profile, with magnesium increasing and becoming dominant at depth. Exchangeable sodium is present in small amounts in the upper 3 ft but increases to 10% of the exchange capacity at a depth of 5 ft. Total nitrogen and organic carbon contents were 0·07 and 0·79% respectively and available P_2O_5 was 653 p.p.m. The total soluble salt content is low.

(vi) *Shallow Soils on Various Rocks*

Bruce.—These soils occur in areas of gently undulating to low hilly relief on a variety of parent rocks. They are widespread in areas of folded Carboniferous and Permian sediments, where their distribution is governed by the lithology and strike pattern of the underlying strata. They are dark brown to black, medium to heavy clay soils underlain by bed-rock at depths of 24 in. or less. Physical and chemical properties vary but most of these soils are strongly alkaline below thin self-mulching surface horizons.

(c) *Texture-contrast Soils*

The soils of this group have profiles with sandy or loamy surface horizons and abrupt changes to clayey subsoils. They are widespread throughout the area and have been described elsewhere in Queensland by Hubble (1961), Isbell (1957), Beckmann and Thompson (1960), and others. The soils have formed on a wide variety of parent materials derived from igneous and sedimentary rocks, alluvium, and the lower zones of denuded, deep-weathering profiles.

Some of the members of this group are solodized solonetz or solodic soils formed by clay illuviation under the influence of sodium salts, resulting in the development of coarse, columnar-structured B horizons. Other soils are almost certainly polygenetic in origin and have formed by the deposition of medium- to coarse-textured materials on older clayey soils. They frequently have stone lines consisting of rounded or subangular quartz, billy, or ferruginous gravels above the subsoils. Gravelly or stony phases occur in all the soils of this group.

These soils generally occur in areas of very gently undulating relief with slopes of less than 5%, but they also occur in areas of hilly relief with very steep slopes. On the basis of 340 observations, they have been classified in two main subgroups according to depth of sola. These groups are further subdivided into eight families according to differences in texture and thickness of surface soils and subsoil reaction (Table 13).

(i) *Shallow Texture-contrast Soils*

Southernwood.—This family has sandy or loamy surface soils generally less than 15 in. thick, occasionally thicker, which are underlain by acid to mildly alkaline, sandy clay to heavy clay subsoils. Bed-rock of varying lithologies occurs at depths of 24 in. or less.

Surface soil texture is predominantly sandy loam but ranges between sand and clay loam, and moderate to large quantities of gravel frequently occur in the subsurface horizons. The surface soils are chiefly dark brown to reddish brown in colour. These soils have massive structure and set hard when dry. Subsurface soils are frequently lighter in colour and a sporadic or conspicuous bleach may occur.

Subsoil texture is usually light to medium clay but ranges from sandy to heavy clay. Colours are mainly dark red or reddish brown, but brown, grey-brown, or very dark grey-brown also occur. Structure is medium, subangular or angular blocky, and consistence firm to hard when dry. Reaction is generally slightly acid or neutral but ranges from strongly acid to mildly alkaline. The vegetation is chiefly eucalypt woodland dominated by silver-leaved or narrow-leaved ironbarks, or brigalow–blackbutt scrub.

Medway.—These soils are similar to those of Southernwood family but have strongly alkaline subsoils, occasionally with columnar structure. Eucalypt woodland dominated by silver-leaved ironbark, Normanton box, or brigalow–blackbutt scrub is characteristic.

(ii) *Deep Texture-contrast Soils*

Luxor.—This family has sandy surface soils more than 15 in. thick, usually about 20 in. but sometimes as much as 36 in. These are underlain abruptly by light to medium clay subsoils, brown or yellowish brown in colour, frequently with prominent mottling. Subsoil reaction is moderately acid to mildly alkaline. These soils occur in areas of very gently undulating relief with slopes rarely exceeding 5%. They are poorly drained.

Surface soil textures range from sand to sandy loam, and gravel commonly occurs in the subsurface horizons. Colours are brown to dark grey-brown and gradually become lighter in the subsurface, or a conspicuously bleached horizon may occur. The surface soils have slightly acid reaction, massive structure, and generally firm consistence when dry.

The clayey subsoils have medium to coarse, subangular or angular blocky structure, occasionally coarse columnar, and hard to very hard consistence when dry. Root penetration is poor. Poplar box woodlands are characteristic.

Broadmeadow.—These soils are similar to those of Luxor family, but small to moderate amounts of carbonate are present in the subsoils, columnar structure is more common, and reaction is strongly alkaline. The vegetation is generally poplar box woodland.

Springwood.—These soils have thin (5–14 in.), brown to grey-brown, sand to sandy loam surface soils overlying brown, yellowish brown, or yellowish red, light to medium clay subsoils. They are more than 3 ft deep. Soil reaction at the surface is slightly acid and moderately acid to mildly alkaline in the subsoils. The vegetation is mainly poplar box woodland but brigalow–blackbutt scrub also occurs.

Taurus.—These soils have thin (less than 15 in.) sand to sandy loam surface soils, dark brown to grey-brown in colour over brown, yellowish brown, or reddish brown light to medium clay subsoils. The subsurface soils commonly are lighter in colour and sporadically or conspicuously bleached. The surface soils are generally slightly acid and there is a gradual increase to strongly alkaline reaction in the subsoils. Structure is massive at the surface and angular blocky, occasionally columnar, in the subsoils, where small to moderate amounts of carbonate are generally present. The surface soils set hard when dry and subsoil consistence is commonly hard to very hard. These soils occur mainly on very gentle, intermediate or lower slopes and poplar box woodland or brigalow–blackbutt scrub are characteristic.

Analytical data for one profile indicate that the surface soil has very low exchange capacity (6·5 m-equiv./100 g soil) but increases to 16·0 m-equiv./100 g in the subsoil. Calcium is the dominant metal ion in the surface soil and upper subsoil but magnesium increases with depth. Exchangeable potassium values ranged from 0·2 to 0·3 m-equiv./100 g and exchangeable sodium was low. Total nitrogen and organic carbon values were 0·03 and 0·28% respectively and available P_2O_5 was 59 p.p.m.

Wyseby.—The soils of this family have brown or dark brown, sandy clay loam to clay loam surface soils, generally less than 12 in. thick, over yellowish brown, brown, or reddish brown, medium to heavy clay subsoils. A sporadically bleached subsurface horizon commonly occurs. Reaction is slightly acid in the surface soils and moderately acid to mildly alkaline in the subsoils. The surface soils have massive or very weak, fine blocky structure and the subsoils have medium angular or subangular blocky, occasionally columnar, structure and generally hard to very hard consistence when dry. These soils occur on very gentle lower slopes under poplar box woodland or brigalow–blackbutt scrub. They also occur in areas of undulating relief on granite under silver-leaved ironbark. Coarse billy gravel is commonly present in the surface soils in areas under brigalow–blackbutt communities.

Analytical data from one profile of a sedentary soil on granite indicate a moderate exchange capacity of 16–18 m-equiv./100 g soil and 60% base saturation in both surface soil and subsoil. Calcium is the dominant metal ion and magnesium is subdominant. Exchangeable potassium values in surface and subsoil horizons were 0·6 and 0·3 m-equiv./100 g respectively and exchangeable sodium is low. Total nitrogen and organic carbon values were 0·1 and 1·6% respectively and 60 p.p.m. of available P_2O_5 were present in the surface soil.

Retro.—These soils are extensive and widespread throughout the area. They occur mainly on very gentle slopes on the lower parts of denuded weathering profiles, formed on a variety of parent rocks. They have thin, brown to dark grey-brown, sandy clay loam to clay loam surface soils, generally 2–8 in., occasionally thicker, over brown, dark brown, or red, medium to heavy clay subsoils. A very thin, sporadically bleached subsurface horizon commonly occurs. They are more than 3 ft deep. Reaction is slightly acid to mildly alkaline in the surface horizons and strongly or very strongly alkaline in the subsoils where small to moderate amounts of soft carbonate accumulations are generally present. Massive surface soils and blocky, occasionally columnar, structure and hard consistence in the subsoils are characteristic. The vegetation is typically brigalow and/or gidgee scrub, sometimes with yapunyah, or brigalow–blackbutt scrub. Poplar box or silver-leaved ironbark woodlands are less common.

Analytical data on samples from four profiles indicate cation exchange capacities of 12–15 m-equiv./100 g soil in the surface horizons and 14–21 m-equiv./100 g soil in the subsoils. Base saturation ranges from about 50% in the surface soils to more than 90% in the lower horizons. Calcium is the dominant exchangeable cation in the upper profiles but magnesium commonly increases at depth and may become dominant. Exchangeable potassium values range from 0·1 to 1·0 m-equiv./100 g soil with the higher values in the surface soils. Exchangeable sodium is low at and near the surface but increases with depth and comprises 14–25% of the exchange capacities in two of the four profiles. Total nitrogen contents in the surface soils of two profiles were 0·08 and 0·09% and organic carbon was 1·1% in both cases. The available P_2O_5 contents were 45 and 74 p.p.m.

Clay mineral determinations on subsoil samples from two profiles indicate that montmorillonite is dominant or subdominant and kaolin, illite, and quartz either subdominant or accessory.

(*d*) *Red and Yellow Earths*

These soils are widespread and occur extensively in the western half of the area below the Great Dividing Range in the Belyando catchment. They form the upper zones of more or less intact or only slightly denuded areas underlain by deep weathering lateritic profiles. These areas form part of very gently undulating to nearly level landscapes developed mainly on Tertiary sediments but also on other rocks of varying lithologies and ages. The soils have also formed on coarse- to medium-textured alluvia on levees and back slopes in well-drained situations.

The most important characteristics of these soils are their red to yellow colours, with various intergrades, gradational or occasionally uniform texture profiles, and moderately acid to neutral reactions. Those soils with moderate clay contents have massive structure and earthy, vesicular fabric, and those with low clay contents have single-grain structure and sandy fabric.

The soils have been grouped on the basis of 140 observations in six families according to differences in colour, texture, and depth.

Dunrobin.—The soils of this family have dark reddish brown or dark brown sandy loam to sandy clay loam surface soils that grade to red or yellowish red sandy clay loam or light clay at depths of less than 2 ft. They are generally more than 3 ft deep but may be underlain by massive laterite or indurated mottled zone between 2 and 3 ft. Pisolitic ironstone occurs infrequently in the lower profiles. Soil reaction is usually slightly acid to neutral throughout but occasionally may be moderately acid. The soils are well drained. The typical vegetation is woodland dominated by various eucalypts, mainly silver-leaved ironbark but also bloodwood, ghost gum, poplar box, or yellowjack.

Analytical data in respect of two profiles indicate the intense weathering and leaching to which these soils or their parent materials have been subjected. The profiles occur on residual lateritic formations and have exchange capacities equivalent to 4·9 and 9·1 m-equiv./100 g soil and 50–80% saturation with metal ions. In one of the profiles calcium is the dominant exchangeable cation throughout, but in the other magnesium becomes dominant below 2 ft. Exchangeable potassium values range from 0·1 to 0·6 m-equiv./100 g soil with the higher contents at the surface. The value for total nitrogen in both profiles was 0·03% and organic carbon ranged from 0·41 to 0·47%, giving C : N ratios of 14 and 16. The available P_2O_5 contents were 6 and 12 p.p.m.

Clay mineral analysis in respect of the lower part of one profile indicated that kaolin was dominant, with quartz and talc as accessory minerals.

Struan.—These soils are similar to those of Dunrobin family but they have yellowish brown or brownish yellow occasionally mottled subsoils, they generally contain pisolitic ironstone in the lower profiles, and probably are less well drained. They are more than 2 ft deep. A common feature in areas of these soils is the occurrence of numerous elongated termite mounds 2–3 ft in height. Silver-leaved ironbark woodland is the typical vegetation.

Annandale.—Sand to sandy loam textures to depths of 2 ft or more, and a gradual increase in clay content to sandy clay loam or light clay at depth, are characteristic of the soils of this family. Depths generally exceed 4 ft and in most cases are greater than 6 ft. Colours are brown to reddish brown at the surface, gradually becoming red or yellowish red at depth. Soil reaction is moderately acid to neutral throughout. Typical vegetation is an open woodland dominated by bloodwood, ghost gum, or narrow-leaved ironbark.

Forrester.—These soils are similar to those of Annandale family but have yellowish brown or brownish yellow subsoils. They are generally more than 3½ ft deep and are underlain by indurated mottled zone, sometimes with pisolitic ironstone in the lower profiles. Poplar box, silver-leaved ironbark, ghost gum, or bloodwood woodlands are typical.

Gregory.—These soils are 24 in. or less in depth and are underlain generally by concretionary or massive laterite, mottled-zone materials, or weathered rock. They commonly occur on low rises or near scarp edges where the surface cover has been largely stripped off. Soil reaction ranges from very strongly acid to neutral. Woodlands dominated by lancewood and bendee or bloodwood, silver-leaved or narrow-leaved ironbarks, are typical, the first two species invariably occurring on the more acid soils.

Wilpeena.—These soils are similar to those of Dunrobin family but they occur on higher levees and plains near major streams, and have formed on coarse- to medium-textured alluvia. They are more than 5 ft deep and have brown sandy or loamy surface soils that grade to reddish brown or yellowish red sandy clay loam or light clay at depths of less than 2 ft. They are generally massive but may have weak subangular blocky structure in the subsoils. Soil reaction is neutral throughout. They are well drained but are subject to occasional overflow. Poplar box woodland is the typical vegetation.

Analysis results in respect of one profile near Albro on the Belyando indicated that the exchange capacity was slightly higher than in the lateritic red earths and ranged from 9·1 to 12·4 m-equiv./100 g soil. The soil was 80–90% saturated, predominantly with calcium. In the surface soil the value for exchangeable potassium was 0·51 m-equiv./100 g soil and total nitrogen and organic carbon values were 0·05 and 0·74% respectively. Available P_2O_5 was 131 p.p.m.

(*e*) *Dark Brown and Grey-brown Soils*

The soils of this group occur mainly in the south of the area in gently undulating to low hilly terrain. They have formed mainly on parent materials derived from Triassic shales and mudstones and Tertiary basalt, and to a lesser extent on Permian sediments. They have either uniform medium to fine textures or gradational texture profiles in which the clay content gradually increases with depth. The soils are shallow to moderately deep. On the basis of 35 observations they have been subdivided into two families according to differences in texture and underlying materials.

Gindie.—These soils are dark brown loams to medium clays generally less than 15 in. deep, underlain by almost pure carbonate derived from weathered basalt or Permian marine sediments rich in fossils. Soil reaction is moderately to strongly alkaline throughout. The surface soils are friable and have fine granular structure grading to weak medium subangular blocky. Softwood scrub commonly occurs on these soils, or a woodland dominated by bloodwood or mountain coolibah.

The most extensive areas of these soils are below the basalt escarpments of the Buckland Tableland, where they occur on low ridges with masses of large basalt boulders and alternate with dark cracking clay soils of the Rolleston and May Downs families in swales. Under softwood scrub these soils have a moderate to high content of organic matter.

Cheshire.—The soils of this family are mainly dark brown or grey-brown clay loams to light clays at the surface that grade to grey-brown or yellowish brown medium or heavy clays at depths of less than 2 ft. They have formed on parent materials derived from Triassic shales and mudstones, and on colluvium. They are generally more than 3 ft deep. Soil reaction is slightly acid at the surface and gradually becomes moderately to strongly alkaline at depths of 2–3 ft. Small to moderate amounts of soft carbonate accumulations are usually present. The typical vegetation is brigalow–wilga scrub, generally with an understorey of false sandalwood, currant bush, and limebush. The soils are severely sheet-eroded in places, possibly where the vegetation has been disturbed by fire.

Other members of this family have uniform medium to fine textures throughout and have formed on parent materials of varying origin. They are not extensive. Soil reaction is generally slightly acid at the surface, becoming moderately to strongly alkaline at depth. At two sites under softwood scrub reaction was strongly alkaline at the surface and moderately acid at depth.

(*f*) *Uniform Coarse-textured Soils*

The soils of this group are uniform sands to sandy loams formed on quartz sandstones and conglomerates of various ages and on colluvial fans derived from the Tertiary land surface. They occur throughout the area but are most extensive in the south in gently undulating to hilly terrain on the Precipice and Colinlea Formations. On the basis of 90 observations they have been classified into two families according to differences in depth of sola. No analytical data are available for these soils but in view of their high contents of quartz sand, they almost certainly have low fertility and poor water-retaining capacities.

Petrona.—These soils are uniform sands or loamy sands less than 3 ft in depth and occur generally in areas of hilly relief on slopes of up to 10%. Colours at the surface are brown to dark brown and change gradually to brown, pale brown, or yellowish brown in the lower profiles. They are structureless and are slightly to strongly acid throughout. The characteristic vegetation is silver-leaved or narrow-leaved ironbark woodland with admixtures of cypress pine and black wattle. Rock outcrops are numerous in some areas.

Highmount.—These soils occur on gentle, lower slopes below sandstone ranges and hills. They have brown to black, humic-stained surface soils about 12 in. thick underlain by brown, yellowish brown, or yellowish red subsoils. Textures are uniform sands to loamy sands throughout and they are more than 3 ft deep and commonly much deeper. Soil reaction is slightly to moderately acid. Woodlands of silver-leaved ironbark or ghost gum with admixtures of cypress pine, black wattle, or bloodwood are characteristic.

(*g*) *Shallow, Rocky Soils*

This group comprises shallow, rocky soils or lithosols which occur mainly on hills and mountains generally in association with numerous rock outcrops. The soils are usually less than 12 in. deep, but small pockets of deeper soils may occur, and they have no profile differentiation apart from slight humic staining at the surface. They are most extensive in areas of quartz sandstone, metamorphic, and volcanic rocks. These soils are classified in two families according to differences in texture and parent rock.

Rugby.—These soils have uniform medium to fine textures often with gravel or rock fragments and have formed mainly on basalt or shaly rocks. Soil reaction is generally slightly acid to neutral. Silver-leaved or narrow-leaved ironbark or mountain coolibah woodland is characteristic.

Shotover.—The soils of this group have uniform coarse textures generally with gravel or rock fragments and have formed mainly on quartz sandstones, metamorphic and volcanic rocks, and on lateritic scarps. Soil reaction ranges from slightly to very strongly acid. Woodlands dominated by silver-leaved and narrow-leaved ironbarks, yellowjack, and lemon-scented gum or bendee, lancewood, and rosewood scrubs are typical.

(*h*) *Miscellaneous Land*

Saline muds occur in the almost flat, seasonally flooded floors of Lakes Buchanan and Galilee. They are very sticky, massive clays with a thin "puffy" salt crust during the dry season.

IV. Origin and Occurrence of the Soils

The occurrence of the soils in relation to the land systems and to some of the more important factors that have influenced their development is discussed briefly in this section.

(*a*) *Occurrence of the Soils*

The distribution of the various soils in the 43 land systems is shown in Tables 14 and 15 and in relation to the area as a whole on the small-scale soils map. The tables show the estimated occurrence of individual soil families in each land system and their relationships to groups of land systems arranged according to geomorphology.

The arrangement differs slightly from that shown in Part VI in that red and yellow earths are considered to be characteristic of land systems on the stable or slightly stripped Tertiary land surface and texture-contrast soils are believed to occur in erosional and depositional land systems within the weathered zone (cf. Monteagle and Pinehill land systems). This arrangement conforms with the groups shown in the catenary sequence of land forms, soils, and vegetation illustrated in Table 2.

(*b*) *Past Climatic and Geomorphic Influences*

The nature and distribution of the soils in the 19 land systems that occur on residuals of the Tertiary land surface or on erosional and/or depositional landscapes within the weathered zone have clearly been influenced more by past climate and geomorphic history than by any other factors. In particular, the effects of deep weathering tend to mask lithologic differences in all except quartz sandstones. These land systems together cover about 18,000 sq miles of the area and the dominant soils fall into three main groups which occur generally in catenary sequence.

Red and yellow earths together with deep uniform coarse-textured soils on fans derived from them are dominant in five land systems (Ronlow, Lennox, Tichbourne, Durrandella, and Degulla) covering 7800 sq miles in the western plains and tablelands region. These highly leached soils rich in sesquioxides and kaolinitic clay often with much concretionary ironstone are believed to have formed under more humid climatic conditions than those of the present day.

Texture-contrast soils are dominant in the group of five land systems on the upper to lower parts of the Tertiary weathered zone (Monteagle, Pinehill, Humboldt, Disney, and Loudon). They cover about 6000 sq miles throughout the area. The soils commonly have the typical morphology of solodized solonetz or solodic soils and a preponderance of exchangeable sodium and magnesium ions in the clayey subsoils. Other soils in this group have clearly formed by the deposition of coarse-textured materials over older clayey soils and do not have genetically related horizons. These two types of texture-contrast soils appear to occur in close association and they support the same vegetation.

Cracking clay soils are dominant in nine land systems on the lower parts of the Tertiary weathered zone in sedimentary rocks (Blackwater, Ulcanbah, Somerby, Islay, and Willows) and basalt (Kinsale, Wondabah, Avon, and Moray). They cover 4300 sq miles mainly in the north-central clay plain region and have strongly developed gilgai microrelief over about 1500 sq miles (Somerby and Islay land systems). Natal and Logan clay soils are characteristic of the uniform Avon and Moray land systems in the north-east, where they are considered to have formed on transported materials derived from weathered basalt. The parent materials of these soils have obviously been subjected to less intense weathering than those of the other groups. This is evidenced by their higher base status and proportions of montmorillonoid clay minerals.

