Lands of the Mitchell–Normanby Area, Queensland

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and R. Story

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PART I. INTRODUCTION AND SUMMARY DESCRIPTION OF THE MITCHELL–NORMANBY AREA

By R. W. Galloway*

I. Introduction

(a) *Location and Extent*

The Mitchell–Normanby area described in this report occupies the lower two-thirds of the Cape York Peninsula and lies between the fourteenth and eighteenth parallels of south latitude. It covers approximately 55,000 sq miles and has maximum length and width of about 290 miles. The western boundary is defined by the coast of the Gulf of Carpentaria and the eastern boundary is partly the Pacific coast and partly the Great Divide between west-flowing and east-flowing drainage. On the south-west it abuts on the Leichhardt–Gilbert area surveyed in 1953–54 (Perry *et al.* 1964).

(b) *Settlement and Communications*

The total population is about 8000, of whom rather more than half are of European origin and the remainder mainly Aborigines, with some Thursday Islanders. The largest settlement is Cooktown (population 430) on the east coast. Mareeba (population *c.* 5000) lies just outside the south-east corner of the area and Coen (population 75) lies just to the north. There are, in addition, a number of small mining settlements, mostly in a state of decay, such as Chillagoe and Almaden. The rest of the population is on cattle stations or on Aboriginal reserves on the east and west coasts. The main occupation is raising beef cattle on very large cattle stations and in the south and east there is a little mining for a variety of metals. Tourism is a minor but increasing resource.

The main access route is the Mulligan Highway from Mareeba to Cooktown and the Peninsular Developmental road which runs north-west from a point on the Mulligan Highway 30 miles from Cooktown (Fig. 1). From Mareeba another road runs west and north-west almost to the Gulf coast, then swings south to Normanton. From these main routes a sparse network of medium- to poor-quality roads and station tracks penetrates the rest of the area. Most of the roads are impassable at times in the wet season.

A useful introductory account of the history of settlement and the major types of country in the Cape York Peninsula is given by Whitehouse (1947).

(c) *Origin and Method of Survey*

Since this sparsely settled area is little known in detail, rational development will require greater knowledge of the nature of the country. To meet part of this need, the present survey was undertaken at the request of the Queensland Department of

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Primary Industries as a rapid reconnaissance designed to give an outline of the major types of land. As a first step, characteristic photo patterns were identified and delineated on air photographs at scales of 1 : 50,000 and 1 : 85,000. Then the nature of the land forms, soils, and vegetation of these patterns was investigated during three weeks' field work carried out by helicopter in August 1966. Finally,

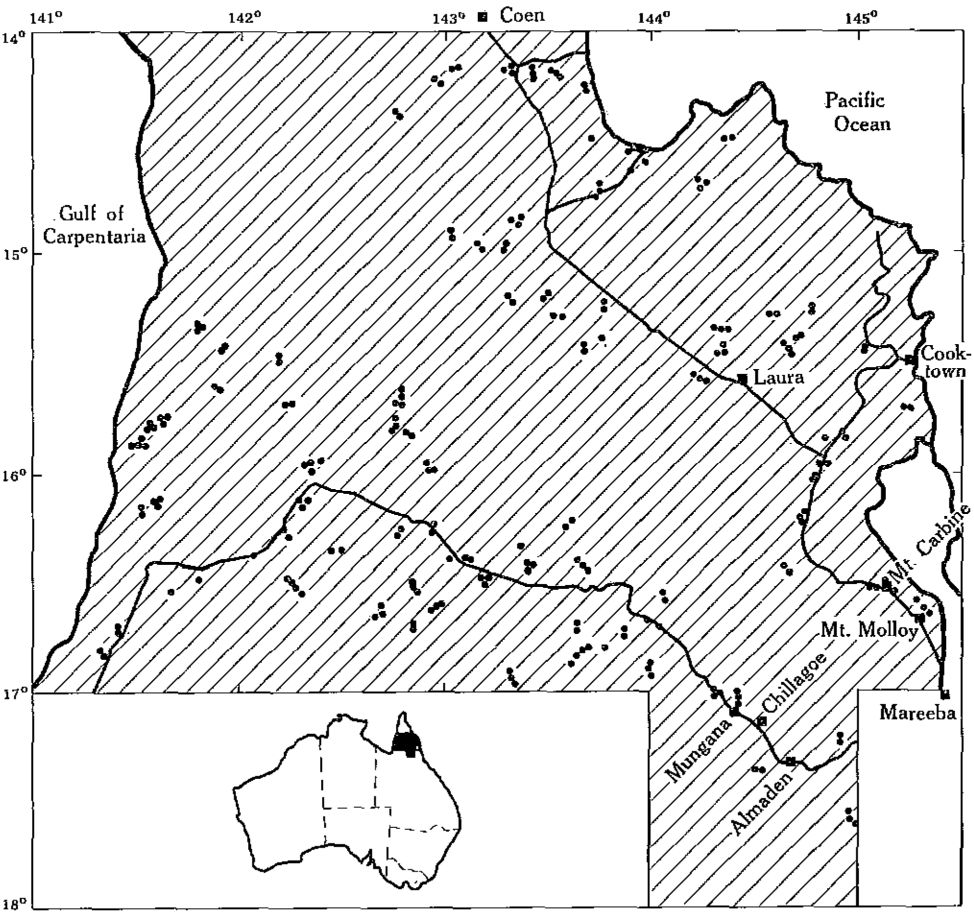

Fig. 1.—Main roads, settlements, and sampling sites.

the photo interpretation and field work were collated and 20 types of country or land systems were identified. These are described in Part II and their distribution is shown on the accompanying map at a scale of 1 : 1,000,000.

During the survey, observations were made at 220 localities (Fig. 1); as this is an average of only 1 observation per 250 sq miles, the survey information cannot be detailed and the maps are highly generalized. The density of observations ranges from 1 per 850 sq miles in mountainous areas to 1 per 35 sq miles on lowlands with cracking clay soils.

II. General Description

(*a*) *Relief*

The relief of the Mitchell–Normanby area can be described in terms of six physical regions; their distribution is shown in Figure 2.

(i) *Eastern Highlands.*—Broken relief, ranging from sea level to 4400 ft, occupies the eastern 20% of the area from Cape Melville southwards. It is the most varied

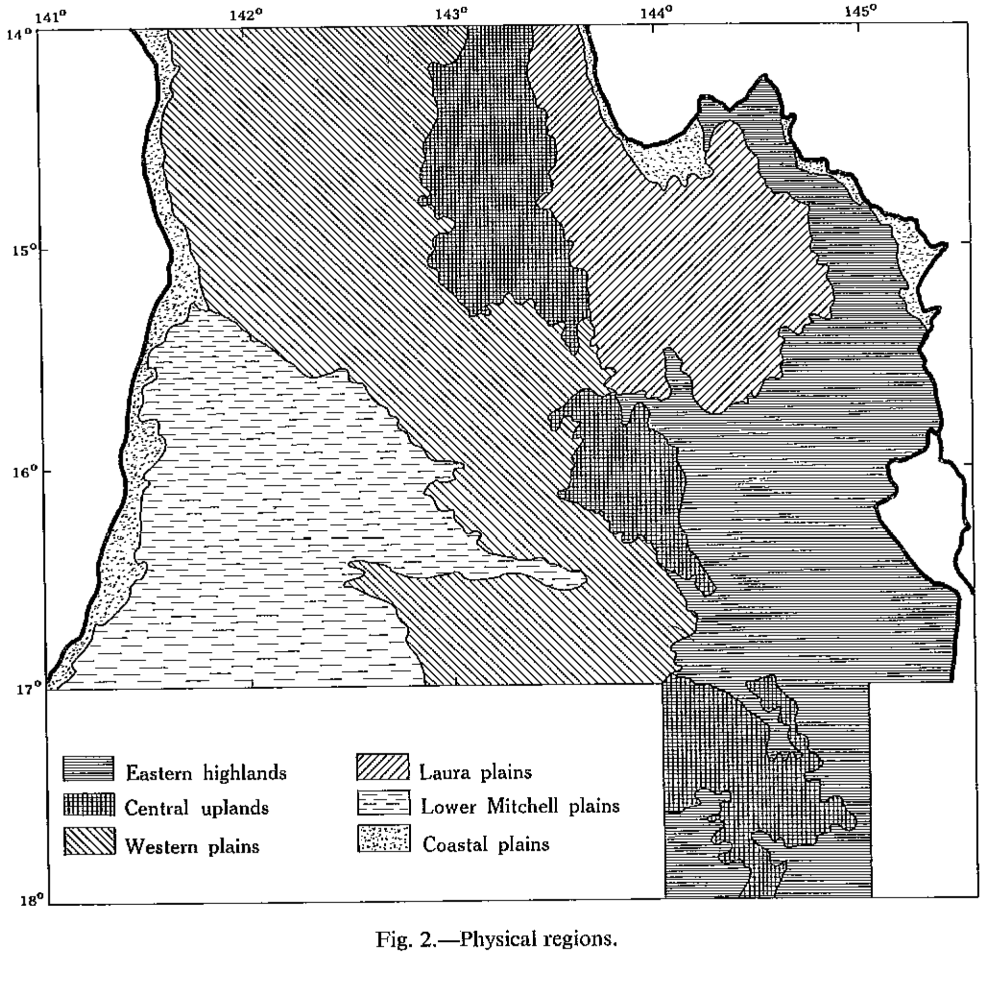

Fig. 2.—Physical regions.