(*c*) *Lithology and Relief*

In the erosional land systems largely below the Tertiary weathered zone, soil type and distribution are governed mainly by lithology and relief. In five land systems

TABLE 14

OCCURRENCE OF SOIL FAMILIES IN THE LAND SYSTEMS OF THE TERTIARY LAND SURFACE AND WEATHERED ZONE

Percentage area of land system with each soil

Major Group and Family	Tertiary Land Surface					Land Systems within Tertiary Weathered Zone													
	Upper Catena					Mid Catena					Lower Catena								
	Ronlow	Lennox	Tichbourne	Durrandella	Degulla	Monteagle	Pinehill	Humboldt	Disney	Loudon	Blackwater	Ulcanbah	Somerby	Islay	Willows	Kinsale	Wondabah	Avon	Moray
Alluvial soils																			
Davy																			
Clematis			< 5										< 5		< 5				
Warrinilla																			
Moolayember																			
Cracking clay soils																			
Pegunny								10	< 5		10	10	55	70	10				
Rolleston						< 5		10			50	40	15	10	50	35			
Natal																		40	65
Logan																		60	35
Arcturus																5			
May Downs																30	10		
Glenora																15	70		
Teviot											10								
Vermont											5	5	< 5	< 5	< 5				
Bruce																5			

Texture-contrast soils																	
Southernwood				< 5					10	20					5		
Medway			< 5														
Luxor		5	< 5	10	10	20	25	5	10	10			< 5	< 5	5		
Broadmeadow		5				10	25	5		10							
Springwood				< 5		20		5	5				< 5	< 5			
Taurus			< 5	< 5		5	5	10	5		5			< 5	5		
Wyseby		< 5		< 5				< 5	10	10		15					
Retro		< 5		10		15	20	50	25		20	25	20	10	15		
Red and yellow earths																	
Dunrobin	55	20	35	5	5	10	25	< 5	10	10		< 5			< 5		
Struan	20	40	30		10	5		< 5	10	< 5		< 5	< 5				
Annandale	25	5		10					5	5							
Forrester		5	15		20				5								
Gregory		5	< 5	20		< 5				< 5							
Wilpeena		< 5			< 5												
Dark brown and grey-brown soils																	
Gindie												< 5					
Cheshire															5		15
Uniform coarse-textured soils																	
Petrona			5			< 5			< 5								
Highmount		5		10	50	< 5			< 5						< 5		
Shallow rocky soils																	
Rugby						< 5				10						5	
Shotover			5	25		< 5				20							
Miscellaneous land																	
Saline mud flats																	

TABLE 15

OCCURRENCE OF SOIL FAMILIES IN THE LAND SYSTEMS BELOW THE TERTIARY WEATHERED ZONE AND ON ALLUVIUM

Percentage area of land system with each soil

Major Group and Family	Erosional Land Systems largely below the Tertiary Weathered Zone																			Alluvial Land Systems				
	Mountainous			Hilly						Undulating to Level														
	Bogantungan	Carborough	Percy	Borilla	Copperfield	Hope	Portwine	Kareela	Waterford	Playfair	Craven	Rutland	Hillalong	Peakvale	Skye	Cungelella	Wharton	Mantuan	Oxford	Alpha	Banchory	Comet	Funnel	Galilee
Alluvial soils																								
Davy		< 5								< 5										15		5		
Clematis								< 5	< 5													5	10	10
Warrinilla																				5		5	< 5	
Moolayember																							< 5	
Cracking clay soils																								
Pegunny													10											
Rolleston								15					15	< 5		10	20							
Natal																								
Logan																								
Arcturus									15					< 5					25					
May Downs								10											50					
Glenora								15	25										15					
Teviot							5				10	5	20					65						
Vermont							< 5	< 5	< 5							5		30	5	15	70	50	60	
Bruce							5		40										5					

Texture-contrast soils																							
Southernwood	10				10	20	20				25	25		10									
Medway	5	< 5				25	30				25	25											
Luxor				< 5		10	5			15	5				10	10	< 5		25				
Broadmeadow	10	< 5				10	5				5	5		15	10		5			10			15
Springwood	5			< 5	< 5	10	5										5						
Taurus		< 5			< 5		25	5			15	10	50	30	30	10	5		20		5	< 5	10
Wyseby					< 5	5						5		30		10	< 5			5		5	
Retro					< 5						10	15		< 5	20	10	15			15	20	15	
Red and yellow earths																							
Dunrobin		< 5			5					5					5								
Struan										5					5								
Annandale																	< 5						
Forrester										5													
Gregory					5				5														
Wilpeena																			20		10		
Dark brown and grey-brown soils																							
Gindie								35										< 5					
Cheshire			5					5							5	45	40						
Uniform coarse-textured soils																							
Petrona		10		10						45					5								
Highmount		10								25					5								5
Shallow rocky soils																							
Rugby			95			5		5	10			< 5		< 5			5						
Shotover	70	65		80	70	15						< 5		< 5									
Miscellaneous land																							
Saline mud flats																							60

(Bogantungan, Carborough, Percy, Borilla, and Copperfield) with mountainous to hilly relief covering 4500 sq miles, shallow rocky soils predominate. They occur chiefly on resistant quartz sandstones but also on volcanic and metamorphic rocks in the central highland, northern hills, and southern scarpland regions. Playfair land system with undulating relief on quartz sandstone has dominantly uniform coarse-textured soils.

The shallow texture-contrast soils with some cracking clays occur in narrow belts following the strike lines of folded sedimentary rocks in five land systems (Craven, Hope, Hillalong, Portwine, and Rutland). These land systems are mainly in the eastern and western lowland regions, with undulating to hilly relief. Deep texture-contrast soils are dominant in two land systems developed on partially weathered shales and sandstones (Skye) and on granite (Peak Vale) and together cover over 1000 sq miles.

Basalt and shales in the basalt lowland and southern scarpland regions both give rise to fine-textured soils low in quartz. Kareela land system has hilly relief on slumped basalt sheets below the Buckland Tableland in the south. Dark brown and grey-brown soils occur on bouldery ridges and cracking clay soils have developed in linear vales. Cungelella and Wharton land systems cover about 1500 sq miles of undulating land in the south and have dominantly dark brown and grey-brown soils derived mainly from shales. Dark cracking clay soils are dominant in Oxford, Mantuan, and Waterford land systems covering 2600 sq miles on basalt and shales in the east and south. The first two have undulating to level relief and mainly deep soils and Waterford land system with hilly relief has dominantly shallow soils.

Land form, mode of deposition, and the nature of source materials largely determine soil distribution in the five alluvial land systems. Cracking clay soils are dominant in Banchory, Comet, and Funnel land systems, covering 2000 sq miles of lower alluvial plains which are subject to seasonal flooding. These land systems are adjacent to streams that rise mainly in areas of basalt, shales, and basic sediments. Alpha land system occurs on moderately well-drained upper plains and terraces of streams with source areas of predominantly quartzose rocks and has mainly texture-contrast soils and alluvial red earths. Saline muds have accumulated on the floors of the intermittent lakes in Galilee land system.

(*d*) *Halomorphic Influences*

The extensive occurrence of texture-contrast soils with solodized solonetz or solod morphology and cracking clay soils with appreciable contents of soluble salts indicates that halomorphic influences have been widespread in the area. A similar situation occurs in the eastern parts of the Fitzroy region and has been recorded in other parts of Queensland (Hubble and Isbell 1958; Isbell 1957). The most extensive occurrences of these soils in the area are in the erosional and/or depositional landscapes formed on denuded Tertiary weathering profiles generally below scarps (Table 2). The possible source of salts which influenced soil formation at these sites is indicated by analytical data on 11 samples of mottled- and pallid-zone materials exposed on scarps in various parts of the area. The soluble salt contents ranged from 0·38 to 7·0% in a pallid-zone residual near Lake Buchanan. The soluble material consisted mainly of sodium chloride and significant amounts of magnesium ions were present in some samples. The source of the salts and the processes whereby they accumulated in these materials are not clear but it is considered most likely that they originated from the parent rocks and accumulated as a result of deep weathering. If appreciable quantities of sodium salts are generally present in these materials their distribution by lateral surface and subsurface seepage may account for the widespread occurrence of solodized soils in the catenary sequence on weathered Tertiary landscapes.

(*e*) *Climatic Influences*

The influence of present climatic conditions on soil formation is considered to be subdominant in relation to the other factors discussed. They influence soil development mainly in two ways. Under the generally low seasonal rainfall and high potential evaporation the rate of leaching is probably slow in all except the more permeable coarse-textured soils. Soluble materials incorporated either by weathering *in situ* or by run-off and seepage from higher ground are not rapidly translocated to deeper levels or removed from the profiles. Under these conditions soils formed on "fresh" rocks tend to retain their basic constituents and are generally somewhat shallow. These effects are evident in the shallow soils formed on basic sediments in Rutland and Craven land systems and the cracking clay soils derived from basalt in Oxford land system.

The long periods of seasonal aridity, high temperatures, and low humidity do not favour the accumulation of organic matter and the soils generally have very low contents. Only in the more dense scrubs where the soil surface is protected from insolation are there appreciable amounts of humic material, for example, in the soils of Gindie family under softwood scrub in Kareela land system.

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PART VIII. VEGETATION OF THE NOGOA–BELYANDO AREA

By L. Pedley*

I. Introduction

(a) Environmental Influences

Because of the diverse climatic, lithologic, and pedologic environments described in the preceding Parts, there is a wide range of habitats and consequently a wide range of vegetation types, associations in the sense of Beadle and Costin (1952). Most environmental characters change gradually and the resulting change in vegetation is also gradual. Abrupt changes in edaphic conditions occur, however, and observed discontinuities often correspond with the edaphic changes.

Almost the entire area is burnt periodically, probably most frequently in the drier parts, and vegetation of all types is affected by fire. Gidgee and softwood scrubs are least affected, but frequent fires on their fringes have probably reduced the area of these communities. Grazing animals, native and introduced, have also affected the vegetation to some degree. The effect is most marked near watering points and on stock routes, but Hart (1955) reported a replacement of sheep by cattle in the Emerald–Capella area owing to the increase of white spear grass (*Aristida leptopoda*).

(b) Major Formations

The major plant formations in the area are woodland, scrub, and grassland. Woodlands with eucalypts most prominent occupy most of the area. They decrease in height and density with increasing aridity. Some are grassy woodlands (savanna woodland of Beadle and Costin 1952) but there are often well-developed lower tree strata and a shrub stratum as well as the tallest tree stratum (see below). As well as woodlands there are more or less closed tree communities dominated by *Acacia* spp. When best developed these are forests in the nomenclature of Beadle and Costin (1952) but frequently the trees are not of forest form, having boles much shorter than their canopies, and often the communities are too low and open to be truly forests. They are known colloquially as "scrubs" and that name is used here. Softwood scrub that approximates to Webb's (1959) definition of semi-evergreen microphyll vine woodland or thicket is included in these closed communities. An important difference between woodland and scrub is that in the latter the tree stratum influences the composition and density of the lower strata, particularly the grass stratum, whereas the various woodland strata influence each other little and are independently distributed.

Grasslands occur on fine-textured soils, but edaphic factors other than texture may be important. The gradual change to woodland and the more abrupt transition to scrub seem to depend on water relations within the soil. Gidgee scrub in Moray land system and grassland in the adjoining Avon land system both occur on dark

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cracking clay soils derived from similar parent material. In the main, the gidgee occurs on soils alkaline throughout whereas the grassland soils are alkaline at or near the surface but acid at depth.

(c) *Plant Geography*

Eucalypts are the most prominent trees in the area and predominate in all woodland communities except one. There are about 30 species. Species of the lower strata occurring with woodland communities are usually not eucalypts. Many genera occur, but *Acacia* is the most important, not only in the number of species but also in the number of individuals. *Acacia* is also the most important scrub genus though only five species are important. *Bothriochloa* spp. and *Aristida* spp. are the most widespread and important grass species. *Dichanthium sericeum* is of significance on dark cracking clays, and *Paspalidium* spp. are the most important of the species associated with scrubs.

Field identification of some plants is extremely difficult, particularly some species of *Eucalyptus*. *E. drepanophylla* is the more widespread narrow-leaved ironbark in the area, but as it is not easily distinguished from *E. crebra* both have been called narrow-leaved ironbark. *E. populnea* and *E. brownii* are closely related and grade into each other in the northern part of the survey area. For convenience *E. brownii* is treated as having leaves more than 3½ times as long as broad. It is then confined to the extreme north of the area (Fig. 10) and intermediate forms are considered to be *E. populnea*. A similar state of affairs probably also occurs with *E. normantonensis*. The species so called here is rather different from *E. normantonensis* as found in the type locality and may be an undescribed species grading into true *E. normantonensis*. There are also taxonomic problems in *Acacia*. A number of evidently undescribed species occur in the area. These have been related to their nearest allies.

Distributions of some important species are shown in Figure 10. The ranges of the scrub-forming species blackwood, brigalow, and gidgee are significant, as within the area where their ranges overlap, communities often contain two and sometimes all three species. The ranges of bonewood, shrub wilga, and yellowwood in relation to those of brigalow and gidgee explain why bonewood and shrub wilga occur in midstorey communities in brigalow scrub only while the yellowwood community is associated with both brigalow and gidgee scrubs.

In the area the limits of bonewood, shrub wilga, *E. normantonensis*, *E. populnea*, and brigalow (in the northern part) are more or less parallel and show a SW.–NE. trend. This suggests that the distribution of these species may be determined by one climatic factor.

(d) *Classification of Vegetation*

Except in grasslands the vegetation of the area is characterized by the development of several well-defined layers. In the woodland and scrub formations sometimes only two layers, a tree and a grass layer, can be distinguished, but more frequently one or two lower tree layers and a shrub layer occur between the tree and grass layers. Some scrub communities are even more complex because of the presence of a sparse tree layer above the dense tree layer and the lower associated layers.

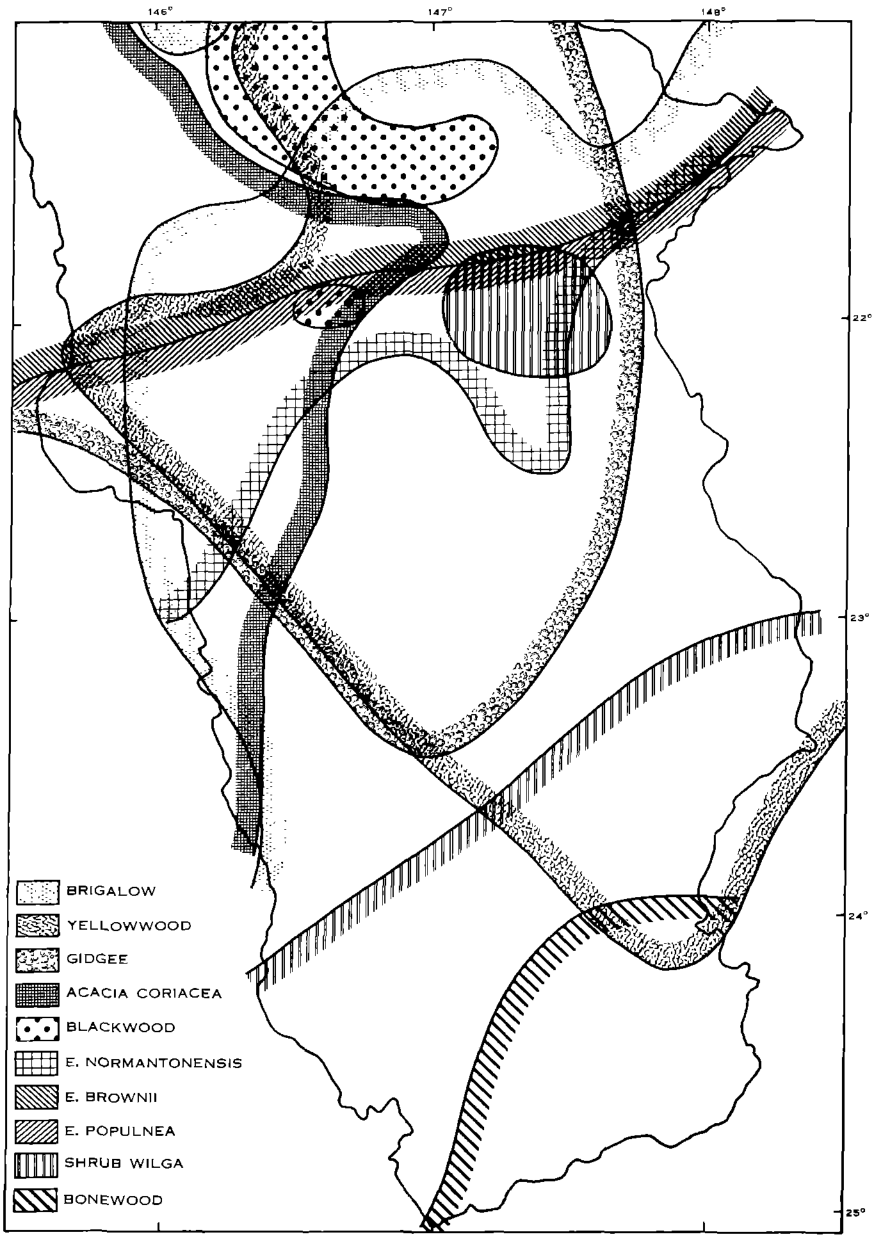

Fig. 10.—Approximate distribution of important woody species.

TABLE 16

COMBINATIONS OF UPPER STRATUM, MID-STOREY*, AND GRASS SYNUSIAE IN WOODLANDS

Woodland Communities	Grass Communities									
	Eastern Mid-height Grass	Scrub Grass	Eastern Spinifex	Blue Grass	Arid Scrub Grass	Sandstone Spinifex	Frontage Grass	*Tripogon loliiformis*	Samphire	*Sporobolus virginicus*
E. melanophloia	b, c, d, x, m		d	x	b	b				
E. populnea	b, c, x		x		b					
Narrow-leaved ironbark	a, b, r, x, c, m		a, m, s		b					
E. orgadophila	b, x			x						
E. polycarpa–E. papuana	b, x		a, d, m, x							
E. similis	a		a							
E. microtheca	c			x						
E. normantonensis	x, b		x							
Sandstone			s			s				
Frontage							x, b			
Fringing	x									
E. cambageana	c	c			b			c		
E. thozetiana	c	c						c		
Grevillea	x									
Miscellaneous	c, x		a	x				c, x	x	x

*Mid-storey communities: a, *Acacia leptostachya*; b, arenicolous; c, argillicolous; d, *Acacia coriacea*; m, *Melaleuca nervosa*; r, *Acacia rhodoxylon*; s, sandstone; x, no mid-storey community.

Species tend to react individually to environmental factors and generally the range of one species does not coincide with the range of any other species. Similar habitats have similar arrays of species but rarely are any two stands floristically identical.

Any classification of the vegetation is therefore somewhat arbitrary, but if the prominent species (there are few in any habitat) of each of the layers are considered then a number of fairly well-defined plant communities can be recognized in each of the layers. On the whole the distribution of the synusiae of one layer is independent of the distribution of the synusiae of other layers. The vegetation of the area has therefore been divided into synusiae, as has been done for the adjacent Leichhardt–Gilbert area by Perry and Lazarides (1964). The classification is more complicated owing to the more complex vegetation.

Though distinct communities may be recognized in each of the intermediate tree and shrub strata they can be combined, with little loss of precision, into midstorey communities. These are not an important feature of the vegetation of the area. As the majority is restricted to woodlands and the rest to scrubs they have been discussed in two groups, though there may be some inter-group relationships.

All woody plants with tree forms are considered trees, regardless of size. Consequently *Eremophila mitchellii* is treated as a tree though it is sometimes only 6 ft tall. A list of botanical names with authors and common names is given in Appendix II; the ranges of some important species are given in Figure 10. Where communities are substantially the same as those described by Perry and Lazarides (1964) the same name has been used even if it is not appropriate in this area; for example, eastern spinifex is best developed in the west of the area.

The relationship between upper stratum, midstorey, and grass synusiae in the woodland formation is shown in Table 16. There are 61 different phytocoenoses, 16 of which are of minor importance. Almost one-third have *E. melanophloia* or narrow-leaved ironbark as the tree stratum component. Every midstorey community is associated with one or both of these tree communities. Other upper stratum synusiae, even the widespread *E. populnea* community, enter into few phytocoenoses. Extreme cases are sandstone woodland which is associated with sandstone midstorey and usually sandstone spinifex, and *Grevillea* woodland with eastern mid-height grass without any midstorey community.

More than half of the phytocoenoses have either eastern mid-height grass or eastern spinifex as the grass layer component. The other grass communities are of less importance in woodlands and, in fact, samphire and *Sporobolus virginicus* communities are never associated with trees or shrubs.