region in terms of geology and relief. In the north there is a deeply dissected sandstone plateau; in the south the relief is mainly hills and mountains on folded sediments but includes extremely rocky mountainous areas on granite and volcanic rocks. The eastern limit of this physical region follows the Great Divide in the south and the coast in the centre and north. The coastal section includes rugged headlands and cliffs on hard rocks, extensive dune fields, and restricted plains on young coastal sediments.

(ii) *Central Uplands.*—This region, comprising 12% of the area, consists of undulating country on weathered and fresh metamorphic and granitic rocks as well as slightly more accidented country on folded greywackes and other sediments. Patches of sand and gravel occur locally, while tors are a feature of some of the granite areas.

(iii) *Western Plains.*—This region forms 31% of the total area. It lies mostly between 200 and 500 ft above sea level but rises locally to over 1000 ft on the Great Divide. It consists mostly of sandy or loamy plains on weathered terrestrial sediments laid down in Tertiary times, slightly dissected in most areas by shallow valleys, and often pitted by shallow closed depressions. In the southern part occurrences of shaly rocks give rise to gently undulating areas with deep clay soils.

(iv) *Laura Plains.*—This region, mostly below 300 ft and occupying 13% of the area, coincides with a structural basin floored by sedimentary rocks. It consists of low tablelands and plains and resembles the western plains described in the previous paragraph. The surface is generally sandy or loamy except where shale and claystone are locally exposed and give rise to heavier-textured soils.

(v) *Lower Mitchell Plains.*—These occupy about 20% of the area and all lie below 250 ft. They consist of Late Tertiary to Recent alluvial sands, silts, and clays with a relief of channels, levees, back plains, and back swamps on the younger parts.

(vi) *Coastal Plains.*—These form a continuous fringe between 2 and 15 miles wide along the west coast, are extensive round Princess Charlotte Bay in the north-east, and occur locally in embayments of the east coast. They comprise 4% of the Mitchell–Normanby area. The plains are developed on young marine and fluvial clays and on low sand ridges a few feet high that run for long distances more or less parallel to the coast.

(*b*) *Drainage*

The Great Divide separates the area draining east or north to the Pacific from the much more extensive area that drains west to the Gulf of Carpentaria (Fig. 3). East of the Great Divide the major river is the Normanby which flows north to Princess Charlotte Bay. Several shorter streams, of which the largest are the Endeavour River and Annan River near Cooktown, flow directly to the east coast. West of the Great Divide the main drainage artery is the Mitchell which, with its tributaries the Alice, Palmer, Walsh, and Lynd, drains nearly half the area. Other rivers west of the Great Divide that flow directly to the Gulf of Carpentaria include the Staaten and the Coleman.

All the rivers have a marked seasonal regime. High water with extensive flooding occurs during the rainy season (November–April), while towards the end of the dry season even the largest rivers cease flowing except where deep sands provide a continuous supply of ground water (Hann River) and in the narrow belt of high rainfall in the south-east. Permanent water-holes, however, are a common feature along the major streams.

By Australian standards the area has a large run-off. The Mitchell probably carries 8,000,000 ac ft per annum to the sea, a volume equivalent to that of the

Murray where it joins the Murrumbidgee, and the Normanby system carries 6,000,000 ac ft.

(*c*) *Geology*

Precambrian metamorphic rocks and related granites crop out in a meridional belt which runs through the centre of the area (see geology map) and broadly corresponds to the central uplands physical region. Extensive areas of these rocks are covered

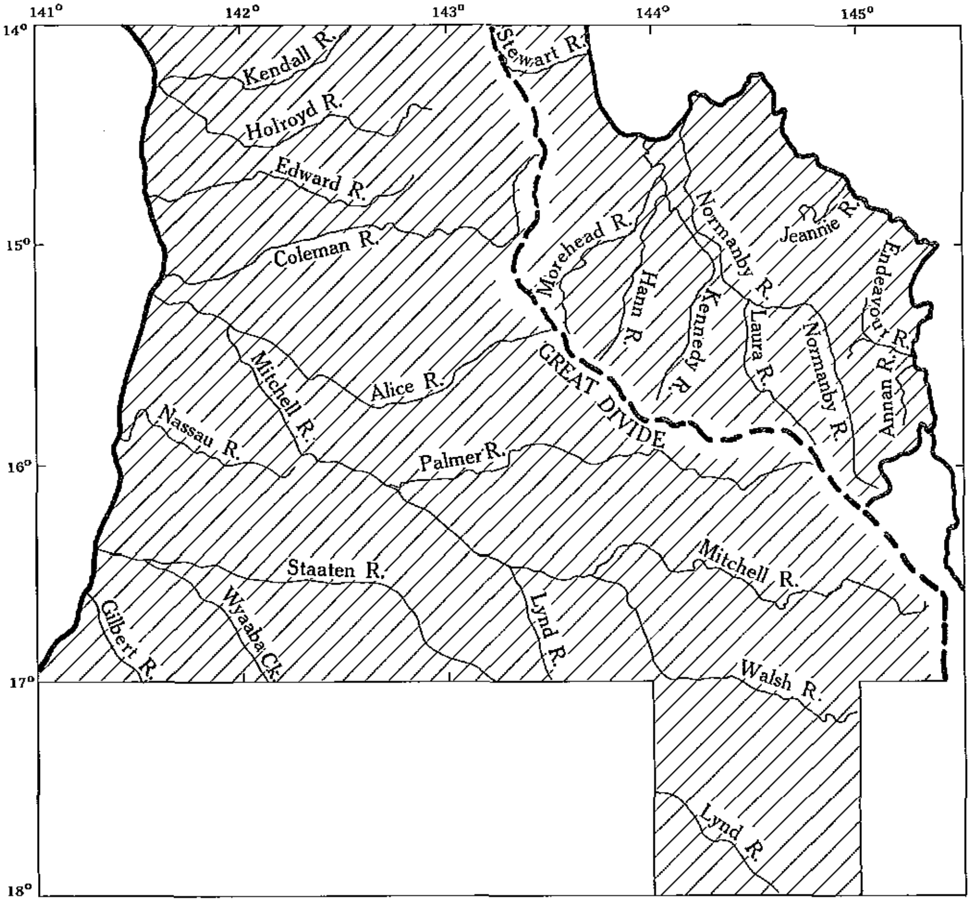

Fig. 3.—Drainage.

by a thin cover of Tertiary residual sand and gravel and deep weathering has affected the rocks in places.

Palaeozoic greywackes and other sediments occupy an extensive area in the south-east and east. These rocks have been extensively deformed and locally metamorphosed and are interspersed with granite intrusions. They give rise to generally steep broken country forming part of the eastern highlands physical region. On the western margin is a north–south belt 5–8 miles wide and 90 miles long of rather older folded sediments including chert, greywacke, and reef limestone.

In the south, in the upper basins of the Tate, Walsh, and Lynd Rivers, Palaeozoic granite and volcanics (mainly resistant welded tuffs) crop out. The granites have been deeply weathered in places but the volcanic rocks have scarcely been affected. These rocks underlie the southern parts of the eastern highlands physical region.