In Table 17 the combinations of tree layer communities with communities of other layers in scrubs are given. Because grass communities are not of great importance in scrubs the table has been constructed to emphasize midstorey and tree communities. It is evident that phytocoenoses containing gidgee and brigalow are structurally and floristically closely related. The *Geijera parviflora* community does not occur with the gidgee community because the ranges of the prominent species do not overlap (Fig. 10). Midstorey communities are absent from lancewood, bendee, cypress pine, and *Melaleuca tamariscina* communities.

Grass communities are more definitely correlated with tree communities than they are in woodlands. Scrub grass is most prominent in brigalow, gidgee, belah, and softwood communities; arid scrub grass in lancewood and bendee; eastern mid-height grass in cypress pine; and sandstone spinifex in *Melaleuca tamariscina*.

TABLE 17

COMBINATIONS OF TREE LAYER COMMUNITIES, MID-STOREY, AND GRASS* SYNUSIAE IN SCRUBS

Scrub Synusiae	Mid-storey Communities				
	Nil	*Eremophila mitchellii*	*Terminalia oblongata*	*Geijera parviflora*	Softwood
Brigalow	p, b	p, b	p, b, d	p, b	p, b
Gidgee	p, b	p, b	p, b, d		p, b
Belah		p, b	p, b, d		
Softwood	p				
Lancewood	a, l				
Bendee	a, l				
Cypress pine	b				
Melaleuca tamariscina	s				

* Grass synusiae: a, arid scrub grass; b, eastern mid-height grass; d, blue grass; l, *Tripogon loliiformis* community; p, scrub grass; s, sandstone spinifex.

Emergent eucalypt communities with associated brigalow and gidgee communities are shown in Table 18. The absence of *E. populnea* and *E. thozetiana* from gidgee scrub and of *Eremophila mitchellii* community from scrubs with emergent *E. microtheca* is noteworthy.

TABLE 18

RELATIONS BETWEEN BRIGALOW AND GIDGEE COMMUNITIES AND EMERGENT EUCALYPTS

Mid-storey community: o, absent; e, *Eremophila mitchellii*; g, *Geijera parviflora*; y, *Terminalia oblongata*

Scrub Synusiae	Emergent Eucalypt			
	E. cambageana	*E. populnea*	*E. thozetiana*	*E. microtheca*
Gidgee	e			o, y
Brigalow (and blackwood)	o, e, y, g	o, e, g	e	o, y

(*e*) *Distribution of Vegetation*

The occurrence of tree layer communities of woodlands and scrubs and of grass communities in the land systems is shown in Tables 19–21.

Woodlands are not important in any depositional land system within the Tertiary weathered zone or in Wondabah, Humboldt, and Kinsale erosional land systems within the Tertiary weathered zone. The most widespread tree communities of woodland, *E. melanophloia* and *E. populnea*, are well developed on stable or moderately stripped Tertiary land surfaces, the former in Tichbourne, Lennox, and Degulla, the latter in Monteagle, Pinehill, and Degulla land systems. They are also prominent in erosional land systems largely below the Tertiary weathered zone, *E. melanophloia* especially in Portwine, Borilla, Playfair, Craven, Rutland, and Peak Vale, and *E. populnea* in Skye and Hillalong land systems. *E. populnea* is also the predominant tree community in Alpha, a post-Tertiary alluvial land system.

The narrow-leaved ironbark community is best developed in some erosional land systems below the Tertiary weathered zone, notably Carborough, Bogantungan, Percy, Hope, Copperfield, and Borilla, but it also predominates in Disney, an erosional land system within the Tertiary weathered zone.

The *E. orgadophila* community is significant in Waterford and is rarely found in land systems associated with the Tertiary weathered zone. On the other hand *E. similis* occurs only in land systems of the stable or moderately stripped Tertiary land surface (especially Ronlow). *E. microtheca* is the only other tree community of significance. It predominates in Funnel land system and is of major importance in Avon land system.

Scrubs are best developed in some erosional and depositional land systems within the Tertiary weathered zone, depositional land systems below the Tertiary weathered zone, and post-Tertiary alluvial land systems. They are of no significance on the stable or moderately stripped Tertiary land surface.

Brigalow is the most widespread tree community. It is especially important in Kinsale, an erosional land system within the Tertiary weathered zone, in Willows, Moray, Blackwater, and Somerby, depositional land systems within the Tertiary weathered zone, in Kareela, Rutland, and Wharton, erosional land systems below the Tertiary weathered zone, and in Comet, a post-Tertiary alluvial land system. The brigalow community with emergent *E. cambageana* is also widespread particularly in Humboldt and to a lesser extent in Wharton land systems.

Gidgee, which is closely allied to the brigalow community, is not widespread. It occurs in land systems within the Tertiary weathered zone, notably Wondabah, Moray, Islay, and Ulcanbah, and in Banchory, an alluvial land system, but is of no significance in land systems below the Tertiary weathered zone.

Other scrub tree communities occupy much smaller areas. Lancewood and bendee communities are widely distributed but are of major importance in Durrandella and Carborough land systems only. Cypress pine scrub is restricted to Playfair land system where it covers about 25% of the area.

Grass communities cover large areas of all land systems except Galilee where they occupy only about one-third of the area. Eastern mid-height grass, scrub grass, eastern spinifex, and blue grass are the most widely spread; other communities are not extensive in any land system.

The eastern mid-height grass community is the most widespread and is the principal community in most land systems where woodlands predominate. Important exceptions are Tichbourne and Ronlow land systems on the stable or moderately stripped Tertiary land surface where eastern spinifex is more extensive, and some

TABLE 19

RELATION BETWEEN WOODLAND TREE LAYER COMMUNITIES AND LAND SYSTEMS

Percentage area of land system with each community

Land System	Woodland Tree Community													
	E. melanophloia	*E. populnea*	Narrow-leaved ironbark	*E. orgadophila*	*E. polycarpa–E. papuana*	*E. similis*	*E. microtheca*	*E. normantonensis*	Sandstone	Frontage	Fringing	*E. cambageana*	*E. thozetiana*	*Grevillea*
Stable or moderately stripped Tertiary land surface														
Tichbourne	40	< 5	5		5	5	< 5	5			< 5		5	
Ronlow	20		< 5			70		< 5						
Lennox	55	15	5		15		< 5				< 5			
Monteagle	15	55	< 5		< 5			5			< 5		< 5	
Pinehill	< 5	85			< 5		< 5				< 5			
Degulla	50	30			15						< 5			
Erosional land systems within the Tertiary weathered zone														
Durrandella		20	15		10			< 5			< 5	< 5	< 5	
Loudon	10	20	5		< 5			15						
Humboldt	< 5	15									< 5	5	< 5	
Disney	< 5	25	30		< 5			5			< 5			
Wondabah				< 5							< 5			
Kinsale	< 5	< 5		< 5							< 5			
Depositional land systems within the Tertiary weathered zone														
Willows	5			< 5	< 5						< 5			
Avon							30				< 5			
Moray							< 5							
Blackwater		10		5							< 5			
Somerby	< 5	5									< 5			
Islay	< 5	10									< 5			
Ulcanbah	< 5	< 5									< 5			
Erosional land systems largely below the Tertiary weathered zone														
Carborough	< 5	5	35		< 5			5	15		< 5			
Bogantungan	< 5	10	85								< 5			
Percy	5		75	20										
Portwine	65	< 5	10	15							< 5			
Hope	10	< 5	65	10							< 5			
Copperfield	5	< 5	65	< 5							< 5			
Borilla	35	10	40								< 5			
Waterford	15			40							< 5			
Kareela	< 5		< 5	15							< 5			
Playfair	25	15	15		< 5					< 5	< 5	< 5		
Craven	35	20	10	10							< 5			
Rutland	35	< 5	< 5	< 5										
Skye	15	60									< 5			
Cungelella	< 5	< 5									< 5	< 5		
Wharton	< 5	< 5												
Peak Vale	70	5	5	5						< 5	< 5			
Hillalong	< 5	60		< 5							< 5			
Mantuan	10	10		< 5			5				< 5			
Oxford				25							< 5			
Post-Tertiary alluvial land systems														
Alpha	15	60					< 5			10	10			
Banchory		< 5					5				5			
Comet	< 5	10					10			< 5	5			
Funnel		15					60			< 5	< 5			
Galilee							< 5							15

TABLE 20

RELATION BETWEEN SCRUB AND EUCALYPT–SCRUB TREE LAYER COMMUNITIES AND LAND SYSTEMS

Percentage area of land system with each community

Land System	Scrub and Eucalypt–Scrub Tree Community											
	Brigalow	Gidgee	Belah	Softwood	Lancewood	Bendee	Cypress Pine	*Melaleuca tamariscina*	*E. cambageana*	*E. thozetiana*	*E. populnea*	*E. microtheca*
Stable or moderately stripped Tertiary land surface												
Tichbourne	< 5	< 5			5				< 5			
Ronlow					< 5							
Lennox	< 5	< 5			< 5							
Monteagle	5	< 5			< 5				< 5		< 5	
Pinehill	< 5	< 5							< 5			
Degulla												
Erosional land systems within the Tertiary weathered zone												
Durrandella	< 5				15	25			< 5	< 5		
Loudon	< 5				10	10		< 5	10	10		
Humboldt	20				< 5				50	< 5		
Disney	15	< 5						< 5	15			
Wondabah	5	70										
Kinsale	60	< 5	15									
Depositional land systems within the Tertiary weathered zone												
Willows	60								15	15		
Avon	< 5											
Moray	35	35										
Blackwater	60	< 5	< 5		< 5				5	5		
Somerby	70	< 5	< 5		< 5				5	5		
Islay	15	65							10			
Ulcanbah	15	60							5	5		
Erosional land systems largely below the Tertiary weathered zone												
Carborough					25	10			< 5	< 5		
Bogantungan												
Percy				< 5								
Portwine	5								< 5		< 5	
Hope	< 5				< 5	< 5						
Copperfield					15	5			< 5	< 5		
Borilla	< 5	< 5		< 5	< 5	< 5			< 5			
Waterford	10	< 5		< 5								
Kareela	35			40								
Playfair	< 5				5	5	25		< 5	< 5		
Craven	15											
Rutland	50								< 5	< 5	< 5	
Skye	15				< 5				< 5		< 5	
Cungelella	20			70								
Wharton	55			5	< 5				20		< 5	
Peak Vale	< 5			5								
Hillalong	20											
Mantuan	< 5											
Oxford												
Post-Tertiary alluvial land systems												
Alpha	< 5	< 5										< 5
Banchory		75										
Comet	50											5
Funnel	10	5										< 5
Galilee		< 5										

TABLE 21

RELATION BETWEEN GRASS LAYER COMMUNITIES AND LAND SYSTEMS

Percentage area of land system with each community

Land System	Grass Community									
	Eastern Mid-height Grass	Scrub Grass	Eastern Spinifex	Blue Grass	Arid Scrub Grass	Sandstone Spinifex	*Tripogon loliiformis*	Frontage Grass	Samphire	*Sporobolus virginicus*
Stable or moderately stripped Tertiary land surface										
Tichbourne	40	< 5	50		5					
Ronlow	35		65							
Lennox	55	< 5	45		< 5					
Monteagle	70	15	5		5		< 5			
Pinehill	70	30								
Degulla	55		40					5		
Erosional land systems within the Tertiary weathered zone										
Durrandella	25	5	< 5		45		< 5			
Loudon	40	15	20		20					
Humboldt	25	70			< 5					
Disney	45	30	25							
Wondabah	< 5	80		15						
Kinsale	5	65		30						
Depositional land systems within the Tertiary weathered zone										
Willows	15	80								
Avon	5	< 5		90						
Moray		70		30						
Blackwater	20	75		< 5	< 5					
Somerby	5	90		< 5	< 5					
Islay	10	90		< 5						
Ulcanbah	10	85					< 5			
Erosional land systems largely below the Tertiary weathered zone										
Carborough	30	< 5	15		20	15	5			
Bogantungan	100									
Percy	90									
Portwine	95	5								
Hope	90	< 5			< 5		< 5			
Copperfield	60	< 5					5			
Borilla	85	10								
Waterford	25	5		60						
Kareela	15	80	< 5	< 5						
Playfair	75	< 5	< 5		10	< 5	< 5	< 5		
Craven	80	15	< 5							
Rutland	45	55	< 5							
Skye	60	25			5					
Cungelella	5	90					< 5			
Wharton	5	80			< 5		5			
Peak Vale	90	< 5						< 5		
Hillalong	60	20		15						
Mantuan	15	< 5		80						
Oxford	15			85						
Post-Tertiary alluvial land systems										
Alpha	75	< 5		< 5				10		
Banchory		50		35			5			
Comet	15	45		25				< 5		
Funnel	25	15		45			< 5	< 5		
Galilee	15								15	< 5

depositional land systems within and below the Tertiary weathered zone (Avon, Waterford, Mantuan, and Oxford) and one post-Tertiary alluvial land system (Funnel) where blue grass predominates. Eastern spinifex is also widespread in Lennox and Degulla, both land systems of the Tertiary surface, and blue grass in Kinsale, Moray, and Banchory.

In land systems where scrub is the most extensive formation scrub grass or rarely arid scrub grass is the most prominent grass community.

The vegetation maps are simplified presentations of the vegetation. Land systems are grouped according to their predominant tree layer community and grass layer community, each of which is mapped separately. Midstorey communities and secondary communities within each land system have been neglected entirely, and small areas of land systems have either been grouped with larger areas of related land systems or omitted. The detailed vegetation pattern can be built up from the land system descriptions and maps. Tables 19–21 give estimates of the proportions of the communities in each land system. In the text and in the tables communities in each group are arranged approximately in decreasing order of the areas they occupy.

II. Grass Communities

(*a*) *Eastern Mid-height Grass*

This, the most extensive of the grass communities in the survey area, occurs on all soil types in all formations but is not extensive on fine-textured soils where the blue grass community is more common or in closed communities where it occupies small areas where the canopy is less dense. In the west of the area eastern spinifex is more common, though there are often mosaics of eastern spinifex and eastern mid-height grass. It occurs on red and yellow earths and texture-contrast soils, and is commonly associated with *E. polycarpa–E. papuana* woodland, *E. melanophloia* woodland, narrow-leaved ironbark woodland, *E. orgadophila* woodland, and *E. populnea* woodland, and occasionally forms grasslands (western parts of Avon and Craven land systems).

The grass layer is normally dense, occasionally sparse on lighter soils, and is composed of perennial drought-evading tussock grasses 3 ft high. The commonest and most constant species is *Bothriochloa ewartiana*, which sometimes forms pure stands. *Heteropogon contortus*, *Themeda australis*, *Chloris acicularis*, *Eriachne* spp. (including *E. mucronata* and *E. obtusa*), *Cymbopogon refractus*, and *Aristida* spp. (including *A. glumaris*, *A. ramosa*, *A. helicophylla*, and *A. jerichoensis*) are common and constant. *Eriachne* spp. and *Aristida* spp. occur on lighter and shallower soils and are most common towards the west of the region. Further study may reveal that they constitute a separate community. Locally important grasses are *Dichanthium fecundum* (in the north-west), *D. sericeum*, *Bothriochloa decipiens*, *B. intermedia*, *Aristida ramosa*, *Cymbopogon bombycinus*, *Eulalia fulva*, *Chrysopogon fallax*, and *Rhynchelytrum repens*. Forbs of a similar height are not common, but *Notoxylinon australe*, *Trichodesma zeylanicum*, and *Waltheria indica* occur.

Shorter grasses and forbs contribute little to the yield of the pasture, but *Aristida browniana*, *A. hygrometrica*, *Enneapogon* spp. (including *E. pallidus* and

E. polyphyllus), and *Schizachyrium obliqueberbe* occur. Forbs include *Polycarpaea* spp., *Zornia* spp., *Desmodium brachypodum*, and *Gomphrena celosioides*.

(*b*) *Scrub Grass*

This community occurs throughout the region. It is best developed in association with brigalow, blackwood, gidgee, and softwood communities on dark cracking clay soils, deep texture-contrast soils, and dark brown and grey-brown soils. It occurs in the shade produced by closed communities and occasionally in woodland with a dense argillicolous midstorey. Where scrubs are open the community often alternates with blue grass on dark cracking clays or eastern mid-height grass on texture-contrast soils.

The grass layer is usually about 1 ft tall and ground cover is low with much bare ground between the perennial tussocks. The community is diverse with many forbs as well as perennial grasses. The commonest and most constant species are the grasses *Paspalidium* spp. (mainly *P. gracile*, *P. caespitosum*, and *P. constrictum*), *Sporobolus* spp. (including *S. scabridus* and *S. caroli*), *Chloris divaricata*, *C. acicularis*, and *Enneapogon* spp., and the forbs *Enchylaena tomentosa*, *Trianthema triquetra*, and *Rhagodia* spp. *Ancistrachne uncinulata*, *Paspalidium jubiflorum*, *Eragrostis megalosperma*, and *Chloris unispicea* are less constant, the last two being fairly common in softwood and brigalow–softwood communities. The sedge *Cyperus gracilis* and fern *Cheilanthes* sp. are common smaller plants. A great number of small forbs that contribute little to the yield of the pasture occur sporadically. Most important are *Justicia procumbens*, *Portulaca oleracea*, *P. filifolia*, *Tribulus terrestris*, *Rhynchosia minima*, and *Boerhavia diffusa*.

Melon-holes in dark cracking clay soils in gidgee, blackwood, and brigalow communities are seasonally flooded and are usually wetter than their surroundings. They support a distinctive flora. *Leptochloa* sp., *Panicum* sp., and *Juncus* spp. are common mid-height (3–4 ft) perennials; *Sesbania* sp., a tall annual, occurs occasionally; *Marsilea* spp. occur in melon-holes wet for long periods; and *Centipeda minima* and *Ammannia* sp. are short-lived, small annuals.

Scrub grass provides a low yield of highly nutritious forage, more suited to sheep than to cattle-grazing. Removal of the protecting tree canopy results in the eventual replacement of scrub grass by eastern mid-height grass or blue grass.

(*c*) *Eastern Spinifex*

Large areas of this community occur in the north and north-west of the Nogoa–Belyando area, mainly in Tichbourne, Ronlow, and Lennox land systems. It extends to the west (the "desert country" of Blake 1938) and is best developed under a mean annual rainfall of less than 20 in. though its range is determined more by edaphic-geological factors than by climate. It usually occurs on red and yellow earths, occasionally on texture-contrast, rarely on uniform sandy and shallow rocky soils. *E. similis* woodland is invariably associated with it and it frequently also occurs with narrow-leaved ironbark, *E. melanophloia*, and *E. polycarpa–E. papuana* woodlands, particularly where *Acacia leptostachya* and *A. coriacea* midstorey communities are associated. Less commonly *E. populnea* and *E. normantonensis* woodlands are its associates.

The mid-height grass layer is characterized by perennial evergreen tussocks of *Triodia* spp., mainly *T. mitchellii* with occasional *T. pungens*. The spaces between tussocks may be bare or have a sparse cover of *Eriachne* spp., *Aristida helicophylla*, and *Cymbopogon bombycinus*. Mosaics of eastern spinifex and eastern mid-height grasses (*Aristida* spp., *Themeda australis*, and *Heteropogon contortus*) frequently occur. The two communities remain quite distinct and do not intermix. This is marked in the groved *E. similis* woodland where eastern mid-height grasses occur beneath the upper and midstorey synusiae and eastern spinifex in the intergroves.

The community has low pastoral value. Grazing is usually restricted to brief periods following a burn, and stocking rates are low. Careful management is necessary over much of the area owing to the presence of the toxic *Gastrolobium grandiflorum* in the frequently associated *Acacia leptostachya* midstorey.

(*d*) *Blue Grass*

This community occurs on dark cracking clays on basalt and Permian shales in the eastern and southern parts of the area, and on clay sheets (Oxford, Avon, and Mantuan land systems). It usually does not occur on Carboniferous shales. It is often treeless and is then commonly known as "downs", but is also associated with *E. orgadophila* woodland, *E. melanophloia* woodland, and *E. microtheca* woodland, and groves of *Acacia pendula* and *A. homalophylla* are common in places. It occurs occasionally in brigalow and gidgee communities especially where the communities are open and *Terminalia oblongata* midstorey occurs. In Oxford land system eastern mid-height grass and not blue grass sometimes occurs under *E. orgadophila* and in Waterford land system both eastern mid-height grass and blue grass are associated with *E. orgadophila* woodland. Sometimes mid-height grass occupies crests and blue grass depressions of linear gilgais.

The mid-height grass layer is composed of drought-evading tussock grasses 3–4 ft tall. The community is floristically diverse and varies considerably in composition from place to place, though *Dichanthium sericeum* is common in most stands. Other moderately common and frequent mid-height grasses are *Aristida latifolia*, *A. leptopoda*, *Astrebla lappacea*, *Enneapogon flavescens*, *Panicum decompositum*, *P. queenslandicum*, and *Thellungia advena*. *Ophiuros exaltatus* is locally common in the north-east and *Astrebla elymoides* is prominent on the alluvium of the lower Belyando. *Astrebla pectinata*, *Bothriochloa erianthoides*, *Sporobolus elongatus* vel aff., and *Paspalidium globoideum* are not very constant. *Bothriochloa decipiens*, *B. ewartiana*, and *Heteropogon contortus*, important members of the eastern mid-height grass community, occur as minor constituents of blue grass downs, not always on sites where transitions might be expected. *Cyperus retzii*, a lower perennial, is common and constant but short grasses are not conspicuous though they may contribute significantly to the pasture following a wet summer. Most common are *Iseilema* spp., *Echinochloa colonum*, and *Chloris divaricata*. Legumes are common and contribute to the grazing value of the community. *Rhynchosia minima*, *Glycine falcata*, *Neptunia gracilis*, *Alysicarpus rugosus*, and *Crotalaria dissitiflora* are most important. Other forbs are *Polymeria longifolia*, *Sida* spp., *Malvastrum spicatum*, *Calotis cuneata*, *Daucus glochidiatus*, and *Atriplex* spp.