During the Mesozoic, widespread marine transgression(s) laid down sediments that are now extensively preserved on the western half of the area, in the Laura basin south of Princess Charlotte Bay, and sporadically elsewhere. The Jurassic, Triassic, and Lower Cretaceous sediments were mainly resistant quartz sandstone from several score to several hundred feet thick. This sandstone survives west and north-west of Cooktown and forms part of the eastern highlands physical region. Moderately resistant Lower Cretaceous sandstone also forms low plateaux on the western margin of the Precambrian belt. Unresistant Cretaceous shale, siltstone, and claystone, in part calcareous and often deeply weathered, underlie much of the western plains physical region where they are largely covered by younger terrestrial deposits. Similar sediments also occur on the Laura plains south of Princess Charlotte Bay.

Small areas of Cainozoic basalt occur in the extreme south-east, in the east, and near Cooktown.

Cainozoic terrestrial sediments cover more than half the area. They include sand, silt, clay, sandstone, sandy claystone, and conglomerate. The sandstone and claystone are the most widespread and are intimately associated with laterite and deep weathering; they extend over most of the western plains and Laura plains physical regions. The sand, silt, and clay were laid down as extensive deltas and flood-plains at various times by the main rivers, and they form the lower Mitchell physical region. Marine and estuarine clays and sands occur continuously along the west coast, round Princess Charlotte Bay, and sporadically along the east coast. Wind-blown sands occur mainly on the east coast, particularly in the Cape Bedford–Cape Flattery area.

(*d*) *Climate*

The area has a subhumid to humid tropical climate with marked wet and dry seasons. Practically all the rain falls in the months from November to April inclusive. Most of the area receives between 35 and 50 in. per year but much higher rainfall, exceeding 100 in., falls on the rugged coastal ranges in the east and north-east. Temperatures are fairly high throughout the year; the mean ranges from about 70–75°F in June and July to 80–85°F in December and January. Humidity is higher in the wet season and near the coasts. Annual pan evaporation is probably 60–80 in.

(*e*) *Soils*

Eight major groups of soils have been recognized. Alluvial soils on recent alluvium are immature and range in texture from medium sands through silty clays to clays. Cracking clay soils, mostly of considerable depth, occur on fine-textured alluvial or coastal sediments and on shales; they are either acid or alkaline at the surface and generally alkaline at depth. Texture-contrast soils have formed mainly on alluvial and colluvial deposits and vary widely in depth and structure of the horizons and in pH. Massive earths are the most widespread soil group; they have gradational profiles in which the clay content increases with depth, and include red and yellow earths and leached grey and brown earths. Structured red and brown soils occur on old alluvial plains and on weathered older rocks; loams or clay loams at the surface grade into clays at depth. Uniform medium- to fine-textured loams or clays with moderately acid reaction occur sporadically on a wide range of parent materials. Uniform coarse-textured soils of acid reaction are widespread on deeply weathered terrestrial deposits and associated colluvium. Shallow rocky soils predominate on hills and mountains.

(*f*) *Vegetation*

Two major botanic types exist in the Mitchell–Normanby area. On the wet, eastern coastal mountains are scattered occurrences of vine forest. These were not examined during the survey. Elsewhere the survey area is under eucalypt and paperbark woodland. Fifteen subdivisions have been recognized within these woodlands; the generalized distribution of eight categories of vegetation based on these subdivisions is shown on the vegetation map.

The eucalypts are mainly stringybark and bloodwood on level well-drained country, ironbark on rugged country, box on lowlands, usually with soils of heavy texture, gums in better-watered valleys in the east, and mixtures of these species. The eucalypt woodlands in places open out to form a parkland often in association with deciduous scrubs; on the other hand denser communities occur in places and include many shrubs.

The paperbark woodlands are likewise very varied in species composition and range from open parkland to fairly dense scrubs.

The grasses are mostly bunch types and are dormant during the dry season.

Limited areas of salt-marsh vegetation and mangrove scrub occur at the coast.

(*g*) *Land Use*

The area is, and will be for the foreseeable future, mainly devoted to raising beef cattle on native pastures on very large properties. Little development has been carried out and stocking rates are very low. Most of the more rugged area in the eastern third is unused but some forestry is carried on in wetter areas. Despite the extreme seasonality of the climate (Plate 5, Fig. 2) and consequent great variability of pasture quality during the course of the year, there seems to be scope for some pasture improvement and rather more intensive grazing. On the limited areas of cracking clay and structured red soils there are possibilities for fodder crop production under dry-land conditions. Other soil types suffer in part from stoniness, risk of flooding, unfavourable structure, poor water-retaining properties, and infertility. Forestry offers a possibility for development in some parts of the area.

III. Acknowledgments

The cooperation of the following individuals and organizations is acknowledged. Mr. R. F. Isbell, Division of Soils, CSIRO, provided much additional soils information from his own work in the area. The section on vine forest was written by Dr. L. J. Webb and Mr. J. G. Tracey, both of the Division of Plant Industry, CSIRO. Mr. A. Brunt, of the Commonwealth Bureau of Meteorology, Brisbane, supplied climatic data. Officers of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics furnished much published and unpublished geological information. The Queensland Government Botanist and staff, Brisbane, identified the plant specimens and checked the vegetation chapter.

Plates 6–16 are Crown copyright and have been made available by courtesy of the Director of National Mapping, Department of National Development, Canberra.

IV. References

Perry, R. A., Sleeman, J. R., Twidale, C. R., Prichard, C. E., Slatyer, R. O., Lazarides, M., and Collins, F. H. (1964).—General report on lands of the Leichhardt–Gilbert area, Queensland, 1953–54. CSIRO Aust. Land Res. Ser. No. 11.

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PART II. LAND SYSTEMS OF THE MITCHELL–NORMANBY AREA

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

I. Introduction

The Mitchell–Normanby area has been divided into 20 land systems, each of which consists of tracts of country with similar air-photo patterns and generally with similar relief, rocks, soils, vegetation, and landscape history. They are discussed in the following tabular descriptions and their distribution is shown on the coloured 1 : 1,000,000 map. They are arranged according to relief and, broadly speaking, age of the underlying rocks. From rugged country on old hard rocks the sequence of land systems passes through gently undulating terrain on Mesozoic sediments to plains on Tertiary and Quaternary alluvium.

Each land system is illustrated by a block diagram and by a vertical air photograph (Plates 6–16). The photographs and most of the diagrams are at a scale of about 1 : 50,000 (twenty times greater than that of the land system map). The line on the photographs approximately indicates the area shown by the block diagram. It is hoped that the vertical air photographs will enable users to correlate land system descriptions with the appropriate patterns on mosaics or other air photographs of the area. The vertical exaggeration of the block diagrams is $\times 10$ for plains and $\times 2\frac{1}{2}$ for all other areas. The land systems have been named after 1 in. to the mile photo mosaics on which they are extensively developed.

Each land system is in turn divided into land units which are smaller more homogeneous areas that recur repeatedly. The units are too small to be mapped individually but their distribution within the land system is indicated in the following tabular descriptions; typical examples are indicated by numbers on the vertical air photographs and their spatial relationships and association with geology are indicated on the block diagrams. As a general rule, the units within each land system are arranged in topographical sequence from the highest to the lowest. The units are briefly described in tabular form. Dominant soil families and vegetation communities in each land system are listed, and further details can be found under these headings in the soils and vegetation parts of the report.

In view of the brief time spent in the field, the mapping and descriptions of the land systems and land units are highly generalized. More detailed work would undoubtedly lead to further subdivision and fuller descriptions. In a fuller survey, for instance, the mountainous Starcke land system would be split into three separate land systems corresponding to each of the three units recognized here, and doubtless several land units would be defined in each of these three new land systems.

The number of observations made in each unit is listed in the tabulated land system. This figure gives some idea of the degree of generalization.

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II. Major Types of Country

Because the nature of the area is broadly related to the underlying rocks, the land systems have been arranged into major types of country according to dominant geology and relief. This arrangement is also followed in the reference of the land system map, in the tabular description of the land systems, and in the plates.

(a) *Mountains and Hills on Resistant Volcanics, Granite, and Sediments*

This rugged country forms most of the eastern highlands physical region and small parts of the central uplands. Starcke land system consists of rugged mountains, hills, and deeply dissected plateaux carrying ironbark or mixed eucalypt woodland and some box; shallow stony soils with much outcrop and rapid run-off are characteristic. It is divided into three geographically separate units according to geology. Unit 1 is rounded massive hills on granite and volcanics; unit 2 is formed by deeply dissected plateaux of quartz sandstone (Plate 1, Fig. 1); unit 3 comprises very broken country on folded greywackes and other sediments. Limited areas near the east coast receive higher rainfall and form the rugged vine forest country of Rumula land system (Plate 1, Fig. 2). Maytown land system is made up of lower hills forming broken country with short steep slopes (Plate 2, Fig. 1).

(b) *Undulating Country on Fairly Resistant Metamorphics, Granite, Sediments, and Basalt*

Hodgkinson land system on greywackes and other sediments and Arkara land system on metamorphics (Plate 2, Fig. 2) generally carry ironbark or bloodwood–stringybark woodland. They form the greater part of the central physical region on shallow or gravelly soils. The relief for the most part is gently rolling with small hills and steeper ridges on particularly resistant beds.

Lukin land system on basalt consists of plains and low stony plateaux with structured red soils supporting open bloodwood and box savannah.

(c) *Plains and Lowlands on Unresistant Shale, Claystone, and Siltstone*

Maple land system (Plate 3, Fig. 1) consists almost entirely of lowlands and plains with clay soils carrying deciduous scrub or grassland; small areas have a sandy detrital cover with yellow earths and bloodwood–stringybark woodland. In Brixton and Annaly land systems the proportion of bloodwood–stringybark woodland on earth soils is much higher.

(d) *Plains and Lowlands on Weathered Terrestrial Sediments*

This is the most extensive major type of country making up much of the western plains and Laura plains physical regions. Koolburra land system occurs in level to gently undulating divides and has sandy earths overlying deep weathered profiles and supports bloodwood–stringybark woodland (Plate 3, Fig. 2). Slight dissection and stripping have given rise to the very extensive Balurga land system in which shallow valleys with paperbark woodland on the slopes and grassy floors are separated by broad interfluves with sandy red earths and bloodwood–stringybark woodland. Further stripping has given rise to part of the Mottle land system comprising paperbark plains and patches of eucalypt woodland (Plate 4, Fig. 1).

(e) *Plains on Older Alluvium and Colluvium*

Extensive plains were built up by the Mitchell and Normanby river systems in Plio–Pleistocene times. The older parts form the Leinster land system (Plate 4, Fig. 2) and are dominated by paperbark woodland and massive leached earth soils. The somewhat younger Dunbar land system has a well-preserved system of old levees and channels crossing plains with paperbark woodland. Ninda land system occurs on alluvial and colluvial fans of varying age carrying varied eucalypt and paperbark woodlands and scrub.

(f) *Plains on Younger Alluvium*

These plains have been built up in geologically recent times by the main rivers of the area. Alluviation is still active in parts and much of the area is regularly flooded. An intricate microrelief of levees, back plains, and channels is characteristic. Radnor land system is on slightly earlier alluvium, lies slightly higher, and has more mature soils than Cumbulla land system. Levees carry eucalypt woodland or, locally, gallery forest while back plains support open savannah or grassland.

(g) *Plains and Dunes on Young Coastal Sediments*

Clay plains, low sand ridges, and dunes fringe the west coast and much of the east coast. Inkerman land system (Plate 5, Fig. 1) is dominantly poorly drained plains with saline or alkaline clay soils above tide level. Battersea land system is rather lower and includes extensive areas of tidal mud flat with salt-marsh vegetation or bare areas.

Flattery land system consists of complex dune fields on the north-east coast. Most of the dunes have long since been stabilized and carry eucalypt woodland or scrub.

III. Correlation with the Leichhardt–Gilbert Survey

The adjoining Leichhardt–Gilbert area was surveyed in 1953–54 (Perry *et al.* 1964).* While some land systems and their boundaries are continuous across the border between the two survey areas, in other cases there is a discontinuity.

There are two main reasons for these apparent discrepancies.

Firstly, the two areas are indeed different; in particular, the rainfall is considerably higher in the Mitchell–Normanby area than over most of the Leichhardt–Gilbert area. Consequently, the representative vegetation and soils of land systems in comparable situations in the two survey areas can be very different even though they tend to merge near the boundary. Changes in the relative importance of units over such extensive areas can lead to differing groupings of similar land units being recognized in the two survey areas.

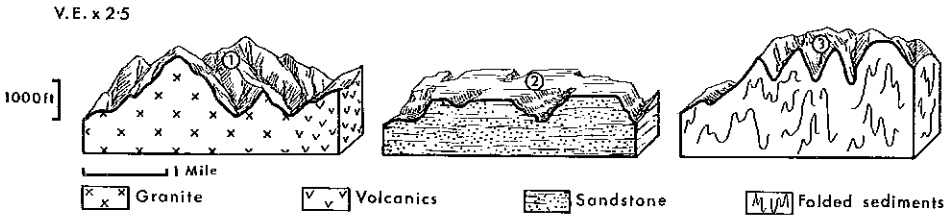
Secondly, field work by surface transport occupied 6 months in the Leichhardt–Gilbert area compared to 3 weeks by helicopter in the Mitchell–Normanby survey. Consequently, the emphasis in field observations and the degree of detail varied considerably between the two areas.

* Perry, R. A., Sleeman, J. R., Twidale, C. R., Prichard, C. E., Slatyer, R. O., Lazarides, M., and Collins, F. H. (1964).—General report on lands of the Leichhardt–Gilbert area, Queensland, 1953–54. CSIRO Aust. Land Res. Ser. No. 11.

In view of these difficulties, the Mitchell–Normanby survey was essentially carried out with no direct reference to the Leichhardt–Gilbert area and it was decided not to use the same name even for a land system that was similar in the two areas. Such similar land systems are indicated in the land system tabular descriptions in the present report.

(1) Starcke Land System* (6560 sq miles)

Mountains on volcanics, granite, greywackes, and other sediments; deeply dissected plateaux on quartz sandstone; shallow rocky soils; ironbark or mixed eucalypt woodland.

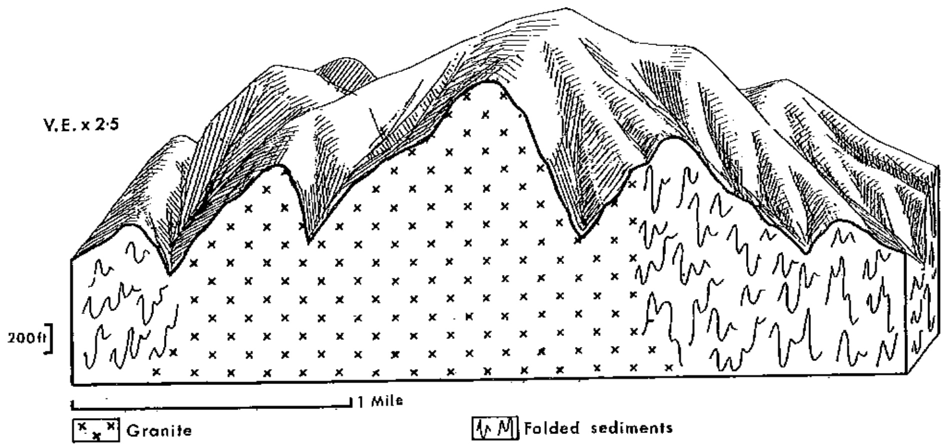


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 2 obs.	40% Mainly in south	Mountains on granite and volcanics; 2000–4000 ft above sea level; extremely rocky with extensive outcrops; narrow valleys with little or no alluvium	Mainly rocky land and shallow rocky soils, Mungana; small areas of shallow sandy soils, Cardwell (Uc4.2), with abundant gravel	Outcrop with some deciduous scrub (*Petalostigma* present), elsewhere ironbark woodland (*E. shirleyi*, *E. cullenii*, *E. brevifolia*, *Callitris*, shrubs, *Xanthorrhoea*, in east with *E. alba*) over *Themeda australis*, *Schizachyrium*, some spinifex
2 4 obs.	35% Mainly in north	Dissected sandstone plateaux; local relief 200–1500 ft; restricted summit surfaces locally with ironstone gravel caps; rocky benches and cliffs on upper slopes; very restricted sandy alluvial foot slopes in narrow valleys	Mainly outcrop and shallow rocky soils; shallow gravelly red and yellow earths, Brooklyn (Gn2.11, 2.24), on summit surfaces; shallow uniform sandy soils, Cardwell (Uc2.21), on foot slopes	Mixed eucalypt woodland, evergreen mixed scrub, or paperbark woodland; shrubs common, short or mid-height grass; some lancewood scrub
3 2 obs.	25% Mainly in centre	Dissected mountains on folded sediments and metamorphics; local relief 300–2000 ft; restricted colluvial foot slopes, stony in upper part, subject to gullying and sheet erosion	Mainly shallow rocky soils, Emu (Um4.1), with stony surface strew and minor outcrops; minor areas of texture-contrast soils, Stewart (Db2.43), on foot slopes	Ironbark woodland (*E. cullenii*); foot slopes, box woodland with *M. viridiflora*, *E. cullenii*, and bloodwood; both over *Themeda australis* and both with some *E. alba* in the east

* Similar to Wairuna, Ortona, Torwood, and Leichhardt land systems of the Leichhardt–Gilbert area.