The community provides a large quantity of good forage and has a high stocking rate. Much of the area is being cultivated. Under heavy stocking, changes occur in the composition of the pasture, *Dichanthium sericeum* being replaced by *Thellungia advena* and *Aristida latifolia.*

Blake (1938) regarded blue grass and Mitchell grass downs as fluctuating climaxes and the occurrence of Mitchell grasses in the blue grass community seems to confirm this. In the more arid parts of the area, however, blue grass is occasionally replaced not by Mitchell grass, as would be expected if the climax were predominantly a climatic one, but by eastern mid-height grass, chiefly *Bothriochloa ewartiana.*

(*e*) *Arid Scrub Grass*

This community occupies only a small area though it occurs throughout the region, most frequently on shallow red and yellow earths and shallow rocky soils associated with bendee and lancewood scrubs. In the south-west of the region (Skye and Playfair land systems) it also occurs, where understorey strata are dense, with *E. populnea*, *E. melanophloia*, and narrow-leaved ironbark woodlands, usually on uniform sandy soils, but occasionally on texture-contrast soils.

The very sparse grass layer is composed of perennial drought-evading tussock grasses 1–2 ft high and harsh, diffuse, non-gramineous perennials about the same height. *Cleistochloa subjuncea* and *Aristida caput-medusae* are the most common and constant species, and *Neurachne mitchelliana*, *Scleria* spp. (including *S. novae-hollandiae*), *Lomandra* sp., and *Fimbristylis* sp. are also fairly common. *Paspalidium* spp. and elements of eastern mid-height grass community, mainly *Aristida* spp., occur occasionally. Forbs are of minor importance, but *Sida* spp., *Hibiscus sturtii*, and *Mitrasacme* sp. are occasionally important and *Cheilanthes* sp. is a constant but minor species. Patches of bare ground and small areas of the *Tripogon loliiformis* community are common.

Arid scrub grass is extremely sparse, harsh, and unpalatable and has little grazing value.

(*f*) *Sandstone Spinifex*

This community is restricted to sandstone hills and outwash from these in Carborough land system on the southern margin of the area. It occurs on uniform sandy soils and shallow rocky soils usually in association with sandstone woodland, occasionally with *E. melanophloia* woodland.

The mid-height grass layer is characterized by perennial evergreen tussocks of an ecotype of *Triodia mitchellii.* Taxonomically this ecotype cannot be separated from the more widespread form of the species that characterizes the eastern spinifex community but it has a distinctive appearance in the field. It is more robust, with broader leaves, and is more resinous. Other associated grasses are neither common nor constant though *Cleistochloa subjuncea* and *Cymbopogon refractus* occur in some stands.

Sandstone spinifex is harsh, unpalatable, and often inaccessible to stock, and consequently is of no value.

(*g*) Tripogon loliiformis *Community*

Some levees in Comet, Banchory, and Funnel land systems show a scarred pattern on aerial photographs. These scarred areas, which are of limited extent, mainly in the north of the area, are either bare or support low *Eremophila mitchellii* communities over *Tripogon loliiformis* community. Soils are usually texture-contrast. The grass community is also found in small areas on shallow rocky soils associated with bendee and lancewood scrubs, on texture-contrast soils with *E. cambageana*–brigalow–*Eremophila mitchellii*, and in Wharton land system with *Eremophila mitchellii* on eroded dark brown and grey-brown soils.

Ground cover is extremely low and perennial grasses are 6 in. or less in height. The most common and constant species is *Tripogon loliiformis*. Other species that frequently occur are *Chloris scariosa*, *C. truncata*, *Sporobolus* spp., and *Bassia* spp. (including *B. echinopsila* and *B. tetracuspis*). Annual forbs are seasonally important, with *Portulaca oleracea* and *Evolvulus alsinoides* most common.

Forage yield is negligible.

(*h*) *Frontage Grass*

Associated with frontage woodland on levees mainly in Alpha and Degulla land systems and on areas of loose sand in Playfair land system is found frontage mid-height grass. It occurs on red and yellow earths and uniform sandy soils.

The rather sparse mid-height grass layer is composed of grasses that also occur in the eastern mid-height grass community. *Heteropogon contortus*, *Chloris acicularis*, *Aristida ramosa*, and *A. glumaris* are the most constant species and make up most of the bulk of the community. Other less important species are *Bothriochloa decipiens*, *Rhynchelytrum repens*, and *Lomandra leucocephala*. Forbs are locally conspicuous, especially *Sida* spp., *Malvastrum spicatum*, *Goodenia* spp., and *Evolvulus alsinoides*. Annual weeds *Acanthospermum hispidum* and *Argemone ochroleuca* occasionally form dense stands.

Forage production is moderate, but the community is usually fully used because it is adjacent to water in the major streams and little clearing of the open woodland is necessary. Heavy stocking probably results in wind movement of the sandy soil.

(*i*) *Samphire*

Recent beach ridges and flats near Lake Buchanan and beach ridges and part of the bed of Lake Galilee are covered with samphire. Associated with samphire (*Arthrocnemum* spp.) are *Bassia* spp., *Atriplex* spp. including *A. nummularia*, *Fimbristylis* sp., and *Rhagodia parabolica*. Ground cover is low. The community is usually treeless, but scattered low *Eremophila mitchellii*, *Acacia salicina*, *Hakea leucoptera*, and *Acacia farnesiana* occur at Lake Galilee.

The community is of low value as fodder, but on Lake Galilee it is grazed by sheep in conjunction with the eastern mid-height grass community.

(*j*) Sporobolus virginicus *Community*

On sand flats near Lakes Buchanan and Galilee there are small areas of *Sporobolus virginicus* grassland. The grass is a perennial, moderately dense, and is usually associated with less common smaller species, mainly *Epaltes australis* and several sedges. Agronomically the community is of little importance.

III. Tree Communities of Woodlands

(*a*) *Upper Stratum*

(i) Eucalyptus melanophloia (*Silver-leaved Ironbark*) *Woodland*.—This, the most extensive of the tree communities in the region, occurs in many land systems but is best developed in Lennox, Portwine, Degulla, Tichbourne, Borilla, and Peak Vale. It is found on various soils, red and yellow earths, texture-contrast soils, and uniform sandy soils being most important, and dark cracking clays and shallow rocky soils less so. The midstorey communities associated with silver-leaved ironbark are to some degree correlated with soil groups though the correlation is not exact.

The tree stratum is 30–50 ft tall, occasionally as low as 25 ft and up to 60 ft, with 10–80 trees per acre. It is lowest and most open in low-rainfall areas (<22 in.). *E. melanophloia* is the most constant and by far the commonest species. *E. populnea* is fairly constant though not common. *E. polycarpa* and *E. dichromophloia* occur frequently, the former never where the argillicolous midstorey is present, the latter never where the arenicolous and *Acacia coriacea* communities are present.

E. melanophloia grassy woodlands occur frequently throughout the area but are most extensive in Waterford and Oxford land systems on dark cracking clays and in Peak Vale on texture-contrast soils. Eastern mid-height grass (*Bothriochloa ewartiana, Themeda australis, Heteropogon contortus*) usually forms the grass layer, but blue grass (*Dichanthium sericeum, Panicum decompositum*) occurs on dark cracking clays. The argillicolous midstorey is found on texture-contrast soils and red and yellow earths. Associated with it are eastern mid-height grasses (*Bothriochloa ewartiana, B. decipiens, Heteropogon contortus*, and *Themeda australis*). In Playfair and Skye land systems the arenicolous midstorey is frequently associated with *E. melanophloia* tree stratum on uniform sandy soils and texture-contrast soils. Eastern mid-height grass (*Bothriochloa ewartiana, Aristida glumaris*) and less commonly sandstone spinifex and arid scrub grass are associated. There are large areas, particularly in Lennox land system in the west, of *Acacia coriacea* midstorey with silver-leaved ironbark tree stratum. This usually occurs on red and yellow earths and is associated with eastern spinifex and mosaics of eastern spinifex and eastern mid-height grass.

(ii) E. populnea (*Poplar Box*) *Woodland*.—This is one of the two most extensive woodland communities in the region. It is best developed on the Tertiary land surface and on alluvium but occurs on rocks of all types except basalt and in almost every land system. There are extensive areas in Monteagle, Pinehill, Alpha, Hillalong, and Skye land systems. It is found mainly on texture-contrast soils with red and yellow earths of secondary importance.

The tree stratum is 35–60 ft tall with 15–60, occasionally 100 trees per acre. The commonest and most constant species, often the only species in some stands, is *E. populnea*. As noted above, *E. brownii* and not *E. populnea* occurs in the northernmost part of the area, but it is ecologically so similar to *E. populnea* that it is included here in this community. *E. melanophloia* is a fairly constant member of the community and is quite frequent in Skye land system. *E. polycarpa* and *E. papuana* are occasional in some stands, but not with the argillicolous midstorey. *Acacia excelsa*, *Brachychiton populneum*, *E. drepanophylla*, and *E. alba* (in Hillalong land system) are less constant and much less common.

The tree layer is associated either with the argillicolous and arenicolous midstorey or with no midstorey community. *E. populnea* woodland without midstorey occurs mainly on alluvium, but is not restricted to these sites and occurs throughout the range of the community. It is associated with eastern mid-height grass (*Bothriochloa decipiens*, *B. ewartiana*, *Chloris acicularis*, *Aristida glumaris*), rarely eastern spinifex. The argillicolous midstorey is associated mainly on alluvium and on the Tertiary land surface. With the eastern mid-height grass layer these synusiae constitute the most widespread phytocoenosis in the region. The argillicolous midstorey is especially well developed in Pinehill land system where dense lower strata occur consistently. Brigalow is sometimes an important constituent, particularly on sites adjacent to the *E. populnea*-brigalow communities discussed below. The arenicolous midstorey is not as common an associate as the argillicolous midstorey but is important, especially on soils derived from quartzose sediments. Eastern mid-height grass is commonly associated though arid scrub grass occurs where the low tree or shrub layers are dense.

(iii) *Narrow-leaved Ironbark Woodland*.—This community occurs throughout the Nogoa–Belyando area in many land systems, but is best developed in Bogantungan, Hope, and Copperfield land systems. It occurs on several soil groups, most frequently on texture-contrast soils, red and yellow earths, uniform sandy soils, and shallow rocky soils. It is the most extensive community in Lennox land system where this occurs in the north-east. Here narrow-leaved ironbark woodland occurs to the exclusion of *E. melanophloia* woodland, though small areas of narrow-leaved ironbark occur throughout Lennox.

The most common and constant species is *E. drepanophylla*. There are 20–50 trees (occasionally to 100) per acre, usually 40–60 ft tall. Field identification of *E. drepanophylla* and *E. crebra* is difficult, but using the criteria given by Blake (1953) it is concluded that *E. drepanophylla* is common and widely spread whereas *E. crebra* is restricted to Copperfield land system where it is common. *E. decorticans* occurs in this community in the south of the region but is more common in the sandstone woodland. *E. setosa*, *E. papuana*, and *E. polycarpa* are fairly constant though never prominent in any stand. *E. citriodora* and *E. peltata* are common, the former in areas of high rainfall, particularly on shallow rocky and deep sandy soils, and both occur in almost pure stands.

The tree stratum is not often found without any midstorey community. The arenicolous midstorey community (*Acacia cunninghamii*, *A.* sp. aff. *burrowii*, *Petalostigma pubescens*, *Callitris columellaris*, *Carissa ovata*) occurs particularly on rocks of Permian age. *Acacia rhodoxylon* midstorey community is associated usually with *E. crebra* (see above) in Copperfield land system. In the north-west, narrow-leaved ironbark and *Acacia leptostachya* midstorey are occasionally associated and here on fans *Melaleuca nervosa* midstorey and narrow-leaved ironbark are associated. North of Narrien the community is associated with an attenuated form of sandstone midstorey on shallow rocky soils on sandstone.

Eastern mid-height grass is the most common grass layer associate, very sparse where there is *Acacia rhodoxylon* midstorey. In the north, and west of the Belyando River, always where *Acacia leptostachya* community occurs, eastern spinifex is associated alone or in a mosaic with eastern mid-height grass. In Hope land system in the south-west arid scrub grass occurs, especially where the lower strata are dense.

This community is exploited to a minor extent for forestry purposes north of Bogantungan and near Blair Athol.

(iv) Eucalyptus orgadophila (*Mountain Coolibah*) *Woodland*.—This community is most extensive in Oxford and Waterford land systems in the eastern and southern part of the region, mainly on dark cracking clay soils. It also occurs in the southern part in Craven and Portwine land systems, mainly on texture-contrast soils where it forms a mosaic with silver-leaved ironbark woodland. In Oxford land system it grades into blue grass downs, though these on the whole occur on deeper soils.

The tree stratum is 30–50 ft tall, rarely 60 ft, with 5–50 trees per acre, the lowest density being where there is transition to grassland. *E. orgadophila* is the commonest and most constant species, and *E. dichromophloia* and *E. melanophloia* are constant but not common. *E. terminalis* occurs occasionally on calcareous soils east of Clermont. In Craven land system *Brachychiton populneum* and *Acacia excelsa* often form a small proportion of the tree layer.

On basalt and Permian shales, except rarely where there is a softwood scrub–woodland ecotone and where *Macrozamia moorei* occurs, there are no associated midstorey species. In the Craven land system the argillicolous midstorey is a constant associate, *Geijera parviflora* (tree wilga), *Eremophila mitchellii*, *Ventilago viminalis*, and *Carissa ovata* being the commonest constituents. *Callitris columellaris*, not usually an element in this community, is also fairly common and constant. *E. orgadophila* woodland with the argillicolous midstorey is confined to Carboniferous and Carboniferous–Permian sediments and does not occur on the Tertiary land surface.

E. orgadophila grassy woodland has the blue grass (*Dichanthium sericeum*, *Panicum queenslandicum*) grass community associated, though on the shallowest soils on hills eastern mid-height grass (*Bothriochloa ewartiana*, *Heteropogon contortus*) is more common. Where the argillicolous midstorey occurs, eastern mid-height grass (*Bothriochloa ewartiana*) is always associated.

(v) Eucalyptus polycarpa–E. papuana *Woodland*.—This community occupies small areas in Lennox, Degulla, and other land systems. In Lennox it occurs on the highest part of the Tertiary surface in a position similar to that occupied by *E. similis* woodland, though the two communities are not found close together. It is usually on red and yellow earths, but occasionally also on shallow rocky soils or uniform sandy soils.

The tree layer is 30–60 ft high, rarely on shallow rocky soils 20 ft, sometimes in the eastern parts taller. *E. polycarpa* and *E. papuana* are common and constant species; *E. drepanophylla*, *E. melanophloia*, *Grevillea parallela*, and *Acacia bidwillii* occur in some stands; and where the community occurs on outwash fans from the Tertiary land surface smaller trees of *E. peltata* are important constituents.

Midstorey communities are often absent, but the arenicolous, argillicolous, *Acacia coriacea*, and *Melaleuca nervosa* communities occur. *Acacia cunninghamii*, *Bursaria incana*, *Callitris columellaris*, and *Lysicarpus angustifolius* are the most important representatives of the first, and where the *E. polycarpa–E. papuana* community is very disturbed, dense pure stands of *Acacia cunninghamii* often result. *Melaleuca nervosa* midstorey is associated with the community on fans (Degulla land system). The ground cover is predominantly eastern mid-height grass with occasional eastern spinifex, though eastern spinifex commonly occurs in association with *Melaleuca nervosa* and *Acacia coriacea* and often with the arenicolous midstorey.

(vi) Eucalyptus similis *Woodland*.—On the western margin of the region on elevated country receiving about 20 in. average annual rainfall there are extensive areas of this community with some inclusions of *E. melanophloia* woodland. It occurs on red and yellow earths and occupies the highest part of the Tertiary surface and characterizes Ronlow land system.

A feature of the community is that it is groved and on aerial photographs produces an easily recognized pattern. The groves are aligned across the slope and are somewhat narrower than the treeless intergroves. The tree layer is 25–45 ft tall and there is an average of 25–55 trees per acre over the whole community, groves and intergroves. *E. similis* is the commonest species. *E. trachyphloia*, *E. setosa*, and *E. drepanophylla* also occur but are of little importance except in the south where *E. similis* is absent and *E. trachyphloia* occurs in groves.

Groving is not confined to the tree layer. Within the groves the *Acacia leptostachya* community is well developed, with eastern mid-height grass forming the ground stratum. The intergroves, however, have no midstorey and eastern spinifex always occurs.

A structurally rather different but floristically similar community occurs in small areas on sandy red earths in Lennox land system. *E. similis*, *E. drepanophylla*, and *E. trachyphloia* form a woodland, rather tall for the region (about 65 ft), with a moderate arenicolous midstorey (*Callitris columellaris*, *Lysicarpus angustifolius*) and a mosaic of eastern spinifex and eastern mid-height grass.

(vii) E. microtheca (*Coolibah*) *Woodland*.—This community is developed on fine-textured soils, dark cracking clays, alluvial soils, and rarely texture-contrast soils, mainly in Funnel and Avon land systems. It is found in similar situations throughout northern Australia where rainfall is suitable and is usually regarded as being periodically flooded. Flooding is infrequent on some sites in Avon land system.

The tree layer is of medium height (30–50 ft) and varies from very open to moderately dense (5–40 trees per acre). It grades into grassland, brigalow and gidgee scrubs, and rarely *E. populnea* woodland. *E. microtheca* is the only species, and except for scattered individuals of *Acacia salicina*, *A. farnesiana*, *A. oswaldii*, and *Eremophila bignoniiflora*, in most stands there is no midstorey community. Where coolibah and *E. populnea* woodlands intergrade, usually in Alpha land system, the argillicolous midstorey is well developed. Coolibah–brigalow and coolibah–gidgee communities are discussed below.

Blue grass (*Cyperus retzii*, *Thellungia advena*, and *Astrebla* spp.) is usually associated, though occasionally eastern mid-height grass occurs.

(viii) Eucalyptus normantonensis (*Normanton Box*) *Woodland*.—This community occurs in scattered, small areas north of lat. 23°S. It is most common in Monteagle, Tichbourne, and Loudon land systems, mostly on texture-contrast, occasionally on shallow rocky, soils and red and yellow earths. It generally occurs immediately below scarps or hills covered with lancewood or bendee scrubs.

The tree layer is 20–40 ft tall with 5–30 or occasionally more trees per acre. *E. normantonensis* is the only species in this layer. Lower strata are uncommon. Scattered *Carissa ovata* occurs in some stands and in the north-east the arenicolous midstorey community (*Casuarina luehmannii* most common) is sometimes evident. Eastern mid-height grass and eastern spinifex occur in the grass layer, the latter mainly in the west.

(ix) *Sandstone Woodland*.—In the south of the area on sandstone hills in Carborough land system, this community occurs on shallow rocky and uniform sandy soils. The tree stratum is about 40 ft tall with 20–50 trees per acre. It is floristically more diverse than other communities in the area. *E. decorticans* is the most constant species and is common in most stands. *E. cloeziana*, *E. peltata*, and *Angophora costata* are fairly constant though usually less common. *E. tenuipes*, *E. intermedia*, and *E. polycarpa* are occasional in some stands.

The tree stratum is associated with sandstone midstorey (*Acacia cunninghamii*, *Ricinocarpos pinifolius*, *Boronia* spp.) and sandstone spinifex synusiae. The complete phytocoenosis corresponds to "shrub woodland—sandstone form" of Story (1967).

(x) *Frontage Woodland*.—This community is of limited extent on sandy levees fringing major streams or along former streams in Alpha land system. There are also small occurrences, not associated with streams, on loose sand in Playfair land system.

The tree layer is tall (60–80 ft) and open (5–10 trees per acre). *E. polycarpa*, *E. papuana*, and *E. tessellaris* are the commonest and often the only species. *E. melanophloia* occurs occasionally and *E. dealbata* is prominent in Playfair land system. There is usually no midstorey except in Playfair land system where there is a patchy development of the arenicolous midstorey (mainly *Callitris columellaris*). Frontage grass is invariably associated with frontage woodland.