(2) Rumula Land System (320 sq miles)

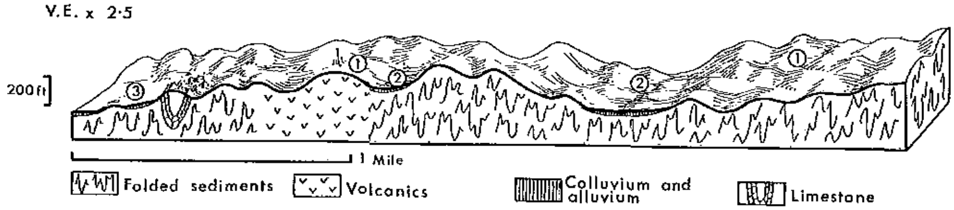
Mountains on granite, greywackes, and other sediments; uniform fine-textured soils and structured red loams; vine forest.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 1 obs.	Throughout	Steep rugged mountains on granite and folded sediments	Structured red acid loams to clays, Springvale (Gn3.14, 3.11), and uniform acid red and brown loams and clays, Frazer (Um4.2, Uf4.2); outcrops and shallow rocky soils extensive in places	Vine forest

(3) Maytown Land System (3560 sq miles)

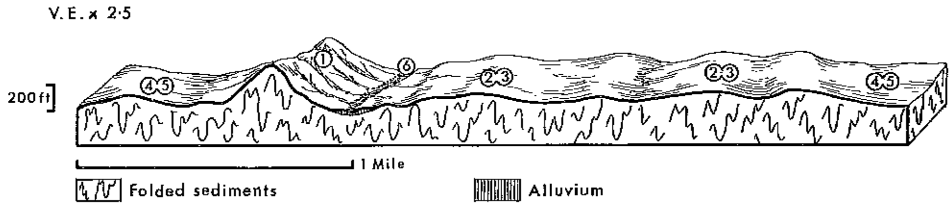
Closely dissected low hills on volcanics, greywackes, and other sediments; shallow gravelly uniform medium- to fine-textured soils; *ironbark woodland, some box woodland.*



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 4 obs.	75% Throughout	Closely dissected hills; local relief 100–500 ft; slopes mostly 15–60% and 100–500 yd long; much outcrop; active gullying and stream erosion	Shallow gravelly uniform medium- to fine-textured soils. Maitland (Um2.12, Uf4.2, 1.41), very stony at surface (2–3 in. diam.)	Ironbark woodland (*E. cullenii*), shrubs common near outcrop; some box woodland usually on gentle slopes, with bloodwood, *Petalostigma banksii*, and ground cover of *Themeda australis* and *Aristida;* some gum woodland in east
2 1 obs.	20% Throughout	Colluvial foot slopes; 10–100 yd long; stony upper parts with slopes 10–20%; sandy and loamy lower parts with slopes 1–15%; few outcrops; gullying and sheet erosion common	Texture-contrast soils, Gamboola (Dy3.41) and Stewart (Db2.43); minor shallow rocky soils, Mungana (Uc4.11)	Box woodland as in unit 1; patches of paperbark woodland (*M. viridiflora*) with similar ground cover, some gum woodland in east
3 2 obs.	5% Chillagoe area	Broader foot slopes; partly colluvial from limestone, partly erosional with sporadic outcrop	Structured red and brown soils, Springvale (Gn3.15) and Wyaaba (Gn3.25)	Ironbark woodland (*E. cullenii*), or paperbark woodland (*M. viridiflora*) with an admixture of deciduous scrub (no *Petalostigma*) and ground cover of short grass

(4) Hodgkinson Land System (930 sq miles)

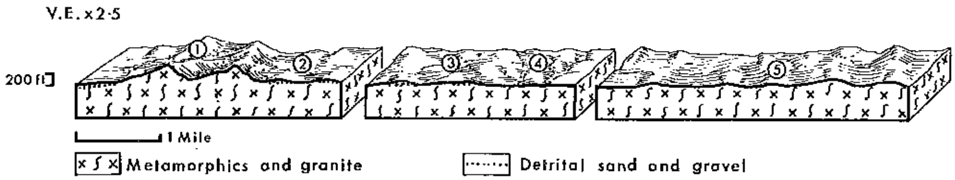
Undulating to hilly country on greywacke and other sediments; shallow gravelly soils; ironbark woodland.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 1 obs.	10% Sporadic	Closely dissected hills and strike ridges; local relief 100–500 ft; slopes mostly 15–60%; much outcrop; active gullying and stream erosion	Shallow gravelly fine-textured soils, Maitland (Uf1.41, 4.2)	Ironbark woodland as in unit 1 of Maytown land system
2 2 obs.	45% Throughout	Crests and upper slopes; 50–250 yd long; local relief 40–100 ft; slopes mainly 3–10%; stony in places	Shallow gravelly uniform medium-textured soils, Maitland (Um4.1); moderately acid with 10–50% gravel to 1 in. diam.	Ironbark woodland (*E. cullenii*) with paperbark, scattered box, and elements of deciduous scrub (*Petalostigma* present); ground cover *Themeda australis*, *Heteropogon contortus*, *Schizachyrium*
3 2 obs.	<5% In south-east	As for unit 1	Shallow gravelly massive earths, Brooklyn (Gn2.14), and shallow (24 in.) structured red soils, Springvale (Gn3.14)	Mixed eucalypt woodland (bloodwood, *E. cullenii*, *M. viridiflora*, *Casuarina torulosa*, *Acacia flavescens* over *Themeda australis*, *Heteropogon contortus*, *Aristida*)
4 6 obs.	35% Throughout	Lower slopes; 50–250 yd long; local relief 10–50 ft; slopes 0–5%; rarely stony but some gullying and sheet erosion; includes colluvial aprons below limestone ridges near Chillagoe	Shallow to moderately deep massive earths, mainly with abundant gravel, Brooklyn (Gn2.42, 2.84) and Kalinga (Gn2.24); minor uniform grey sands, Bathurst (Uc2.2), and, below limestone ridges, gilgaied strongly alkaline cracking clay soils, Gilbert (Ug5.34)	Deciduous scrub (with or without *Petalostigma*), sometimes open, with scattered box; some mixed eucalypt woodland (*E. alba*, bloodwood, box, *E. cullenii*, *E. shirleyi*, *M. acacioides*, *M. viridiflora*, *Erythrophleum* over *Themeda australis*, *Heteropogon contortus*, *Chrysopogon fallax*, *Schizachyrium*)
5 1 obs.	<5% Throughout	As for unit 3, but no limestone influence	Leached grey massive earths, Staaten (Gn2.82)	Ironbark woodland (*E. shirleyi*) but very variable
6 1 obs.	<5% Throughout	Narrow alluvial flats and terraces; possibly subject to flooding	Gradational structured acid to neutral brown loams, Wyaaba (Gn3.25, 3.54); probably also texture-contrast soils	In east, gum woodland; in west, ironbark woodland as for unit 5

(5) ARKARA LAND SYSTEM* (5670 SQ MILES)

Undulating country and low stony hills on metamorphics and granite; massive earths and uniform sandy soils; bloodwood–stringybark or ironbark woodland.

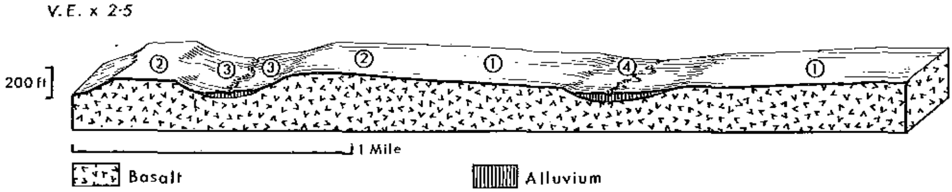


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 1 obs.	15% In north	Hills and strike ridges; local relief 100–500 ft; stony with much outcrop	Mainly shallow uniform sandy soils with abundant rounded gravel (up to 3 in. diam.), Cardwell (Uc2.21); minor sandy yellow earths, Clark (Gn2.74, 2.24), and texture-contrast soils, Gamboola (Dr2.61)	Mixed eucalypt woodland (bloodwood, *E. tetrodonta*, *E. cullenii*, *Erythrophleum*, palms, *Hakea*, *Grevillea*) with fairly dense evergreen shrubs and mainly tall grass (*Heteropogon triticeus*, *H. contortus*, *Coëlorachis*, *Aristida*)
2 1 obs.	20% In north	Undulating country probably with deep sand on slopes and interfluves and shallow open valleys	Deep uniform sandy soils, Healy, Bridge, and Bathurst (Uc2.21, 4.2); extensive sandy yellow earths, Clark (Gn2.74); minor texture-contrast soils, Gamboola (Dy3.41)	Upper slopes, bloodwood–stringybark woodland; lower slopes and valleys, paperbark woodland
3 9 obs.	15% In centre	Undulating country on metamorphics; crests with patches of detrital sand or gravel and occasional outcrop; slopes probably 5–10% with sandy or stony surface and some outcrop; foot slopes and valley floors often with no definite channels	Mainly loamy red earths on crests and upper slopes, Coleman (Gn2.15), commonly with gravel, minor shallow sandy soils, Cardwell (Uc2.12); on lower slopes texture-contrast soils, Gamboola (Dy2.42) and Hanna (Dy3.41), and uniform sandy soils, Bathurst (Uc2.21); minor leached grey earths, Staaten (Gn2.94)	Upper slopes, bloodwood–stringybark woodland with an admixture of ironbark; lower slopes and valleys, paperbark woodland
4 0 obs.	10% In centre	Undulating country with fairly closely spaced shallow valleys	Mainly texture-contrast soils, Hanna (Dr2.12)	Not sampled; other workers report ironbark woodland
5 4 obs.	40% In south	Undulating country on little-weathered granite and metamorphics; even slopes 2–10%; low rocky knolls common on crests; narrow sandy alluvial flats and drainage floors	Shallow gravelly uniform sandy soils, Cardwell (Uc4.2), on upper slopes; massive yellow and brown earths, Kalinga (Gn2.94) and Staaten (Gn2.45), on lower slopes; texture-contrast soils, Stewart (Dd1.83), in drainage floors	Hills, ironbark woodland or bloodwood–stringybark woodland, with deciduous scrub on outcrops (*Petalostigma* present); some mixed eucalypt woodland; box woodland on flats

* Similar to Kilbogie land system of the Leichhardt–Gilbert area.

(6) Lukin Land System (270 sq miles)

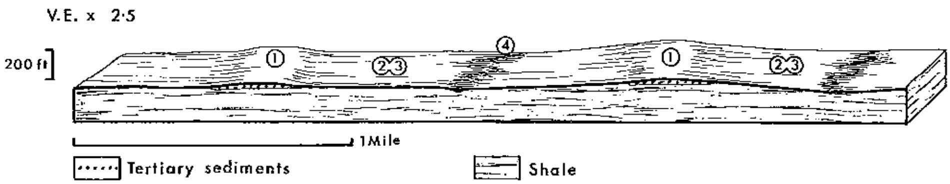
Plains and low stony plateaux on basalt; structured red soils; box woodland, some bloodwood, ground cover of kangaroo grass and black spear grass.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 1 obs.	50% Coastal plain north of Cooktown, possibly on basalt in extreme south-east	Gently undulating plains with few outcrops on weathered basalt; ¼–2 miles across	Gradational or uniform clay loams to clays; red subsoils with smooth-ped structure; acid to neutral reaction; moderately deep to deep, Springvale (Gn3.11, Uf6.31)	Box woodland (*E. leptophleba*) with some bloodwood; ground cover of *Heteropogon contortus*, *Themeda australis*, *Dichanthium*
2 1 obs.	35% Mainly in Butchers Hill area, possibly also on basalt in extreme south-east	Stony undulating plains and plateau tops; bouldery outcrops common; ¼–2 miles across	Very shallow rocky neutral clay loams, Emu (Um6.41)	Savannah of bloodwood and *Grevillea mimosoides*, ground cover as unit 1
3 1 obs.	5% Mainly in Butchers Hill	Colluvial foot slopes; 50–200 yd long; upper parts stony with slopes 25–50%; lower parts mainly clay with slopes 0–5%; some gullying	Shallow to moderately deep gradational neutral red loams to clays, Springvale (Gn3.12); minor cracking clay soils	As for unit 1
4 0 obs.	10% Throughout	Alluvial flats; probably mainly clay; up to 400 yd wide	Probably cracking clay soils	From photo pattern mainly box woodland; some grassland and savannah

(7) Maple Land System (230 sq miles)

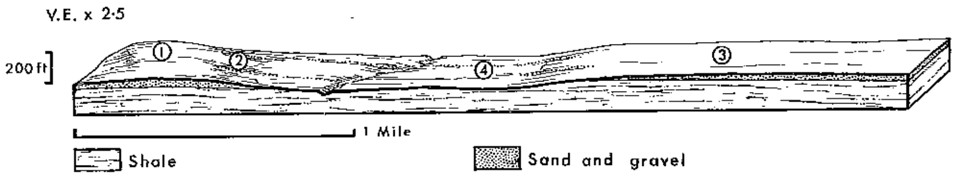
Plains and undulating lowlands on shale; cracking clay soils; deciduous scrub or grassland.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 1 obs.	<5% Sporadic	Crests of low rises; slopes 0–2%; thin layer of sandy gravelly detritus on weathered shales	Loamy yellow earths with abundant concretionary ironstone, Kalinga (Gn2.22); minor uniform fine-textured soils with abundant concretions on lower slopes, Mimosa (Uf6.31), and texture-contrast soils, Hanna (Dr2.12)	Bloodwood–stringybark woodland, or box woodland (*E. microneura*) over *Aristida*, *Heteropogon contortus*, *Dichanthium*
2 2 obs.	65% Throughout	Plains on shales; slopes 0–2%; occasional minor outcrops	Moderately deep to deep cracking self-mulching clay soils, Wrotham (Ug5.22, 5.14)	Deciduous scrub (no *Petalostigma*)
3 3 obs.	30% Throughout	As for unit 2	Moderately deep to deep cracking clay soils, mottled at depth, Wrotham (Ug5.22, 5.24); sparse gravel strew on surface in places	Grassland (*Schizachyrium*, *Iseilema*, Cyperaceae, *Alloteropsis*, *Sorghum*, Leguminosae)
4 0 obs.	<5% Throughout	Alluvial flats; clay and sand; presumably flooded in wet season	Probably cracking clay soils	Deciduous scrub or grassland as for units 2 and 3

(8) Brixton Land System (570 sq miles)

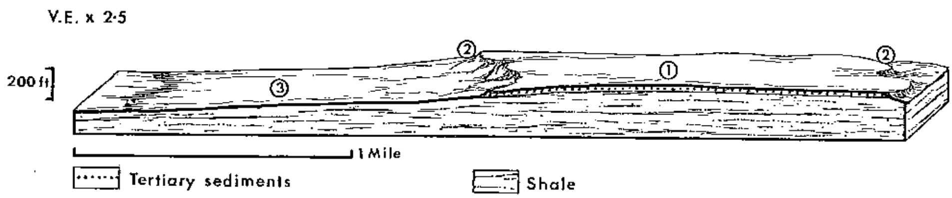
Plains and lowlands on shales and shallow weathered terrestrial sediments; yellow earths; savannah woodland or box woodland.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 1 obs.	10% Sporadic	Rises capped by sands and gravels; gently undulating; 100–1000 yd across	Shallow acid very gravelly massive earths and uniform sands, Brooklyn (Gn2.14) and Cardwell (Uc4.2)	Bloodwood–stringybark woodland; some savannah of *Erythrophleum* and occasional *E. microneura, E. argillacea;* sparse ground cover of mixed grasses
2 2 obs.	10% Sporadic	Upper slopes immediately below unit 1; slopes 5–10%; stony in places; 50–200 yd long; frequent gullies	Texture-contrast soils with thick sandy sometimes gravelly surface soils over acid mottled subsoils, Gamboola (Dy3.41)	Box (*E. argillacea*) or paperbark woodland with scattered bloodwood; sparse ground cover of mixed grasses
3 1 obs.	60% Throughout	Plains and broad interfluves on shale with thin loam and sand cover; slopes 0–2%	Mainly loamy yellow earths, Kalinga (Gn2.22, 2.61); extensive uniform fine-textured structured soils, Mimosa (Uf6.31); both with much concretionary ironstone and gravel	Box woodland (*E. microneura, E. argillacea*) over *Aristida, Heteropogon contortus, Dichanthium, Schizachyrium*
4 2 obs.	20% Throughout	Undulating lowlands on shales; slopes 0–5%; 200–2000 yd across; some gullies on steeper parts	Deep dark cracking clay soils, Wrotham (Ug5.16)	Deciduous scrub (no *Petalostigma*); or grassland and savannah (scattered *E. microneura, E. argillacea*, ground cover of *Themeda australis, Sorghum*, Leguminosae, Cyperaceae, *Heteropogon contortus, Dichanthium, Iseilema*)