(xi) *Fringing Forest and Woodland*.—Major streams throughout the area are lined by this community. Tree canopies usually touch and the community is usually a forest. Considerable stratification occurs. The tallest stratum may reach 75 ft, but in more arid localities 40–50 ft is usual. On coarse-textured soil *E. tereticornis* is most common and constant with lower trees of *Casuarina cunninghamiana* and *Melaleuca* spp. (including *M. linariifolia*). *E. camaldulensis* and *E. tessellaris* are of occasional occurrence and *Melaleuca argentea* is common on the largest streams (Suttor and Cape Rivers). *Callistemon viminalis* and *Acacia glaucocarpa* occur on streams on the eastern side of the Drummond Range. On fine-textured soils *E. microtheca* and *E. tereticornis* with lower *Melaleuca* spp. are the commonest species. Small streams are lined either with *E. populnea* or, on fine-textured soils, *E. microtheca*, brigalow, gidgee, and *Melaleuca bracteata*, the latter mainly on soils derived from granite and basalt.

(xii) Eucalyptus cambageana (*Blackbutt*) *Woodland.*—*E. cambageana* usually forms scrubs with brigalow, but occasionally very small areas of *E. cambageana* woodland occur without brigalow. These woodlands are on texture-contrast soils in Humboldt land system and are more frequent in the more arid parts, that is, near the limit of the range of brigalow, though small areas in the extreme south are of some significance.

The tree stratum is tall, 40–65 ft, with 30–80 trees per acre, that is, somewhat more dense than when it is associated with brigalow. *E. cambageana* alone occurs in the tree stratum. *E. cambageana* woodland is usually associated with sparse argillicolous midstorey (*Eremophila mitchellii, Carissa ovata, Erythroxylum australe*) and grades into *E. cambageana*–brigalow or blackwood communities (see below). The associated grass communities are usually mosaics of sparse eastern mid-height grass, scrub grass, and occasionally arid scrub grass. In the extreme south of the area the arenicolous midstorey (chiefly *Acacia sparsiflora*) occurs in small areas with the *E. cambageana* tree stratum. This combination is restricted to Triassic sediments (Rewan Formation).

(xiii) E. thozetiana (*Yapunyah*) *Woodland.*—*E. thozetiana* is also usually associated with brigalow, but in the north and west of the area very small areas of *E. thozetiana* woodland without brigalow occur on texture-contrast soils. The tree stratum is 55–65 ft, occasionally 75 ft, tall with 10–30 trees per acre. *E. thozetiana* is usually the only species, but *E. cambageana, E. normantonensis,* and *Acacia shirleyi,* which commonly occur in adjacent communities, are also found. The argillicolous midstorey (*Eremophila mitchellii, Carissa ovata*) is a constant associate and a gradual transition to *E. thozetiana*–brigalow community can usually be traced.

(xiv) Grevillea *Woodland.*—This community occupies a small area on fans, sand plains, and older beach ridges near Lake Buchanan in Degulla and Galilee land systems. It occurs on texture-contrast and uniform sandy soils. Structurally and floristically the community is extremely simple. The tree stratum is 30–40 ft tall with 10–40 trees per acre. *Grevillea striata* and *Acacia bidwillii* are common in all stands and *Grevillea parallela* and *Acacia salicina* are constant though less common.

There is no well-defined lower stratum though *Myoporum deserti* occurs occasionally. Sparse eastern mid-height grasses, mainly *Chrysopogon fallax* and *Aristida* spp., are always associated.

Cole (1963) classified *Grevillea* woodland as open savannah woodland.

(xv) *Miscellaneous Tree Communities.*—Stands of other species of eucalypts occur but are of such limited extent that they have not been considered in the communities described. *E. tereticornis* woodland occupies small areas of dark cracking clay soils in depressions in Lennox and Ronlow land systems. North of Clermont where Avon land system abuts on Moray land system there are small areas of a tall grassy woodland (70 ft tall, *c.* 40 trees per acre) of *Acacia* sp. aff. *cana.* They occur on sites similar to those occupied by coolibah woodland.

Stands of *E. oleosa* var. *glauca* and *E. exserta* occur but are so rare that they are of phytogeographical rather than ecological interest.

(b) *Midstorey Communities*

Midstorey communities vary greatly in density and composition, and occur rather sporadically. Some are restricted to particular woodland communities, but usually their distributions do not coincide with the distributions of woodland communities and presumably they react independently to environmental factors. Their sporadic occurrence is difficult to explain. In some cases burning profoundly influences their distribution, density, and composition. In places the arenicolous community is probably maintained at a high density by periodic fires which stimulate germination of some species, notably *Acacia* spp. On the other hand, intense fires may eliminate *Callitris columellaris* from the community.

The variable composition of the communities results in nomenclatural difficulties, and the first two communities have been named from a property of the soils on which they often occur. Possible confusion between the argillicolous community and the related *Eremophila mitchellii* midstorey community of scrub, in both of which *E. mitchellii* is the most common and constant species, is also lessened.

(i) *Argillicolous Community*.—This community is widely distributed in the Nogoa–Belyando area as it is the most frequent midstorey associate of the *E. populnea* woodland. It is best developed in Pinehill land system and least important in the extreme north-west. It occurs on soils ranging from dark cracking clays to shallow rocky soils but two-thirds of the stands examined are on texture-contrast soils and most of the remainder on red and yellow earths.

The community is composed of several layers, each of which is strictly a separate synusia but which are treated here for convenience as one community. The upper layer, which is always lower than the associated tree layer, is occasionally absent but is usually moderately dense and varies from 20 to 40 ft tall; the lower layer, rarely absent, is sparse to moderate and usually 10–20 ft tall; the shrub layer is usually well developed. Composition of the community varies considerably from stand to stand, but *Eremophila mitchellii* in the lower layer and *Carissa ovata* in the shrub layer are the most common species and occur in almost all stands of the community. On shallow and eroded soils (for example, in Craven land system) the two species sometimes form stands, together or alone, without any associated woodland. *Geijera parviflora* (tree wilga) and *Ventilago viminalis* in the upper tree layer, *Albizia basaltica* in the lower tree layer, and *Erythroxylum australe* and *Capparis lasiantha* in the shrub layer are usually fairly common and constant. Many other species occur sporadically in the community, some of which are most common in particular associated woodlands. Brigalow is often present when the community occurs with *E. populnea*, and indicates a transition to the *E. populnea*–brigalow communities discussed below. *Acacia excelsa, Flindersia dissosperma, Bauhinia carronii, Heterodendrum oleifolium*, and *Cassia brewsteri* are sometimes frequent but never in *E. melanophloia* woodland.

E. populnea woodland is the most widespread associated tree community but *E. melanophloia*, *E. orgadophila*, *E. thozetiana*, and *E. cambageana* woodlands are also associated. In every case eastern mid-height grass completes the phytocoenosis, with mosaics of scrub grass where the community is very dense.

Though usually associated with a taller tree synusia, the community, occasionally in Pinehill, rarely also in Monteagle land systems, on red and yellow earths, occurs without a taller tree stratum. Then occasional low *E. papuana* occur in the upper layer, *Exocarpos latifolius* in the lower layer, and *Croton phebalioides* in the shrub layer. This community has some affinity with softwood scrub, and is a slightly denser facies of arid low woodland of Perry and Lazarides (1964). On old beach ridges of Lake Galilee the community is taller and more open.

The argillicolous community is sharply divided from all others except the arenicolous community into which it grades. Some species, particularly *Albizia basaltica*, occur in both, though with different frequencies. In *E. orgadophila* woodland, *Callitris columellaris*, a component of the arenicolous community, is fairly constant in the argillicolous community.

(ii) *Arenicolous Community*.—This community is widely distributed, mainly in Skye, Playfair, and Monteagle land systems, and is second in importance only to the argillicolous community among the midstorey synusiae. It occurs on uniform sandy soil, red and yellow earths, and texture-contrast soils that are usually sandier, at least in the uppermost portion, than soils supporting the argillicolous community.

Two layers are well defined in the community; the upper, of small trees 10–30 ft high or more when *Callitris columellaris* is present, is always lower than the tree layer and is sparse to moderately or occasionally very dense; the lower is a sparse to moderately dense shrub layer that is occasionally lacking.

Floristically the community varies greatly from site to site and no species occurs in all stands. *Acacia cunninghamii* is often common, though absent from some stands. Closely related species, *A. sparsiflora*, *A.* sp. aff. *burrowii*, *A.* sp. aff. *cunninghamii*, and *A.* sp. aff. *julifera*, and not *A. cunninghamii* occur in some localities. *Callitris columellaris* is common in the community in the south of the area but is absent from the north. *Petalostigma pubescens*, *Alphitonia excelsa*, *Casuarina luehmannii*, and *Eremophila mitchellii* are fairly common, less constant species, though the last is never as prominent as it is in the argillicolous community. *Carissa ovata* and *Dodonaea viscosa* are the commonest and most constant shrub-layer components. Other locally common species of low constancy are *Albizia basaltica*, *Lysicarpus angustifolius* (with *E. polycarpa*–*E. papuana* and *E. melanophloia* woodlands), *Acacia bancroftii* (in *E. melanophloia* and narrow-leaved ironbark woodlands), and *Persoonia falcata* (in *E. polycarpa*–*E. papuana* woodland).

There is a marked correlation between soils and associated woodland strata. Narrow-leaved ironbark woodland mainly on texture-contrast soils, *E. melanophloia* woodland mainly on uniform sandy soil, *E. polycarpa*–*E. papuana* woodland mainly on red and yellow earths, and *E. populnea* woodland on texture-contrast soils and red and yellow earths are the chief associated woodland communities. *E. cambageana* and *E. normantonensis* woodlands are occasional associates. Eastern mid-height grass is the commonest grass community. In the south on uniform sandy soils, arid scrub grass occurs occasionally. In the west mosaics of eastern mid-height grass and eastern spinifex occur with *E. polycarpa*–*E. papuana* woodland. In Playfair land system small areas of loose sand, not on levees, carry a characteristic phytocoenosis of frontage woodland, arenicolous midstorey (mainly *Callitris columellaris* and *Acacia* spp.), and frontage grass.

The arenicolous community is probably the one most affected by fire. *Callitris columellaris* is often markedly reduced by fire, but dense stands of *Acacia* spp. often occur after burning.

(iii) Acacia coriacea (*Desert Oak*) *Community*.—Large areas in the west, mostly in Lennox land system, support this community, with *E. melanophloia* and occasionally *E. polycarpa–E. papuana* woodland. It always occurs on red and yellow earths and is associated with eastern mid-height grass, eastern spinifex, and mosaics of the two.

Floristically and structurally the community is a simple one. A sparse tree layer is composed of *Acacia coriacea* with occasional *Petalostigma pubescens*, *Albizia basaltica*, and *Acacia salicina*. A sparse shrub layer sometimes occurs. *Acacia tenuissima* is the most constant species but *Carissa ovata* may predominate in some stands. *Acacia leptostachya* and *A. laccata* occur occasionally.

(iv) Acacia leptostachya *Community*.—In the north-western part of the area there are scattered areas, usually small, of this community. It occurs on shallow red and yellow earths, uniform sandy soils, and occasionally texture-contrast soils, chiefly in Ronlow and Tichbourne land systems where it is of major importance.

The community consists of a moderately dense to dense shrub layer 4–8 ft high. *Acacia leptostachya* is faithful to the community and always common. Other moderately constant species, common in places, are *A. leptocarpa*, *A. stipuligera*, and *Distichostemon* sp. Species much less common and constant are *Acacia tenuissima*, *A. brevifolia*, *A. laccata*, *A. orthocarpa*, *A. torulosa*, *A. whitei*, *Gastrolobium grandiflorum*, *Maytenus cunninghamii*, *Petalostigma banksii*, and *Hovea longipes*.

The community is always associated with *E. similis* woodland, and occasionally with narrow-leaved ironbark and *E. polycarpa–E. papuana* woodlands. As well as being associated with these tree communities *Acacia leptostachya* community occurs in large areas in Tichbourne land system without any upper storey except for scattered low trees of *E. setosa*. In this heath formation *Melaleuca uncinata* is often as common as *Acacia leptostachya*.

Eastern spinifex is the most frequently associated ground community, occasionally with small inclusions of eastern mid-height grass.

Periodic fires may on some sites maintain the density of this community, though on the whole climatic and edaphic conditions are more important, particularly in the areas of heath.

(v) *Sandstone Midstorey Community*.—This community occurs on quartzose sandstone, mainly of lower Jurassic and lower Permian age in Carborough land system in the southern part of the area where it is associated with sandstone woodland on shallow rocky and uniform sandy soils. An attenuated phase of the community is associated with narrow-leaved ironbark woodland on shallow rocky soils on hills north of Narrien. Here the quartzose sandstone is of Carboniferous age. In the south the community is associated with sandstone spinifex and the northern occurrence is associated with eastern spinifex.

The community has a moderately dense to dense shrub layer with a few scattered small trees sometimes present. Like others on similar areas of sandstone in eastern Australia, the community is floristically very rich. Its composition varies greatly from place to place and no species is even moderately common. *Ricinocarpos pinifolius*, *Dampiera* sp., *Acacia conferta*, *Boronia rosmarinifolia*, *B. obovata*, *Dodonaea filifolia*, *Hovea longifolia*, and *Acacia* sp. aff. *linifolia* are common in places. *Acacia cunninghamii* and *Lysicarpus angustifolius* are small trees that occur occasionally. *Grevillea decora*, *Jacksonia ramosissima*, *Olearia* sp., *Acacia simsii*, and *Xanthorrhoea* sp. are characteristic of the attenuated phase of the community.

(vi) Acacia rhodoxylon *Community*.—This community is almost entirely confined to shallow rocky soils in Copperfield land system mainly in the central portion of the area. It is associated with narrow-leaved ironbark woodland which in this land system is composed almost entirely of *E. crebra*. The community is composed of a usually dense layer of small trees about 25 ft tall with a sparse shrub layer. *Acacia rhodoxylon* is often the sole constituent of the upper layer with occasional *A. sparsiflora* and *Flindersia dissosperma*. *Erythroxylum australe* is the commonest and most constant shrub-layer species. Sparse eastern mid-height grass, mainly *Eriachne* spp., forms the grass synusia.

(vii) Melaleuca nervosa *Community*.—In Degulla land system and to a minor extent in Alpha land system in the north-west of the area there are small areas of *Melaleuca nervosa* midstorey associated with *E. polycarpa–E. papuana* woodland (often with a high proportion of *E. peltata*) and rarely with narrow-leaved ironbark and *E. melanophloia* woodlands. It occurs on red and yellow earths and rarely on uniform sandy soils and is floristically and structurally simple. There is a sparse upper layer 15–20 ft tall of *Melaleuca nervosa*, occasionally with some *Acacia bidwillii*, and a sparse lower layer 8–12 ft high is often developed. No species is constant in this layer; *Petalostigma pubescens* is most common and *Acacia coriacea* and *Persoonia falcata* are locally so. *Acacia leptostachya* is the most important constituent of the shrub layer when it is developed. Eastern spinifex invariably occurs with the community.

There is a transition to the *Acacia leptostachya* midstorey community.

IV. Tree Communities of Scrubs

(*a*) *Upper Stratum*

(i) *Brigalow* (Acacia harpophylla) *Scrub*.—This community is widespread mainly in the east and south of the area on dark cracking clay soils, texture-contrast soils, and dark brown and grey-brown soils. It is the most important community in Comet, Willows, Blackwater, Somerby, Rutland, Wharton, and Kinsale land systems and is one of the most extensive in the whole area, best developed in areas receiving more than 22 in. annual average rainfall, but near Lake Galilee some areas receive less than 20 in.

The tree stratum is 20–50 ft high and is often dense and tall enough to be properly called forest, but it varies a great deal and woodland or low woodland is quite common. Some communities have several layers of brigalow beneath the tallest layer. These are probably disturbed communities, with the different layers resulting from root-sucker production in response to periodic fires rather than to the establishment of seedlings (Johnson 1964, p. 11). *Acacia harpophylla* is by far the most common and constant species. Other fairly constant species of minor importance are *Bauhinia carronii*, *Heterodendrum oleifolium*, and *Atalaya hemiglauca*. *Acacia cambagei* (in the north), *Brachychiton rupestre* (in the south), and *Geijera parviflora* (tree wilga) are occasionally frequent.

Midstorey communities, *Eremophila mitchellii*, *Terminalia oblongata*, softwood, and in the south *Geijera parviflora* (shrub wilga), are often associated and the community also occurs without lower strata. Scrub grass is by far the most frequent grass layer associate though small areas of eastern mid-height grass occur where stands are more open.

Brigalow–eucalypt communities are common and are dealt with below. Blackwood (*Acacia argyrodendron*) is a closely related species that occurs in the north-west of the area. Few detailed observations were made of blackwood communities but they are structurally and floristically similar to brigalow communities and are not considered separately.

Gradual transitions to eucalypt communities are general, though on alternating beds of sandstone and shale (especially in Rutland land system) the transitions may be sharp. Brigalow scrub–grassland transitions are commonly abrupt and are evidently due to edaphic factors, probably soil drainage.

(ii) *Gidgee* (Acacia cambagei) *Scrub*.—This community occurs in the north of the area and receives less than 24 in. average annual rainfall. It is best developed on dark cracking clay soils, though it also occurs occasionally on texture-contrast soils. It is the dominant vegetation type in Wondabah, Moray, Banchory, Ulcanbah, and Islay land systems.

The tree layer varies from 25 to 50 ft with 60–250 trees per acre. The community is on the whole more dense than brigalow communities, but is sometimes fairly open. Most gidgee communities have some brigalow and there are continuous gradients from pure gidgee to pure brigalow communities. There is some evidence that brigalow is invading gidgee scrubs. In more arid parts of the area brigalow is a minor component and appears to be limited to areas where soil moisture is locally high; for example, on the edges of melon-holes and beside long-established roads. This is in accord with Johnson's (1964) observations on the occurrence of brigalow in gidgee communities in more arid regions. Gidgee does not produce root-suckers as does brigalow, and seral communities are not obvious.

Floristically gidgee scrubs are simpler than brigalow. *Acacia cambagei* is common and constant. Besides brigalow, *Bauhinia carronii* is the only other species at all constant and it is not common. The same midstorey communities occur as for brigalow except that the *Geijera parviflora* (shrub wilga) midstorey is rarely present. Scrub grass is invariably associated with occasional blue grass and rare eastern mid-height grass.

On aerial photographs the patterns produced by gidgee and brigalow scrubs are similar. Gidgee scrub on the whole is a more uniform and solid black probably because it is usually more dense than brigalow. Gidgee scrubs with a lot of melon-holes, however, have a much less dense pattern and are extremely difficult to distinguish with certainty from brigalow scrubs, and as a result the mapping of brigalow and gidgee scrubs may be somewhat inaccurate, particularly in the north-central part of the area where their ranges overlap.

(iii) *Belah* (Casuarina cristata) *Scrub*.—In the east and south of the area small areas of this community occur, usually surrounded by much larger areas of brigalow scrub with which they merge. It is always on dark cracking clay soils.

The tree stratum is 30–65 ft tall and is usually dense. Brigalow is a constant, fairly common component. Associated midstorey communities, *Terminalia oblongata* and *Eremophila mitchellii*, are sometimes present. Sparse scrub grass is the most frequent grass community, with occasional blue grass and rare eastern mid-height grass.

(iv) *Softwood Scrub*.—Two types of softwood scrub occur in the area depending on the presence or absence of bonewood (*Macropteranthes leichhardtii*), the range of which is given in Figure 10. Otherwise, floristically and structurally the two are very similar.

(1) Bonewood scrub occurs on dark brown and grey-brown soils usually on hills in Kareela and Cungelella land systems in the south of the area. Occasionally there is a sparse tree layer of brigalow 50 ft tall; invariably a sparse to moderate tree layer about 40 ft tall of *Brachychiton rupestre* and *Geijera parviflora* (tree wilga); and below this a layer about 25 ft tall, usually dense, occasionally moderate, composed almost entirely of *Macropteranthes leichhardtii*. Other minor species of low constancy are *Denhamia obscura*, *Croton insularis*, *Acacia fasciculifera*, and *Eremophila mitchellii*. The shrub layer is dense or moderately dense, depending on the density of the layer above. *Macropteranthes leichhardtii* and *Carissa ovata* are the most common and constant species. *Ehretia membranifolia*, *Croton phebalioides*, *Erythroxylum australe*, and *Heterodendrum diversifolium* are less constant but occasionally common.

(2) Softwood scrub without bonewood occurs mainly on hills or undulating terrain in Kareela land system in the north-east of the area. There is usually an open tree layer 25–30 ft tall of various species none of which is either common or constant. Most important are brigalow, belah, *Brachychiton rupestre*, and *Geijera parviflora* (tree wilga). There is always a dense shrub layer 6–10 ft tall. Most common and constant species are *Ricinocarpos ledifolius*, *Hovea longipes*, *Citriobatus spinescens*, *Denhamia obscura*, *Heterodendrum diversifolium*, and *Carissa ovata*. Many other species occur and are locally common; some may be faithful. In Percy and Peak Vale land systems there are small areas of attenuated softwood scrub with *Brachychiton australe* the most conspicuous tall species.

In scrub of both types the ground cover is always sparse scrub grass (*Eragrostis megalosperma*, *Paspalidium* spp., and *Ancistrachne uncinulata*).

Transitions to brigalow scrub occur.

(v) *Lancewood* (Acacia shirleyi) *Scrub*.—This community is widely spread on scarps and hills throughout the area on shallow rocky soils and shallow red and yellow earths. It is of major importance in Carborough and Durrandella land systems and of less importance in many others.