(9) Annaly Land System (740 sq miles)

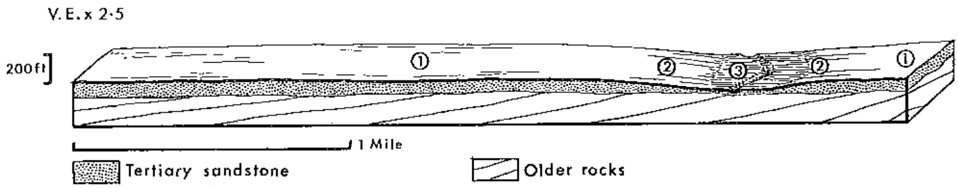
Lowlands on partially dissected terrestrial sediments over shale; massive earths and texture-contrast soils; paperbark or bloodwood–stringybark woodland.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 2 obs.	45% Throughout	Plains and broad interfluves; slopes 0–2%; no surface drainage but some sheet wash; silt or sand; ¼–1 mile across	Mainly leached grey and brown earths, gravelly in places, Staaten (Gn2.94); some shallow gravelly red and yellow earths, Brooklyn (Gn2.24)	Bloodwood–stringybark woodland
2 2 obs.	10% Throughout	Breakaways 5–50 ft high; sheet-eroded foot slopes 50–250 yd across on shales and siliceous hardpan; minor outcrops of laterite; sharply incised gullies; low stony rises	Mainly outcrop and shallow rocky soils, Mungana; minor shallow gravelly uniform medium- to fine-textured soils, Maitland (Uf4.1); uniform sands with abundant gravel below scarps, Bridge (Uc2)	Lancewood scrub and/or paperbark scrub of *M. tamariscina;* scanty ground cover (*Aristida, Schizachyrium, Cymbopogon*)
3 1 obs.	45% Throughout	Undulating lowlands and foot slopes below unit 2 on shale; 100–1000 yd across	Leached grey and brown earths, Crowbar and Staaten (Gn2.94, 2.95, 2.85); on lower slopes texture-contrast soils with thick sandy surface horizons and acid hard subsoils, Gamboola (Dy3.41, 2.81); minor occurrences of structured acid brown soils, Wyaaba (Gn3.22)	Paperbark woodland with bloodwood, *Erythrophleum*, *E. normantonensis*, *E. microneura*, and *Petalostigma banksii*, and good ground cover (*Sorghum*, *Aristida*)

(10) Koolburra Land System (1500 sq miles)

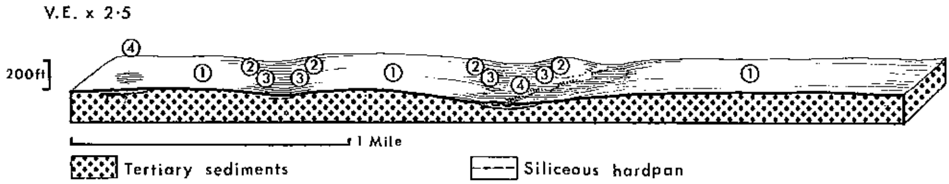
Plains and low plateaux on weathered Tertiary sandstone; sandy red earths; bloodwood–stringybark woodland, some paperbark woodland.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 8 obs.	90% Throughout	Plains and low plateau surfaces; level to gently undulating; slopes 0–4%; generally sandy; no surface drainage; 1–10 miles across	Mainly sandy red earths, Kimba (Gn2.14, 2.12); minor loamy red earths, Coleman (Gn2.15), sandy yellow earths, Clark (Gn2.25), and uniform red or brown acid sands, Healy (Uc2.21) and Bridge (Uc2.21)	Bloodwood–stringybark woodland
2 0 obs.	5% Throughout	Sloping margins of unit 1; slopes 2–8%, 100–1000 yd long; active sheet wash	Probably sandy yellow earths and uniform sandy soils	Bloodwood–stringybark woodland
3 0 obs.	5% Sporadic	Lower slopes and valley floors; 100–1000 yd across; probably sandy surface underlain in part by siliceous hardpan; usually channels 2–10 ft deep; bed load sand	Probably uniform sands and texture-contrast soils	Paperbark woodland or grassland and savannah, as for units 3 and 4 of Balurga land system

(11) Balurga Land System* (13,320 sq miles)

Extensive plains on weathered terrestrial sediments; sandy red and yellow earths and uniform sandy soils; bloodwood–stringybark woodland, some paperbark woodland.

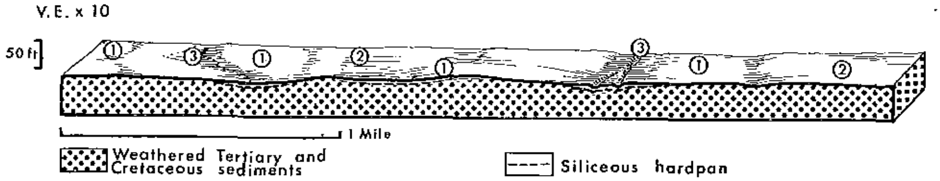


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 11 obs.	65% Throughout	Very extensive plains and broad interfluves; slopes 0–2%; no surface drainage but some sheet wash on steeper parts; up to 100 miles across but shallow valleys of units 2–4 every 1–3 miles	Mainly sandy red and yellow earths, Kimba (Gn2.14, 2.15) and Clark (Gn2.25), occasionally loamy earths on less quartzose rocks; extensive uniform red, yellow, or shallow gravelly sands on quartzose rocks in north and east, Bridge (Uc2.21), Healy (Uc2.21), and Cardwell (Uc2.21)	Bloodwood–stringybark woodland, sometimes with *E. cullenii;* occasional paperbark woodland and evergreen mixed scrub
2 10 obs.	20% Throughout	Mid slopes of shallow valleys dissecting unit 1; slopes 2–8%; few drainage lines but active sheet wash; 100–1000 yd long; occasionally extend over upper slopes and interfluves	Mainly deep yellowish brown to red acid sands, Bridge (Uc2.21, 2.12) and Healy (Uc4.2); extensive sandy red and yellow earths, Kimba (Gn2.4) and Clark (Gn2.82), and leached grey and brown massive earths, Staaten (Gn2.94, 2.84)	Bloodwood–stringybark woodland, tending to be lower and to have more shrubs and fewer bloodwoods than usual; some evergreen mixed scrub and paperbark woodland
3 15 obs.	10% Throughout	Lower slopes of shallow valleys; slopes 2–10%; occasional shallow gullies; siliceous hardpan common; 50–250 yd long	Mainly uniform acid brown and grey sands, Bridge (Uc2.22) and Bathurst (Uc2.20), on upper parts of slopes grading to texture-contrast soils with thick sandy surface and neutral subsoils, Gamboola (Dy2.42); some massive earths, Clark (Gn2.25), Staaten (Gn2.54), and Lorraine (Gn2.86)	Paperbark woodland (*M. viridiflora*) with occasional bloodwood; some evergreen mixed scrub and bloodwood–stringybark woodland; short grass
4 14 obs.	5% Throughout	Floors of shallow valleys; 100–500 yd across; often underlain by siliceous hardpan; smaller valley floors have no channels; larger valley floors have incised channels 2–40 ft deep with bed load sand; also subcircular swampy depressions 100–400 yd across in valley floors and on interfluves	In normal catena, mainly texture-contrast soils, Alice (Dy3.43), Stewart (Dy2.43), and Gamboola (Dy3.42); in areas of quartzose rocks mainly uniform acid grey and brown sands, Bathurst (Uc2.22), Cardwell (Uc4.11), minor alluvial soils, Helenvale (Um6.21), Bosworth (Uf1.43), and Morehead (Uc4.2)	Grassland and savannah, mainly short grass and Cyperaceae with scattered paperbark, bloodwood, and box; some paperbark woodland (*M. viridiflora, M. symphyocarpa*) with similar ground cover

* Similar to Dandry land system of the Leichhardt–Gilbert area.