The tree layer is 25–50 ft tall with 50–250 trees per acre. It is usually a closed community. Lancewood usually occurs alone. Several eucalypts are present in the canopy but none is of high constancy or frequency. *E. drepanophylla* is probably the most important. *Acacia sparsiflora* is the only other tree species of importance and this only in the east of the area. There is no well-developed midstorey. Scattered shrubs of *Erythroxylum australe* are occasional.

Arid scrub grass is the usual grass stratum associate, but bare ground and the *Tripogon loliiformis* community are fairly common. Bendee and lancewood scrubs cannot be distinguished with certainty on aerial photographs and the two have been combined in the map showing tree communities.

(vi) *Bendee* (Acacia catenulata) *Scrub*.—Bendee scrubs occur on shallow soils, uniform sandy soils, red and yellow earths, and texture-contrast soils on hills throughout the area, mainly in Durrandella and Loudon land systems in the south-west. During the survey bendee and lancewood scrubs were invariably found on sites showing signs of deep weathering, and as they are easily picked out on aerial photographs they are useful indicators of weathering.

The tree stratum is 25–30 ft tall with 50–500 trees per acre. Bendee occurs usually alone, but *E. exserta* is an occasional, rare component, and *E. drepanophylla* and *E. populnea* uncommon emergents. Transitions to *E. normantonensis* woodland occur, but bendee–lancewood transitions are rare though the two occupy similar sites and are often contiguous. There is usually no lower stratum except for rare scattered shrubs of *Micromyrtus* sp., *Keraudrinia corollata*, and *Phebalium* sp. The ground is either bare or has a *Tripogon loliiformis* or arid scrub grass layer.

(vii) *Cypress Pine* (Callitris columellaris) *Scrub*.—This community is restricted to the south-west, where it occurs on uniform sandy soils or sandy texture-contrast soils mostly in Playfair land system. The tree layer is 40–50 ft tall and there are 150–500 trees per acre. The canopy is usually complete, but the trees usually branch near the ground and it is preferred to refer to the communities as scrubs rather than as forests. *Angophora costata* and *E. melanophloia* are fairly constant minor species. Low trees such as *Acacia cunninghamii*, *Alstonia constricta*, and *Petalostigma pubescens* occur occasionally. There is usually a sparse cover of eastern mid-height grass (*Aristida* spp., *Cymbopogon refractus*).

Cypress pine communities grade into eucalypt woodland with a more or less dense arenicolous midstorey (mainly *Callitris columellaris* and *Acacia cunninghamii*). These communities may be considered transitional between cypress pine scrub and eucalypt woodland, but as they occupy such large areas they have been considered separately (see above).

At present a little cypress pine is cut for timber, but greater exploitation is possible in the south of the area.

(viii) Melaleuca tamariscina *Scrub*.—Dense scrubs of small extent, 15–20 ft high, composed entirely of *M. tamariscina*, occur mainly in Tichbourne land system. They are of negligible importance and usually are adjacent to more extensive areas of heath—treeless *Acacia leptostachya* community. There is no associated tree layer.

(b) *Midstorey Communities*

Midstorey communities are associated with brigalow, blackwood, gidgee, and belah scrubs on fine-textured soils. They have been distinguished according to the presence or absence of species such as *Terminalia oblongata*, *Geijera parviflora* (shrub wilga), and softwood species, and form a continuum of intergrading communities. *Eremophila mitchellii* occurs in all with different frequencies. The argillicolous community of woodlands and some of the scrub midstorey communities have many species in common and are obviously related.

(i) Eremophila mitchellii (*False Sandalwood*) *Community*.—Throughout the range of brigalow, blackwood, and gidgee communities in the Nogoa–Belyando area this community occurs on dark cracking clay and texture-contrast soils. The latter are more important when eucalypts occur in the community, for example in *E. cambageana*–brigalow communities. The *Eremophila mitchellii* community is stratified. There is usually a sparse to moderate tree layer 15–30 ft tall, occasionally absent; a lower moderate to dense layer, 10–20 ft or less tall; and a well-developed shrub layer. *Bauhinia carronii*, *Ventilago viminalis*, and *Geijera parviflora* (tree wilga) are the most common and constant components of the upper tree layer. *Eremophila mitchellii* is often the sole constituent of the lower tree layer. *Flindersia dissosperma* is much less common and constant, and *Hakea leucoptera* occurs in the west of the area. *Carissa ovata* is the commonest and most constant species in the shrub layer. *Myoporum deserti* is less common and constant, and *Apophyllum anomalum*, *Erythroxylum australe*, and *Cassia nemophila* occur occasionally.

The community is associated with brigalow, blackwood, and gidgee communities and with *E. populnea*, *E. thozetiana*, and *E. cambageana* when these occur with brigalow or blackwood communities. Scrub grass is usually associated with this community though eastern mid-height grass is common where the phytocoenoses are open.

Many species that occur in this community are also important constituents of the argillicolous community of woodlands, and transitions are frequent.

(ii) Terminalia oblongata (*Yellowwood*) *Community*.—This community occurs on dark cracking clay and texture-contrast soils where brigalow, blackwood, and gidgee communities occur, but is absent from the south of the area. It is less common on texture-contrast soils than is the *Eremophila mitchellii* community and is not often associated with *E. cambageana* which is more or less confined to texture-contrast soils. The *Terminalia oblongata* community is stratified. There is one, usually dense, tree layer and a well-developed shrub layer. *Terminalia oblongata* is the most common and constant species of the tree layer. *Eremophila mitchellii* is also common and constant, especially where *E. cambageana* occurs. Other species that occur but are usually not common are *Geijera parviflora* (tree wilga), *Bauhinia carronii*, *Ventilago viminalis*, *Flindersia dissosperma*, and *Brachychiton rupestre*. *Carissa ovata* is the most common species of the shrub layer. *Heterodendrum diversifolium* is also fairly common and constant. Other minor constituents are *Ehretia membranifolia* and *Erythroxylum australe*. Physiognomically and floristically the *Terminalia oblongata* community is closely related to the *Eremophila mitchellii* community.

Scrub grass is the commonest grass layer associate. When the upper layers are open, blue grass and eastern mid-height grass occur.

Terminalia oblongata often occurs in almost pure stands on margins of brigalow and gidgee scrubs where these abut onto grassland or *E. microtheca* woodland. Clearing such communities is difficult and they are of economic importance in the Emerald–Capella area.

(iii) Geijera parviflora (*Shrub Wilga*) *Community*.—There are two growth forms of *G. parviflora.* Tree wilga is a tree up to 30 ft tall with a wide range, and is a constituent of the argillicolous midstorey of woodlands, of softwood scrub, and of the *Eremophila mitchellii* and *Terminalia oblongata* midstoreys of scrubs. Shrub wilga or lavender bush is a shrub up to about 15 ft tall, occurring in the south of the area with a small outlier in the north-central part of the region. The two forms are ecologically rather distinct.

The shrub wilga community is restricted to the south of the area where it occurs in association with brigalow and *E. cambageana*–brigalow communities on dark cracking clays, texture-contrast soils, and dark brown and grey-brown soils in Wharton land system. It is stratified. There is a moderate low tree layer 10–20 ft tall, and a moderately dense to dense shrub layer that may be up to 15 ft tall. *Eremophila mitchellii* is common in the low tree layer, and *Bauhinia carronii* and *Brachychiton rupestre* occur occasionally. *Geijera parviflora* (shrub wilga) is by far the most common and constant species in the shrub layer, which is in some places monospecific. *Carissa ovata*, *Myoporum deserti*, and *Eremocitrus glauca* are less common and constant.

Scrub grass (*Paspalidium* spp., *Chloris acicularis*, *Ancistrachne uncinulata*) is the most commonly associated grass stratum, but eastern mid-height grass (especially *Cymbopogon refractus*) occurs. The community is associated with brigalow but rarely gidgee. Scattered individuals of shrub wilga occur in some gidgee communities north of Clermont.

(iv) *Softwood Midstorey Community*.—This community occurs mainly in the south and north-east on dark cracking clay soils, on uniform fine-textured soils, and rarely on texture-contrast soils. It is associated with brigalow and gidgee scrubs, but it is the least important of the midstorey communities. There is a moderate low tree layer, 10–20 ft tall; a sparse to dense tall shrub layer to 10 ft; and a sparse to dense low shrub layer less than 4 ft tall. *Eremophila mitchellii* and *Terminalia oblongata* occur in the low tree layer. The species of the tall shrub layer are characteristic of the community and are also found in softwood scrubs. None has a high constancy but some are locally common. They are *Citriobatus spinescens*, *Croton phebalioides*, *Acalypha eremorum*, *Macropteranthes leichhardtii* (in the south), and *Erythroxylum australe*. *Ehretia membranifolia*, *Denhamia obscura*, and *Murraya ovatifoliolata* are less important. *Carissa ovata* is common in the lower shrub layer. *Heterodendrum diversifolium* is less common but fairly constant.

The grass layer is sparse, but scrub grass (mainly *Ancistrachne uncinulata*) is occasionally well developed.

Transitions to softwood scrub and to *Eremophila mitchellii* midstorey occur.

(c) *Emergents*

E. populnea, *E. microtheca*, *E. thozetiana*, and *E. cambageana* form communities with brigalow, blackwood, and gidgee. The eucalypts occur as emergent trees in scrub communities without significantly affecting the structure of the scrub component. Consequently these communities consist of four synusiae—the emergent stratum, the scrub stratum, the midstorey community, and the grass stratum. Relations between the first three synusiae are given in Table 18.

(i) Eucalyptus cambageana.—There are extensive areas of *E. cambageana*–brigalow scrub throughout the region, particularly in Humboldt land system, most commonly on texture-contrast soils, rarely on dark cracking clay soils and dark brown and grey-brown soils. *E. cambageana*–gidgee communities are rare, but *E. cambageana*–blackwood scrubs occur in the north-west of the area. The emergent eucalypt layer is 50–75 ft tall with 10–20, rarely more, trees per acre. The brigalow (or blackwood) layer varies a great deal, as do all brigalow communities.

Rarely is there no associated scrub midstorey community. The *Eremophila mitchellii* community is most common, though *Terminalia oblongata* and shrub wilga are important within their ranges. *E. cambageana* does not occur with the softwood midstorey community in the area surveyed. Mosaics of scrub grass and eastern mid-height grass are the usual ground cover.

Brigalow–*E. cambageana* communities are potentially important economically, but cost of clearing the large trees is high and *E. cambageana* seedlings may at times be as troublesome as brigalow suckers.

(ii) Eucalyptus thozetiana.—*E. thozetiana* and brigalow often form communities. They occur on texture-contrast soils and are usually limited in extent. *E. thozetiana* is usually 55–65 ft tall with a small open crown. There are usually 5–30 trees per acre. The associated brigalow scrub is usually slightly less than half the height of the emergent trees and may be fairly open (a range of 40–700 trees per acre). *Eremophila mitchellii* community is always associated though it is often reduced to two species—*Eremophila mitchellii* and *Carissa ovata*. Scrub grass is the normally associated grass synusia.

(iii) Eucalyptus populnea.—Wherever *E. populnea* woodland and brigalow communities occur in the area there are transitional zones which grade from brigalow as a component of the argillicolous midstorey of *E. populnea* woodland to brigalow–*E. populnea* communities. This community occurs on texture-contrast soils and is nowhere very extensive. It is of significance only in Skye land system. *Eremophila mitchellii* is the usual scrub midstorey associate, but shrub wilga midstorey occurs occasionally.

Eastern mid-height grass and scrub grass are most usual grass synusiae, often in mosaics.

(iv) Eucalyptus microtheca.—Coolibah–brigalow and coolibah–gidgee communities occur on dark cracking clays on alluvium. They usually cover small areas and, with *E. populnea*–brigalow scrubs, are more obviously ecotonal than other communities discussed. In Comet land system near Emerald, however, there are extensive areas of *E. microtheca*–brigalow–*Terminalia oblongata* scrub. These often have a high proportion of *T. oblongata* and are difficult to clear completely owing to the difficulty of burning yellowwood.

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PART IX. PASTURE LANDS OF THE NOGOA–BELYANDO AREA

By L. PEDLEY*

I. INTRODUCTION

For the greater part of the area, the major land use is, and is likely to remain, the grazing of natural pastures. The paucity and unreliability of the rainfall limit growth of natural pastures to a period of 3 to 5 months, but an increase in the area of sown pasture species such as Rhodes grass (*Chloris gayana*), buffel grass (*Cenchrus ciliaris*), and Townsville lucerne (*Stylosanthes humilis*) and of grazing crops such as oats and sorghum is likely.

The land systems have been grouped, on the basis of pastoral affinities, into pasture lands which are shown in the small-scale map. There are seven pasture lands, including one of non-range country that is too rugged, stony, or barren for grazing. The pasture lands with their component land systems and major grass communities are shown in Table 22. Those parts of Lennox and Borilla land systems that occur in the north and north-east of the area differ from other parts of these land systems and are included in different pasture lands.

Stocking rates vary considerably within pasture lands and it is difficult to give reliable figures. The ones given are derived partly from the data of Sullivan (1954), Sutherland (1962), and Purcell (1963), and should be compared with the accurate figures of Perry (1964) for similar pasture lands of the Leichhardt–Gilbert area which adjoins the Nogoa–Belyando area.

II. PASTURE LANDS

(*a*) *Scrub Country*

This pasture land occurs chiefly in the south and north-east of the area. Soils are dark cracking clays, texture-contrast, or dark brown and grey-brown soils, and the vegetation is brigalow, blackwood, gidgee, belah, softwood, and eucalypt–brigalow scrubs. It consists usually of flat to slightly undulating plains and occasionally hills, sometimes in the south steep enough to influence land use. The grass vegetation is composed of low (1–1½ ft), perennial, drought-evading grasses, mainly *Paspalidium* spp., *Chloris divaricata*, *C. acicularis*, *Sporobolus* spp., *Ancistrachne uncinulata*, and *Eragrostis megalosperma*. Grasses are sparse and forbs are common in the interspaces. The most conspicuous are *Atriplex* spp., *Enchylaena tomentosa*, and *Bassia* spp. Pasture yield is low, but the forage is of high quality and does not deteriorate during the dry season as much as pasture of other types. When scrub is cleared scrub grass is succeeded by blue grass or eastern mid-height grass, provided there is not a heavy regrowth of scrub species.

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TABLE 22

PASTURE LANDS WITH THEIR COMPONENT LAND SYSTEMS AND MAJOR GRASS COMMUNITIES

Pasture Land and Area	Land System	Estimated Proportion of Grass Communities (%)					
		Blue Grass	Eastern Mid-height Grass	Eastern Spinifex	Scrub Grass	Arid Scrub Grass and/or Sandstone Spinifex	Samphire and Salt-water Couch
Scrub country	Comet	25	15		45		
(9540 sq miles)	Banchory	35			50		
	Kinsale	30	5		65		
	Wondabah	15	< 5		80		
	Kareela	15	< 5		80		
	Moray	30			70		
	Rutland		45		55		
	Ulcanbah		10		85		
	Willows		15		80		
	Islay	< 5	10		90		
	Wharton		5		80	< 5	
	Cungelella		5		90		
	Humboldt		25		70	< 5	
	Blackwater	< 5	20		75	< 5	
	Somerby	< 5	5		90	< 5	
Eastern mid-height	Alpha	< 5	75		< 5		
grass country	Hope		90		< 5	< 5	
(7770 sq miles)	Portwine		95		5		
	Craven		80	< 5	15		
	Peak Vale		90		< 5		
	Skye		60		25	5	
	Playfair		75	< 5	< 5	10	
	Hillalong		60		25	25	
	Pinehill		70		30		
	Monteagle		70	5	15	10	
	Borilla*		85		10		
Eastern mid-height grass–eastern spinifex country (1960 sq miles)	Loudon		40	20	15	20	
	Disney		45	25	30		
Eastern spinifex	Degulla		55	40			
(6520 sq miles)	Lennox†		55	45	< 5	< 5	
	Ronlow		35	65			
	Tichbourne		40	50	< 5	5	
Blue grass country	Funnel	45	25		15		
(3950 sq miles)	Oxford	85	15				
	Waterford	60	25		5		
	Avon	90	5		< 5		
	Mantuan	80	15		< 5		
Lake (260 sq miles)	Galilee		15				20
Non-range	Percy		90				
(4990 sq miles)	Bogantungan		100				
	Copperfield		60		< 5	5	
	Durrandella		25	< 5	5	45	
	Carborough		30	15	< 5	35	

* Approximately 50% included in non-range country.

† Approximately 30% included in eastern mid-height grass country.

The country has a low stocking rate, but some areas of brigalow and gidgee scrubs have been cleared and sown to improved pasture, mainly Rhodes grass (in the north-east and south), or are being cropped (near Emerald). The establishment of improved pasture raises the carrying capacity from 12 to about 60 to 70 cattle per sq mile. The fertility of the soils, particularly of the dark cracking clays, is moderately high and except on steep slopes further clearing for pasture is expected. *E. cambageana* occurs in about one-quarter of the pasture land (mainly Humboldt land system) and is a major obstacle to clearing, especially for cultivation. Brigalow, and to an unknown extent blackwood, regrowth following clearing is also a problem (Johnson 1964). Soil erosion is already evident in cleared brigalow scrub in Rutland and Wharton land systems and extensive clearing on steep slopes in these and Kareela and Cungelella land systems would be unwise.

(*b*) *Eastern Mid-height Grass Country*

This country consists of plains and hills on all rocks except basalt and quartzose sandstones throughout the area. Soils are mainly texture-contrast with some red and yellow earths, and on the whole are shallower and less fertile than those of the blue grass and scrub country. The relief is usually greater than in these pasture lands. The pastures are associated with eucalypt woodlands (mainly *E. populnea*, *E. melanophloia*, and narrow-leaved ironbark) and are rarely treeless. The pasture is characterized by perennial drought-evading tussock grasses (3–4 ft high), *Bothriochloa ewartiana*, *B. decipiens*, *Heteropogon contortus*, *Themeda australis*, *Aristida glumaris*, and *Eriachne* spp. Extensive areas have almost pure stands of *B. ewartiana*, and on shallow or sandy soil and in drier parts of the area *Aristida* spp. and *Eriachne* spp. predominate. Other types of country are associated with it in different land systems, notably frontage grass on levees in Alpha land system, scrub country in Skye, Hillalong, and Pinehill land systems, and non-range country in Playfair, Hillalong, and Monteagle land systems.

Pasture yield is moderate but quality is low in the dry season, particularly after frosts. The lower fertility and shallowness of the soils result in pastures poorer in quality and lower in yield than those of blue grass country. Variations in quality are also greater. Pasture dominated by *Bothriochloa* spp. is better than that dominated by *Aristida* spp. The pastures are burnt regularly at the end of the dry season to remove excess dry grass, to promote fresh growth, and to suppress eucalypt regrowth if clearing has been carried out.

Cattle-grazing is the only land use and the country has little agricultural potentiality. The stocking rate varies a great deal, but probably averages 20 per sq mile over the whole area. Soil fertility and rainfall are low and variable over much of the area, but on many properties suitable land and water are available to irrigate small areas of fodder crops. The provision of more stock watering points, particularly in the west, would probably also increase the carrying capacity.

(*c*) *Eastern Spinifex Country*

Ronlow, Lennox, Tichbourne, and Degulla land systems constituting this pasture land occur on the Tertiary land surface and fans derived from it in the western part of the area. The pasture occurs on red and yellow earths in association with *E. melanophloia* woodland with smaller areas of *E. populnea*, *E. polycarpa–E. papuana*, narrow-leaved ironbark, and *E. similis* woodlands. A well-developed *Acacia leptostachya* midstorey occurs with the last. The country is often termed desert, for example, by Sullivan (1954) and Purcell (1963), but Blake (1938) uses the term in a more restricted sense.

The grass vegetation is a mosaic of perennial drought-resisting eastern spinifex (mainly *Triodia mitchellii*) and eastern mid-height grass (*Bothriochloa ewartiana* and *Aristida* spp.). The pasture responds quickly to light rain and is often burnt so that new growth can be grazed, but productivity, quality, and palatability are low. Grave mineral deficiencies and the occurrence of *Gastrolobium grandiflorum* (heart-leaf poison) in the *Acacia leptostachya* midstorey community present serious management problems. About 10 cattle per sq mile is the average carrying capacity. In higher-rainfall areas, the pasture grades into eastern mid-height grass, usually dominated by *Aristida* spp., and areas of Lennox land system in the east have been included in eastern mid-height grass country.

Some of the soils may be suitable for Townsville lucerne but on the whole they have low fertility and the rainfall is so low and variable that there is little likelihood of any great development of this country.

(*d*) *Mixed Eastern Spinifex–Eastern Mid-height Grass Country*

Loudon and Disney land systems, which constitute this pasture land, occur mainly in the north and centre of the area and consist of hills with vegetation characteristic either of some of the non-range country or of the eastern spinifex country, and intervening lowlands with vegetation characteristic of eastern mid-height grass or scrub country. The hilly parts of the pasture land are of little value, but pastorally the lowlands are similar to eastern mid-height grass or scrub country.

(*e*) *Blue Grass Country*

This pasture land occupies much of the eastern and southern part of the area, usually on basalt, shales, or clay sheets, but with a fair proportion (mainly in Funnel land system) on alluvium. It consists of plains and low hills with dark cracking clay soils, half of it (usually called downs) without trees or with scattered trees or groves of trees, and the remainder with open woodland, chiefly *E. microtheca* and *E. orgadophila* with minor *E. melanophloia*. The grass vegetation is composed of perennial drought-evading mid-height (2–4 ft) grasses with *Dichanthium sericeum*, *Thellungia advena*, *Panicum decompositum*, *P. queenslandicum*, *Aristida leptopoda*, *Ophiuros exaltatus*, and *Astrebla* spp. prominent, the last especially so where blue grass and *E. microtheca* woodland are associated. Shorter grasses, particularly *Iseilema* spp., are seasonally important and the sedge, *Cyperus retzii*, is a major component on some alluvial sites. The forbs, *Polymeria longifolia*, *Rhynchosia minima*, *Calotis cuneata*, and *Crotalaria dissitiflora*, are often conspicuous. The pastures grade into eastern mid-height grass country on shallow soils and in the west of the area, notably near Surbiton where Waterford land system consists solely of *E. melanophloia* woodland over eastern mid-height grass.

Pasture yield is high, but pasture quality is low during the winter (dry season) and stock lose weight. Basal cover, estimated by the line intercept method (Brown 1954), ranges from 1·0 to 4·7% with a mean of 2·3%. Cover is lowest on heavily grazed areas such as stock routes and highest in Oxford land system north-east of Clermont. Except for small areas in the south and west where there are sheep, the country is used for cattle-grazing and the stocking rate averages about 36 per sq mile. When overgrazed, as for example on stock routes, less palatable species such as *Panicum queenslandicum* become dominant. Fluctuations not directly attributable to the effect of grazing may occur in the composition of the pasture, for example the increase of *Aristida leptopoda* reported by Everist (1939).

The soils are fertile, clearing is not a problem, and there is some cultivation where soils are deep and climatic conditions are suitable, mainly in the south and east. Oats and sorghum are grown for forage. Extension of the area under forage crops is to be expected where rainfall is sufficiently high and reliable, and where soils and terrain are suitable.

(*f*) *Lake Country*

This pasture land is restricted to plains and old beach ridges adjacent to Lake Galilee and Lake Buchanan and on the lake floors. About two-thirds of it is saline bare ground and the remainder is eastern mid-height grass, samphire, and salt-water couch. The first pasture is of some value, but the last two are not. Samphire is grazed by sheep at the southern end of Lake Galilee in conjunction with eastern mid-height grass, but the carrying capacity does not exceed five cattle equivalents per square mile.

(*g*) *Non-range Country*

This country is not suited to grazing because it is inaccessible, stony, or barren.

The vegetation of Bogantungan and Percy land systems consists of narrow-leaved ironbark woodland over rather dense, good-quality, eastern mid-height grass (*Themeda australis, Heteropogon contortus*), but the terrain is mountainous and except on their margins the land systems are inaccessible to stock. Run-off from the steep slopes is extremely rapid and the provision of watering points for stock is very difficult. Copperfield land system is dissected, stony country with narrow-leaved ironbark woodland, *Acacia rhodoxylon* midstorey, and eastern mid-height grass. There is much bare ground and rock outcrop, and the pasture is sparse and consists largely of unpalatable and unproductive *Aristida* spp. and *Eriachne* spp. Where slopes are gentle and the midstorey is absent, the eastern mid-height grass is of better quality and the country has some pastoral value. Part of Borilla land system north-east of Mt. Coolon has similar, sparse eastern mid-height grass and a high proportion of rock outcrop, and is included here.

Carborough land system is composed of sandstone hills and mountains. It is largely inaccessible and the grass communities (eastern spinifex, sandstone spinifex, and arid scrub grass) are so poor that they are of no pastoral value. Durrandella land system consists of hills and scarps covered with lancewood or bendee scrub over bare ground or arid scrub grass. The pasture is sparse, of poor quality, and unpalatable.

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PART X. LAND USE IN THE NOGOA–BELYANDO AREA

By R. H. GUNN*

I. INTRODUCTION

Present land use in almost the entire area is the grazing of natural pastures for the production of beef cattle. A small proportion of land is used for grazing wooled sheep at Mantuan Downs, Surbiton, and on properties near Emerald and Lake Galilee. The clearing of brigalow, gidgee, and softwood scrubs for the establishment of improved pastures is being carried out over wide areas and on average is increasing the carrying capacities of these pastures about six-fold (Sutherland 1962).

The production of sorghum, wheat, and other crops such as safflower, linseed, and oats is carried out mainly on the basaltic clay soils around Emerald and Clermont and in the Peak Downs area (Plate 12, Fig. 2). Smaller units of sedentary and alluvial clay soils are used for cropping in the south-east near Tanderra. The total area of cultivated land is probably of the order of 100,000 acres.

Coal of bituminous to sub-bituminous class is mined open cast at Blair Athol mainly for use by the railway and the estimated reserves are of the order of 96 million tons. The mining of gemstones is carried out on a small scale west of Emerald near Willows, Sapphire, and Rubyvale.

The beef cattle industry is by far the most important form of land use in the area and because of natural limitations is likely to remain so. The Fitzroy Basin Land Development Scheme designed to promote development within the Basin will, however, result in more intensive land use particularly in areas with more favourable soil and climatic conditions. According to Mawson (1962) the trend in the future demand for beef is for animals aged about 18 to 30 months without excess fat giving a dressed weight of about 550 lb. To achieve this objective, Mawson suggests that some crop fattening would appear to be necessary.

In this Part an attempt is made to interpret data given in previous Parts in terms of potential land use. Areas judged to be dominantly of one capability class are shown in Figure 11 and potential land use in relation to land systems is indicated broadly in Table 23. Land capability classes in respect of land units are given in the tabulated descriptions of the 43 land systems in Part III. The capability classes are those defined by the United States Department of Agriculture (1958) and are described in Appendix I together with tentative definitions of subclasses. These interpretations are intended to be no more than guides to potential land use in the area and they will almost certainly be modified when more practical experience has been gained.

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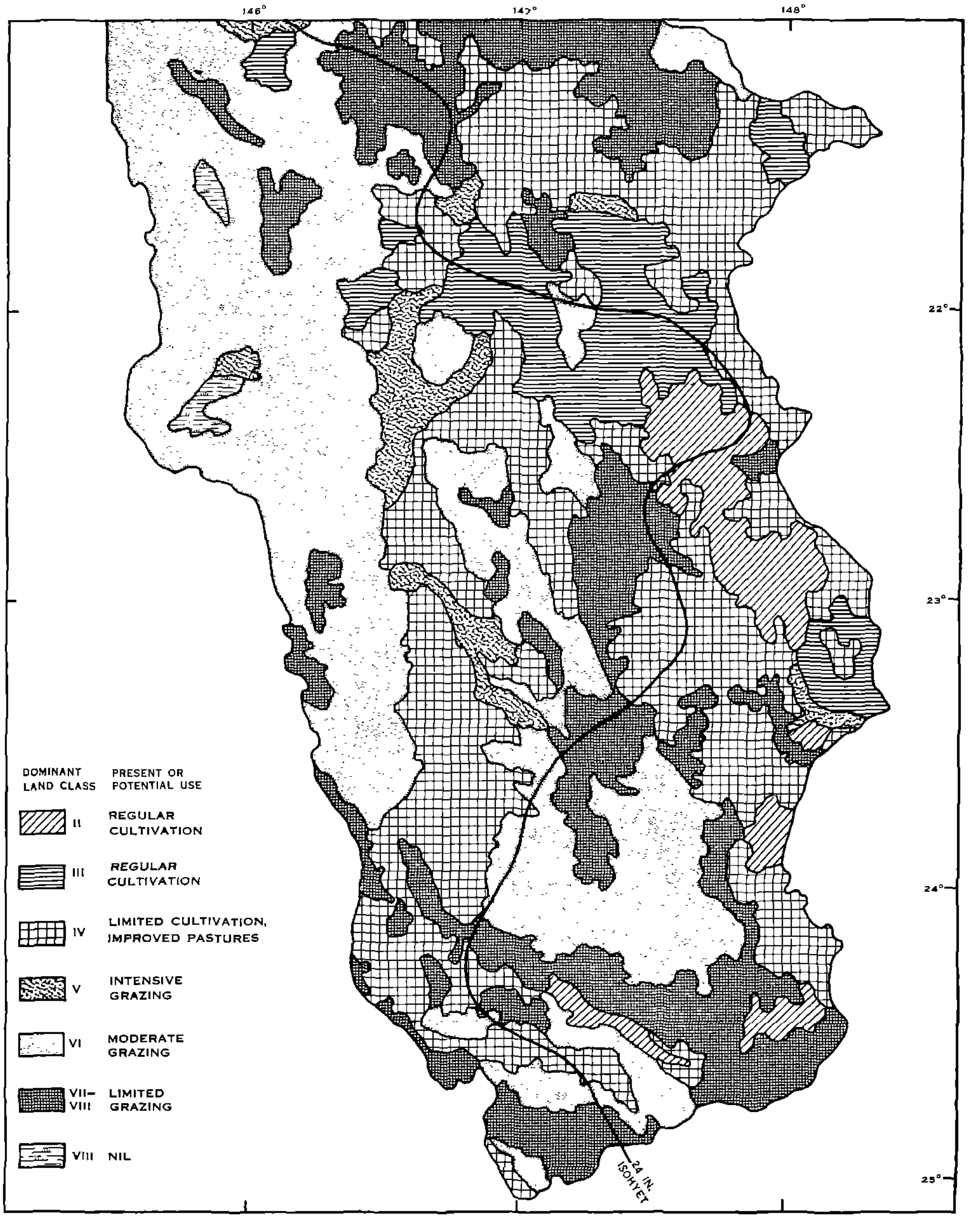

Fig. 11.—Estimated potential land use.

II. Climate and Land Use

In comparison with the eastern parts of the Fitzroy region, rainfall in the area is lower and more variable and extremes of temperature, both below and above the optimum for plant growth, occur more frequently. These are the most important climatic factors influencing land use in the area. In the following brief discussion on the growth of pastures and crops in relation to these factors, the climatic data are taken from Part IV and an assessment of climate and plant growth in the Fitzroy region by Fitzpatrick (1965).

Table 23

ESTIMATED POTENTIAL USE IN LAND SYSTEMS

Land Class	Estimated Potential Use	Land System	Limitations
II	Cultivation with slight limitations	Mantuan, Oxford, and parts of Kinsale, Waterford, and Wondabah	Moderate erosion, unreliable rainfall
III	Cultivation with moderate limitations	Avon, Moray, and parts of Blackwater, Islay, Ulcanbah, and Wondabah	Salinity and/or alkalinity, moderate erosion, low and unreliable rainfall
IV	Limited cultivation and/or pasture improvement	Alpha, Disney, Hillalong, Humboldt, Monteagle, Peak Vale, Pinehill, Somerby, and parts of Blackwater, Islay, Kinsale, Skye, Waterford, and Wharton	Moderate erosion, shallow soils, salinity and/or alkalinity microrelief
V	Intensive grazing	Banchory, Comet, Funnel	Very frequent overflow
VI	Moderate grazing	Craven, Cungelella, Degulla, Hope, Lennox, Portwine, Ronlow, Rutland, Tichbourne, Willows, and parts of Playfair, Skye, and Wharton	Low rainfall, soil fertility, and water-holding capacity; stones, severe erosion
VII–VIII	Limited grazing	Bogantungan, Borilla, Carborough, Copperfield, Durrandella, Kareela, Loudon, Percy, and parts of Playfair	Very steep slopes, rocks, shallow or sandy soils
VIII	*Unsuitable for cultivation or grazing*	*Galilee*	*Salinity and/or alkalinity,* flooding

(a) *Pasture Growth*

The growth pattern of both natural and improved pastures in the area is controlled by suboptimal temperatures during the winter months and the marked seasonal distribution of rainfall. With the onset of rains and increased temperatures in early summer, grass growth is rapid and there is generally a surplus of stock feed. Following the flowering stage there is a rapid decline in the rate of growth and pasture quality deteriorates. During winter growth rates remain at low levels irrespective of moisture conditions and the effects of frost or rain on dry pastures during this period cause further deterioration in quality. The estimated mean annual duration of useful growth (i.e. adequate to provide some green feed for stock) ranges from about 20 wk in the north-east of the area to less than 12 wk in the extreme west.

The decrease in growth periods and increase in rainfall variability from east to west are reflected broadly in the distribution of pasture types, although soil factors such as water-holding capacity, fertility, and lime status also cause changes in the grass vegetation. In the eastern mid-height pastures desert blue grass predominates in the east and *Aristida* species become more common in the drier western parts of this pasture land. In the extreme west where the annual duration of useful growth is 12 wk or less, the grass vegetation forms a mosaic of drought-resisting eastern spinifex and eastern mid-height grasses.

(*b*) *Dryland Crops*

In order to assess the suitability of climatic conditions for summer and winter cropping, Fitzpatrick (1965) has analysed the lengths of individual sequences or "runs" of weeks during which there is soil moisture available without interruption. These are referred to as growth sequences. In these analyses no account is taken of special practices to conserve soil moisture such as fallowing. At Mt. Coolon and Emerald the median lengths of growth sequences between mid-January and April are generally less than 10 wk and at Alpha they do not exceed 6 wk over this period. These estimates indicate that there are clearly strong limitations to the growing of summer crops requiring long periods of active growth. Apart from the drier western half of the area the growth sequences are normally long enough for crops with short maturation periods such as some sorghum varieties and bulrush millet.

With regard to winter cropping the data for Emerald, Mt. Coolon, and Alpha indicate that if a growth period of 12 wk or more is required there is a 35% chance that a week will be without available soil moisture. During the period early May to July the median lengths of growth sequences at Emerald and Alpha do not exceed 7 wk but the per cent chance of a week without estimated available soil moisture at Alpha is considerably higher than at Emerald. At Mt. Coolon the median length of growth sequences ranges from 7 to 10 wk for the same period.

The occurrence of extreme temperatures and their effects on crops in the Central Highlands region are discussed in detail by Skerman (1953). There is an appreciable risk of frosts throughout the area, generally from May to August, particularly in the south in low-lying sites, and frost damage to wheat at time of flowering or to late-planted summer crops is possible. The incidence of heat waves when temperatures exceeding 100°F occur on several consecutive days is a further hazard to crops, especially during the period November to January.

These observations indicate the considerable risks of there being inadequate moisture for both summer and winter cropping in the area, particularly in the western half where rainfall is lower and more variable than in the east. The risks can be reduced to some extent by careful selection of soils with adequate depth and high water-holding capacity and by measures to conserve soil moisture such as summer fallowing, contour cultivation, and thorough weed control. The selection of drought-hardy, short-season crops would also appear to be desirable.

In order to reduce the effects of poor-quality pastures on grazing animals during winter, the growing of fodder crops such as sorghum, safflower, or oats for grazing appears to offer the best possibilities. A study by the Bureau of Agricultural Economics (1964) indicates that liveweight gains of 2 to 3 lb/day are possible by cattle grazing on sorghum and oats during the period May to November in the Central Highlands. A further advantage of this system of cropping on grazing properties is that it provides a very satisfactory method of controlling regeneration in areas newly cleared of brigalow (Johnson 1964) and possibly gidgee and blackwood, particularly if the land is ploughed in summer.

III. Soils and Land Use

In this section some of the more important soil properties affecting land use in the area are considered broadly.

(a) *Soil–Water Relationships*

Under the climatic conditions in the area the more important soil properties affecting soil–water–plant relationships are the available water storage capacity, effective depth, the rate at which water enters and moves through the soil, and physiographic position in relation to run-off and overflow.

Data of Stirk (Reeve, Isbell, and Hubble 1963) indicate that the cracking clay soils are likely to have available moisture storage capacities ranging between 2 and 2·5 in. per foot depth. On the other hand, the sandy red and yellow earths and uniform coarse-textured and shallow rocky soils probably have available storage capacities of the order of 0·7 in. per foot depth. The loamy red and yellow earths have medium- to fine-textured subsoils and their storage capacities are likely to be somewhat higher but still generally low. Moisture storage capacities in the texture-contrast soils are variable. The sandy surface soils of Luxor and Broadmeadow families have low storage capacities and they tend to dry out rapidly. Although moderately high storage capacities are possible in the clayey subsoils, permeability and root penetration are often severely restricted by their hard consistence and massive structure (Plate 6, Fig. 2). For this reason the deep texture-contrast soils have been classified according to differences in the texture and thickness of the surface horizons. A thickness of 15 in. has been taken as the dividing line between those with thick and those with thin surface soils.

The effective depth of soil in relation to the rooting habits of plants is important as it controls the volume of the moisture reservoir. Root penetration in the cracking clay soils is confined mainly to the upper 2 or 3 ft but a small proportion of roots may penetrate to 4 ft or more. In the deep sandy soils, with lower water-storage capacities, there is a tendency for roots to range more widely and draw on stored moisture from a greater volume of soil. In times of moisture stress, the cracking clay soils with depths of 3 ft or more provide larger reservoirs of stored moisture and plants are generally less likely to be affected by drought than in shallow or sandy soils that tend to dry out more rapidly.

The rates at which water enters and moves through soils are controlled largely by their texture, structure, porosity, and moisture content. The cracking clay soils when moist have low rates of infiltration and permeability, but the cracks that form on drying facilitate penetration and absorption when rain subsequently falls. Moisture movement in the texture-contrast soils depends mainly on the texture and depth of the surface soils. Those with deep sandy, friable surface soils tend to absorb water readily but the slowly permeable subsoils retard deeper penetration and lead to periodic saturation or lateral subsurface seepage. Most of the surface soils are massive and become hard and compacted when dry, causing low infiltration and high run-off rates. The sandy red and yellow earths and uniform coarse-textured soils are likely to have high rates of infiltration and permeability. The loamy red and yellow earths are permeable but tend to set hard at the surface, and infiltration is reduced.

Seasonal inundation through overflow by rivers and creeks is an important factor influencing the use of some soils, particularly the alluvial and gilgaied deep clay soils where these occur near major streams, mainly in Comet, Banchory, and Funnel land systems (Plate 11, Figs. 1 and 2). Many of these soils are flooded periodically to depths of 5 ft or more. The frequency, depth, and duration of flooding clearly depend on the magnitude of flood flow and on the elevation of the land, the most serious flooding occurring mainly along the larger streams which are subject to high floods. The depressions in the gilgaied clay soils are also subject to flooding or waterlogging by rainfall and run-off, especially where they are commanded by long slopes with texture-contrast soils (Plate 8, Fig. 2). The possibility of exploiting soil moisture reserves for limited cropping during the winter months in areas that are subject to flooding might be explored in sites where flood velocities are low.

(*b*) *Erosion*

Although high-intensity rain storms occur regularly, the incidence of accelerated erosion in the area is generally slight. However, all soils that occur in areas of sloping relief are liable to erode where the natural vegetation is seriously disturbed. The texture-contrast soils appear to be the most susceptible, particularly shallow soils on base-rich sediments in areas of undulating relief (Craven, Hope, Portwine, and Rutland land systems). Most of these soils have hard-setting, massive, slowly permeable surface horizons and a sparse grass cover. These properties, together with moderately steep slopes, tend to cause rapid run-off and often severe sheet and gully erosion, especially where overgrazing has occurred (Plate 5, Fig. 1).

Despite moderate to strong aggregation in the cracking clay soils and dark brown and grey-brown soils (Cheshire family), they are liable to erode severely in areas of sloping relief where the natural vegetation is disturbed. The occurrence of linear gilgais in some areas of clay soils (May Downs and Teviot families) tends to aggravate the position. Except in the vicinity of scarps where natural erosion is occurring, the red and yellow earths appear to be relatively stable. Sheet and gully erosion was observed in some overgrazed areas and where run-off was concentrated by roads and cattle tracks.

(c) *Fertility*

The red and yellow earths have formed on materials that have been subjected to intense weathering and leaching and they consist largely of residual sesquioxides, kaolinitic clay, and quartz. They are very low in exchangeable bases and are deficient in nitrogen and phosphorus. In the extreme south and in the central part of the area there are extensive occurrences of hilly or mountainous land formed mainly on quartz sandstones where poor sandy or shallow soils are widespread. Severe deficiencies of nitrogen and phosphorus are common in the texture-contrast soils, particularly those with thick sandy surface soils. Furthermore, climatic conditions in the area do not favour the accumulation of organic matter and the soils generally have low contents of nitrogen. For these reasons low levels of fertility may be expected in many of the soils.

On the other hand, the soils formed on relatively fresh rocks and fine-textured alluvium, particularly those derived from Tertiary basalt and some basic sediments (Arcturus, May Downs, Glenora, Teviot, Cheshire, and Vermont families) have moderate to high fertility. They are extensive in the east, north-central, and southern parts of the area. The basaltic soils are similar to those of the Darling Downs but are generally shallower (Hubble 1961). Determinations in the surface horizons of two profiles (Arcturus family) indicate high contents (800 and 3820 p.p.m.) of available phosphorus. In a basalt-derived alluvial clay soil (Vermont family) near Tanderra a similar high value (653 p.p.m.) was obtained. The fertility status of the soils formed on deeply weathered parent materials (Pegunny and Rolleston families) has been assessed by Isbell (1962). They have moderate fertility but will require careful management to maintain an adequate supply of the major plant nutrients. Analytical data on seven surface soil samples of Pegunny family indicate an average total nitrogen content of 0·06% (range 0·03–0·09%) and an average carbon content of 0·5% (range 0·30–0·88%). Available phosphorus is generally low, with an average content of 36 p.p.m. (range 18–64 p.p.m.). Data for Natal and Logan families indicate average total nitrogen and organic carbon contents of 0·06 and 0·71% respectively. Available phosphorus in Logan family appears to be uniformly very low (<10 p.p.m.). In two profiles of Natal family the phosphorus content varied from 9 to 67 p.p.m.

(d) *Salinity*

Slight to moderate salinity hazards are probable in certain cracking clay and texture-contrast soils in the event of their use for crop production or improved pastures with plants that do not tolerate such conditions. In fact, most of the crops and improved pasture species that are grown at present in the area have moderate to high tolerance to saline and/or alkaline conditions. Available analytical data in respect of the soils of Pegunny, Rolleston, Natal, and Logan families indicate that they are slightly to moderately affected by soluble salts, generally below depths of 3 ft but at shallow depths in some soils. Exchangeable sodium percentages are commonly 10 or more at depths below 3 ft. The moderate to high contents of gypsum in the soils of Logan family would assist in their improvement where the gypsum could be incorporated more evenly in the profiles.

Apart from the saline and/or alkaline texture-contrast soils in the vicinity of Lakes Buchanan and Galilee, other similar soils in the area, particularly those with strongly alkaline subsoils (Medway, Broadmeadow, Taurus, and Retro families), are likely to have exchangeable sodium percentages in excess of 15. They are slightly affected by soluble salts and commonly have the typical morphology of solodized solonetz or solodic soils.

(*e*) *Other Aspects*

The moderate to strong development of "melon-hole" gilgais in the soils of Pegunny family presents difficult problems in their use for cropping or improved pastures, and brigalow regrowth tends to be most vigorous in such areas (Isbell 1962; Johnson 1964). The gilgais with very abrupt slopes and closely spaced mounds and depressions present the most serious obstacles to machinery. The soils of Pegunny and Rolleston families, however, provide more suitable media for pasture establishment than those soils which form strong granular, self-mulching surface layers. Because of their high clay contents and narrow moisture range for working, the extensive use of suitable cracking clay soils for cultivation would generally involve sufficient machinery to plant and cultivate when conditions were optimum.

Apart from the shallow rocky soils of Rugby and Shotover families, varying degrees of stoniness would limit, either entirely or in part, the use of certain other soils for pasture establishment or cultivation. In places the basaltic clay soils (Arcturus and May Downs families) are so stony as to prohibit or seriously hinder the use of implements. Similarly, the presence of masses of large boulders of secondary quartzite (billy) in some areas of soils formed on Tertiary weathered zone materials (Rolleston, Wyseby, and Retro families) (Plate 9, Fig. 1) makes their use for purposes other than extensive grazing impossible. The soils of Gindie family are generally too bouldery and stony for scrub clearance.

IV. Irrigation

There are no irrigation schemes in the area but proposals in respect of an area near Emerald are at present being examined. The storage of 1,170,000 ac ft of water would be made possible by the construction of a dam on the Nogoa River about 12 miles upstream from the town. The supply of water would be by gravity and pumping to canals on either bank and about 19,000 ac are considered suitable for the irrigation of cotton, sorghum, lucerne, and wheat on the left bank within the area.

Apart from a few small springs in the south and near Doongmabulla in the north-west, there are no streams with perennial flows in the area. Irrigation on a moderate scale would therefore involve the construction of storage reservoirs. Apart from possible sites on the Suttor River near Eaglefield there appear to be no suitable dam sites on the major streams owing to the generally wide flood-plains, and where valleys are constricted they usually occur in areas of shallow or poor soils.

In terms of irrigable land the areas of basaltic alluvium near Tanderra and Clermont in Mantuan and Funnel land systems appear to be well suited, but measures to control flooding may be required. Parts of Alpha and Comet land systems near

Albro, Frankfield, and Avon Downs, for example, also warrant investigation in this regard. There is scope for small-scale irrigation in many parts of the area for the production of fodder crops such as lucerne if adequate water can be supplied from storage reservoirs or bore holes where underground water is plentiful. The quality of both surface and underground waters should be examined in order to prevent salinity problems, particularly in the more impermeable cracking clay soils.

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APPENDIX I

Land Capability Classes and Subclasses

I. Classes

The capability classes shown in the tabulated land system descriptions indicate broadly the use to which the various kinds of land in the area are best suited. The classes defined below follow the pattern of the United States Department of Agriculture* (1958) and have been recommended for use in Queensland by the Soil Conservation Division, Department of Primary Industries.

(*a*) *Class I Land*

This is land with few or no limitations. With good management it is suitable for long-continued cropping, without special practices. It is nearly level, has deep easily worked soil, and erosion hazard is low. The soils are well drained but not droughty and are either well supplied with nutrients or highly responsive to fertilizer applications. The climate is favourable to a wide range of cultivated crops, pastures, or forest.

(*b*) *Class II Land*

This is land with slight limitations. It is arable land and limitations are few and the practices easy to apply. It may require moderate conservation practices which will depend on the limitations but will include such practices as strip cropping, stubble mulching, etc. where erosion is the major hazard.

(*c*) *Class III Land*

This is land with moderate limitations. It is arable land but limitations may restrict the choice of plants grown, or require special conservation practices, or both. A combination of intensive measures is necessary for permanent use of the land. Such measures as adequate mechanical protection will be necessary if erosion is the limiting factor and the land is cultivated.

(*d*) *Class IV Land*

This is land which is subject to severe limitations and is suitable for occasional but not regular cultivation. It is primarily grazing land. The choice of plants may be very limited or more intensive conservation practices may be necessary.

(*e*) *Class V Land*

This is nearly level land that has little or no erosion hazard even if cultivated, but has other limitations which it is not practical to remove and which prevent the

* United States Department of Agriculture (1958).—Land capability classification. Soils Memorandum SCS–22.

TABLE 24

SUBCLASSES: KIND AND DEGREE OF LIMITATION

Limitation	Degree of Limitation	Class	Subclass
Susceptibility to water erosion	Slope < 1 %, or up to 2 % on short slopes up to 1000 ft long	I	—
	Slope 1–3 %	II*	e_2
	Slope 3–8 %	III*	e_3
	Slope 8–12 %	IV*	e_4
Topography	Slope 12–20 %, or moderate gullying	VI	t_6
	Slope > 20 %, or extreme gullying	VII–VIII	t_{7-8}
Microrelief affecting use of machinery, e.g. gilgais	Tillage interfered with but not impracticable	III	g_3
	Tillage difficult	IV	g_4
	All use of machinery impracticable	V	g_5
Stoniness	Tillage interfered with but not impracticable	III	r_3
	Tillage difficult	IV	r_4
	All use of machinery impracticable	V	r_5
Workability affecting use of machinery, e.g. high clay content, compaction	Slight restriction	II	k_2
	Moderate restriction	III	k_3
	Severe restriction	IV	k_4
Physical properties affecting plant growth, e.g. hardpan, surface crusting	Slight restriction	II	p_2
	Moderate restriction	III	p_3
	Severe restriction	IV	p_4
Wetness, frequency of flooding, or waterlogging	1 in 5 years	III	w_3
	> 1 in 5 years	IV	w_4
	Seasonal	V	w_5
Salinity	Slightly affected	II	s_2
	Moderately affected	III	s_3
	Seriously affected	IV–VII	s_{4-7}
	Salt pan	VIII	s_8
Effective depth of soil	> 48 in.	I	
	36–48 in.	II	d_2
	24–36 in.	III	d_3
	12–24 in.	IV	d_4
	< 12 in.	V	d_5
Available water capacity (in./ft depth of soil)	2 in. or more — high	I	
	1–2 in. — moderate	II	m_2
	< 1 in. — low	III	m_3
Soil nutrient status	Low	III	n_3
	Very low	IV	n_4

* The class may be downgraded according to the susceptibility of a particular soil to erosion, e.g. texture-contrast soil.

normal production of cultivated crops. This land may be used for pasture or forestry with few or no limitations. Special crops may be grown on it but only with the use of special practices.

(f) Class VI Land

This is land which has such severe limitations that it is unsuitable for cultivation, but it is suitable for grazing or forestry subject only to moderate limitation in use. Limitations of soils or slopes are such that pasture improvement practices requiring the use of tractors and machinery are practicable.

(g) Class VII Land

This is land with very severe limitations which make it unsuitable for cultivation and restrict its use even for grazing or forestry. Limitations are such that pasture improvement practices requiring the use of tractors and machinery are impractical.

(h) Class VIII Land

This is land with such severe limitations that it is not suitable for cultivation, grazing, or commercial forestry. Its main value is for watershed protection and wildlife and recreation reserves.

II. Subclasses

The subclasses, together with the kind and degree of limitations in the various classes, are given in Table 24.

APPENDIX II

Check List of Plant Species

Acacia argyrodendron Domin	Blackwood
A. bancroftii Maid.	
A. bidwillii Benth.	
A. brevifolia Benth.	
A. cambagei R. T. Bak.	Gidgee
A. catenulata C. T. White	Bendee
A. coriacea DC.	Desert oak
A. cunninghamii Hook.	Black wattle
A. excelsa Benth.	Ironwood
A. farnesiana Willd.	Mimosa bush
A. fasciculifera F. Muell.	Scrub ironbark
A. glaucocarpa Maid. & Blakely	
A. harpophylla F. Muell.	Brigalow
A. homalophylla A. Cunn. ex Benth.	Yarran
A. laccata Pedley	
A. leptocarpa A. Cunn. ex Benth.	
A. leptostachya Benth.	
A. orthocarpa A. Cunn. ex Benth.	
A. oswaldii F. Muell.	Nelia
A. pendula A. Cunn. ex G. Don	Myall
A. rhodoxylon Maid.	Rosewood
A. salicina Lindl.	Willow wattle
A. shirleyi Maid.	Lancewood
A. simsii A. Cunn. ex Benth.	
A. sparsiflora Maid.	
A. stipuligera F. Muell.	
A. tenuissima F. Muell.	
A. torulosa Benth.	
A. whitei Maid.	
A. sp. aff. *burrowii* Maid.	
A. sp. aff. *cana* Maid.	
A. sp. aff. *cunninghamii* Hook.	
A. sp. aff. *julifera* Benth.	
Acanthospermum hispidum DC.	Star-burr
Albizia basaltica (F. Muell.) Benth.	Dead-finish
Alphitonia excelsa (Fenzl) Benth.	Red ash
Alstonia constricta F. Muell.	Bitterbark
Alysicarpus rugosus DC.	Rough chain-pea
Ammannia sp.	
Ancistrachne uncinulata (R. Br.) S. T. Blake	Hooky grass
Angophora costata (Gaertn.) J. Britt.	
Apophyllum anomalum F. Muell.	Broom-bush
Argemone ochroleuca Sweet	Mexican poppy

Aristida browniana Henr.	Kerosene grass
A. caput-medusae Domin	
A. glumaris Henr.	
A. helicophylla S. T. Blake	
A. hygrometrica R. Br.	
A. jerichoensis (Domin) Henr.	
A. latifolia Domin	Feathertop
A. leptopoda Benth.	White spear grass
A. ramosa R. Br.	
Arthrocnemum spp.	Samphire
Astrebla elymoides F. Muell. ex F. M. Bail.	Hoop or weeping Mitchell grass
A. lappacea (Lindl.) Domin	Curly Mitchell grass
A. pectinata (Lindl.) F. Muell. ex Benth.	Barley Mitchell grass
Atalaya hemiglauca (F. Muell.) F. Muell. ex Benth.	Whitewood
Atriplex nummularia Lindl.	Old-man saltbush
Bassia tetracuspis C. T. White	Brigalow burr or dog burr
B. echinopsila F. Muell.	Red burr
Bauhinia carronii F. Muell.	
B. hookeri F. Muell.	
Boerhavia diffusa L.	Tar-vine
Boronia obovata C. T. White	
B. rosmarinifolia A. Cunn.	
Bothriochloa decipiens (Hack.) C. E. Hubb.	Pitted blue grass
B. erianthoides (F. Muell.) C. E. Hubb.	Satin-top grass
B. ewartiana (Domin) C. E. Hubb.	Desert blue grass
B. intermedia (R. Br.) A. Camus	Forest blue grass
Brachychiton australe (Schott) C. T. White	Broad-leaved bottletree
B. populneum (Schott) R. Br.	Kurrajong
B. rupestre (Lindl.) K. Schum.	Narrow-leaved bottletree
Bursaria incana Lindl.	
Callistemon viminalis (Sol. ex Gaertn.) G. Don ex Loudon	Bottle-brush
Callitris columellaris F. Muell.	Cypress pine
Calotis cuneata (F. Muell. ex Benth.) G. L. Davis	
Capparis lasiantha R. Br. ex DC.	Nipan
Carissa ovata R. Br.	Currant-bush
Cassia brewsteri F. Muell.	Leichhardt bean
C. nemophila Vogel	
Casuarina cunninghamiana Miq.	River oak

C. cristata Miq.	Belah
C. luehmannii R. T. Bak.	Bull-oak
Centipeda minima (L.) A. Br. & Aschers.	
Cheilanthes sp.	Rock fern
Chloris acicularis Lindl.	Spider grass
C. divaricata R. Br.	
C. scariosa F. Muell.	
C. truncata R. Br.	
C. unispicea F. Muell.	
Chrysopogon fallax S. T. Blake	Ribbon grass
Citriobatus spinescens (F.Muell.) Druce	Wallaby apple
Cleistochloa subjuncea C. E. Hubb.	
Crotalaria dissitiflora Benth.	Rattlepod
Croton phebalioides F. Muell. ex Muell. Arg.	
Cymbopogon bombycinus (R. Br.) Domin	Citronella grass
C. refractus (R. Br.) A. Camus	Barbed-wire grass
Cyperus gracilis R. Br.	Slender sedge
C. retzii Nees	Downs nut-grass
Dampiera sp.	
Daucus glochidiatus (Labill.) Fisch., Mey., & Avé-Lall.	Native carrot
Denhamia obscura Meissn.	
Desmodium brachypodum A. Gray	
Dichanthium fecundum S. T. Blake	
D. sericeum (R. Br.) A. Camus	Queensland blue grass
Distichostemon sp.	
Dodonaea filifolia Hook.	Hop-bush
D. viscosa (L.) Jacq.	Hop-bush
Echinochloa colonum (L.) Link	Awnless barnyard grass
Ehretia membranifolia R. Br.	Peach bush
Enchylaena tomentosa R. Br.	Berry cotton-bush
Enneapogon flavescens (Lindl.) N. T. Burbidge	
E. pallidus (R. Br.) Beauv.	
E. polyphyllus (Domin) N. T. Burbidge	
Epaltes australis Less.	
Eragrostis megalosperma F. Muell. ex Benth.	
Eremocitrus glauca (Lindl.) Swingle	Lime-bush
Eremophila bignoniiflora F. Muell.	Creek wilga or gooramurra
E. mitchellii Benth.	False sandalwood, sandalwood, or budda
Eriachne mucronata R. Br.	
E. obtusa R. Br.	
Erythroxylum australe R. Br.	
Eucalyptus alba Reinw. ex Bl.	Poplar gum
E. brownii Maid. & Cambage	Reid river box
E. camaldulensis Dehn.	River red gum
E. cambageana Maid.	Blackbutt or Dawson gum
E. citriodora Hook.	Lemon-scented gum
E. cloeziana F. Muell.	
E. crebra F. Muell.	Narrow-leaved ironbark
E. dealbata A. Cunn. ex Schau.	Tumble-down gum
E. decorticans (F. M. Bail.) Maid.	
E. dichromophloia F. Muell.	Bloodwood
E. drepanophylla F. Muell. ex Benth.	Narrow-leaved ironbark
E. exserta F. Muell.	
E. intermedia R. T. Bak.	
E. melanophloia F. Muell.	Silver-leaved ironbark
E. microtheca F. Muell.	Coolibah
E. normantonensis Maid.	Normanton box
E. oleosa F. Muell. ex Miq. var. *glauca* Maid.	
E. orgadophila Maid. & Blakely	Mountain coolibah
E. papuana F. Muell.	Ghost or cabbage gum
E. peltata Benth.	Yellowjack
E. polycarpa F. Muell.	Grey bloodwood
E. populnea F. Muell.	Poplar box
E. setosa Schau.	Nut-wood
E. similis Maid.	Yellowjack
E. tenuipes Blakely & C. T. White	
E. tereticornis Sm.	Blue gum
E. terminalis F. Muell.	Bloodwood
E. tessellaris F. Muell.	Carbeen or Moreton Bay ash
E. thozetiana F. Muell. ex R. T. Bak.	Yapunyah
E. trachyphloia F. Muell.	Bloodwood
Eulalia fulva (R. Br.) Kuntze	Brown-top
Evolvulus alsinoides (L.) L.	
Fimbristylis sp.	
Flindersia dissosperma (F. Muell.) Domin	Leopard wood
Gastrolobium grandiflorum F. Muell.	Heart-leaf poison
Geijera parviflora Lindl.	Wilga
Glycine falcata Benth.	
Gomphrena celosioides	Gomphrena weed
Goodenia spp.	
Grevillea decora Domin	

G. parallela Knight	Narrow-leaf beefwood
G. striata R. Br.	Beefwood
Hakea leucoptera R. Br.	
Heterodendrum diversifolium F. Muell.	Scrub boonaree or holly bush
H. oleifolium Desf.	Boonaree
Heteropogon contortus (L.) R. & S. ex Beauv.	Black or bunch spear grass
Hibiscus sturtii Hook.	
Hovea longifolia R. Br.	
H. longipes Benth.	
Iseilema spp.	Flinders grasses
Jacksonia ramosissima Benth.	
Juncus spp.	Rushes
Justicia procumbens L.	
Keraudrinia corollata (Steetz) Domin	
Leptochloa sp.	
Lomandra leucocephala (R. Br.) Ewart	Iron grass
Lysicarpus angustifolius (Hook.) Druce	
Macropteranthes leichhardtii F. Muell.	Bonewood
Macrozamia moorei F. Muell.	Zamia
Malvastrum spicatum A. Gray	Malvastrum
Marsilea spp.	Nardoo
Maytenus cunninghamii (F. Muell.) Loes.	
Melaleuca argentea W. V. Fitzg.	
M. bracteata F. Muell.	River or white tea-tree
M. linariifolia Sm.	
M. nervosa (Lindl.) Cheel	
M. tamariscina Hook.	
M. uncinata R. Br.	
Micromyrtus sp.	
Mitrasacme spp.	
Murraya ovatifoliolata (Engl.) Domin	
Myoporum deserti A. Cunn. ex Benth.	Ellangowan poison-bush
Neptunia gracilis Benth.	
Neurachne mitchelliana Nees	Mulga grass
Notoxylinon australe (Benth.) Lewton	
Olearia sp.	
Ophiuros exaltatus (L.) Kuntze	Cane grass
Panicum decompositum R. Br.	Barley grass
P. queenslandicum Domin	Yabila grass
Paspalidium caespitosum C. E. Hubb.	Brigalow grass
P. constrictum (Domin) C. E. Hubb.	Belah grass
P. globoideum (Domin) Hughes	Shot grass
P. jubiflorum (Trin.) Hughes	Warrego summer grass
Persoonia falcata R. Br.	
Petalostigma banksii Britten & S. Moore	
P. pubescens Domin	Quinine bush
Phebalium sp.	
Polycarpaea spp.	
Polymeria longifolia Lindl.	
Portulaca filifolia F. Muell.	
P. oleracea L.	Pigweed
Rhagodia parabolica R. Br.	
Rhynchelytrum repens (Willd.) C. E. Hubb.	Red Natal grass
Rhynchosia minima (L.) DC.	
Ricinocarpos ledifolius F. Muell.	
R. pinifolius Desf.	Wedding bush
Schizachyrium obliqueberbe (Hack.) A. Camus	
Scleria novae-hollandiae Boeck.	
Sesbania sp.	Sesbania pea
Sida spp.	
Sporobolus caroli Mez	Fairy grass
S. elongatus R. Br.	Rat's-tail grass
S. scabridus S. T. Blake	Fairy grass
S. virginicus (L.) Kunth	Salt-water couch
Terminalia oblongata F. Muell.	Yellowwood
Thellungia advena Stapf	Coolibah grass
Themeda australis (R. Br.) Stapf	Kangaroo grass
Trianthema triquetra Rottler ex Willd.	
Tribulus terrestris L.	Caltrop
Trichodesma zeylanicum (Burm. f.) R. Br.	
Triodia mitchellii Benth.	Spinifex
T. pungens R. Br.	Spinifex
Tripogon loliiformis (F. Muell.) C. E. Hubb.	Minute grass
Ventilago viminalis Hook.	Vine-tree or supplejack
Waltheria indica L.	
Xanthorrhoea sp.	Grass-tree
Zornia spp.	