(12) Mottle Land System (489 sq miles)

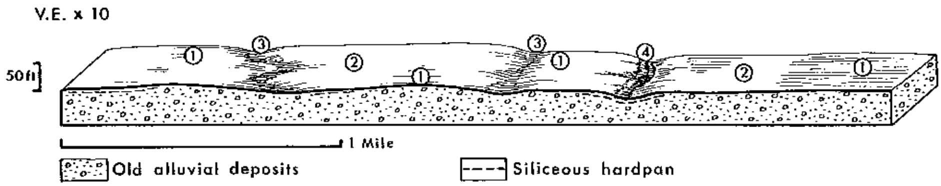
Extensive plains on weathered terrestrial sediments, siltstone, and alluvium; massive earths; paperbark or bloodwood–stringybark woodland.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 7 obs.	35% Throughout	Plains; slopes 0–3%; often forms very slight rises 200–1000 yd across interspersed in unit 2; mainly sands; siliceous hardpan occasional below surface	Uniform brown and grey acid sands on slight rises, Bathurst (Uc2.12) and Bridge (Uc4.2); minor sandy red earths, Kimba (Gn2.10), loamy yellow earths, Kalinga (Gn2.24), and leached grey and brown earths, Staaten (Gn2.95)	Bloodwood–stringybark woodland or mixed eucalypt woodland (bloodwood, box, *E. tetrodonta*, *Hakea*, *Grevillea*, *M. viridiflora*, *M. saligna*); ground cover *Schizachyrium*, *Aristida*, *Eriachne*, *Sorghum*
2 5 obs.	60% Throughout	Plains; ½–4 miles across; slopes 0–2%; siliceous hardpan common below surface	Mainly leached grey and brown massive earths with hardpan, Crowbar (Gn2.95), and texture-contrast soils with thick or thin sandy surface horizons and neutral to alkaline subsoils, Gamboola (Dy3.22) and Alice (Db2.23); some sandy and loamy yellow earths, Clark and Kalinga (Gn2.25)	Paperbark woodland (*M. viridiflora*, *M. saligna*) with some bloodwood and box; some evergreen mixed scrub; ground cover *Schizachyrium*, *Aristida*, Cyperaceae, *Thaumastochloa*, *Drosera*
3 2 obs.	5% Throughout	Floors of shallow valleys; sides slope 2–5%; floors flat and 100–400 yd across; often underlain by siliceous hardpan; smaller valley floors have no channels; large valleys have incised channels 2–20 ft deep with bed load sand; occasional swampy depressions	Texture-contrast soils with strongly alkaline subsoils, Stewart (Dy2.83) and Alice (Dy2.43)	Grassland or savannah (*Eriachne*, *Aristida*, *Schizachyrium*, Cyperaceae, scattered paperbark, bloodwood, *Grevillea*)

(13) LEINSTER LAND SYSTEM* (4330 SQ MILES)

Extensive uniform old alluvial plains; leached grey and brown massive earths with hardpan; paperbark or bloodwood–stringybark woodland.

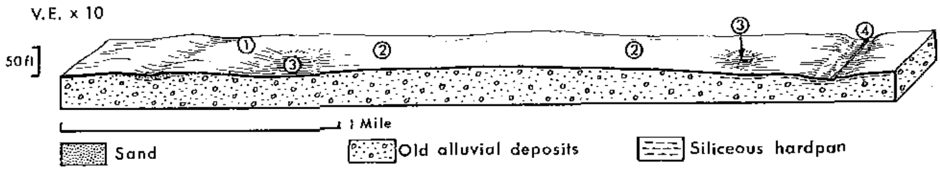


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 7 obs.	30% Throughout	Plains; level to very gently undulating; often on slight rises and old levees; slopes mainly 0–1%, locally up to 2%; mainly medium-textured old alluvium; fairly deeply weathered; siliceous hardpan common below 3 ft	Mainly leached grey and brown massive earths with hardpan horizons, Crowbar (Gn2.94, 2.85); minor loamy yellow earths, Kalinga (Gn2.85) and Welcome (Gn2.86), and sandy yellow earths, Clark (Gn2.25)	Bloodwood–stringybark, box, or paperbark woodland (*M. viridiflora, M. nervosa*), some evergreen mixed scrub; ground cover *Schizachyrium, Sorghum, Chrysopogon fallax, Drosera*, Cyperaceae
2 10 obs.	60% Throughout	As for unit 1 but some tendency to be on slightly lower sites	Mainly leached grey and brown massive earths with hardpan, generally mottled, Crowbar (Gn2.94); extensive brown acid to neutral mottled structured loams, Wyaaba (Gn3.05, 3.25); minor sandy yellow earths, Clark (Gn2.45), and alkaline loamy yellow earths, Lorraine (Gn2.93)	Paperbark woodland (*M. viridiflora*) with scattered bloodwood and mixed grasses and Cyperaceae (*Sorghum, Schizachyrium, Eriachne, Alloteropsis, Chrysopogon fallax, Heteropogon contortus*)
3 3 obs.	5% Throughout	Old valley floors forming broad shallow depressions with no active stream incision; sand to clay; sometimes siliceous hardpan below 3 ft	Mainly leached grey and brown massive earths, Crowbar (Gn2.95, 2.85); some texture-contrast soils with thick sandy surface and neutral subsoils, Gamboola (Dy3.22); often containing concretionary ironstone	Paperbark woodland (*M. viridiflora*) with some box and bloodwood over *Schizachyrium*, Cyperaceae, *Eriachne, Alloteropsis, Aristida*
4 3 obs.	5% Sporadic	Shallow incised valleys 30–100 ft deep, ¼–2 miles wide; scalded and dissected areas common on weathered silts and siliceous hardpan outcrops; streams incised 5–20 ft into hardpan with frequent water-holes	Alkaline leached grey and brown massive earths, Lorraine (Gn2.83), texture-contrast soils, Stewart (Dy3.23), and uniform fine-textured soils, Mimosa (Uf6.41)	Scalds paperbark scrub (*M. foliolosa*) and some box over *Schizachyrium* and *Aristida;* elsewhere box woodland (*E. microneura*) with bloodwood and paperbark over *Schizachyrium*, Cyperaceae, and *Sorghum*

* Similar land forms and vegetation to those of Mayvale land system of the Leichhardt–Gilbert area.

(14) DUNBAR LAND SYSTEM* (4250 SQ MILES)

Extensive old alluvial plains with levees and shallow depressions; massive leached grey and brown earths; savannah or paperbark woodland, scattered box.

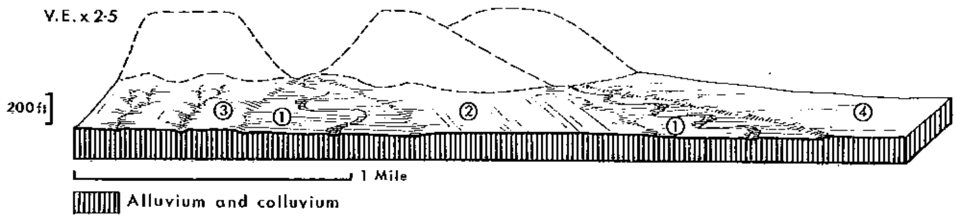


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 4 obs.	15% Throughout	Old levees of former streams; sand and some silt; 5–50 ft high, 100–1000 yd wide	Uniform deep structureless brown sands, Bridge (Uc2.22), and massive leached grey and brown earths, Staaten (Gn2.94, 2.81)	Bloodwood–stringybark woodland; or paperbark woodland (*M. viridiflora*, some *M. nervosa*) with bloodwood and box (*E. microtheca*), and ground cover of Cyperaceae, *Sorghum*, *Eriachne*, *Schizachyrium*, *Chrysopogon fallax*, *Drosera*
2 9 obs.	75% Throughout	Plains; level to very gently undulating; slopes mostly 0–½%; mainly clay and fine sand; possibly flooded in part	Mainly leached grey and brown massive earths, Staaten (Gn2.94, 2.81), minor Crowbar (Gn2.94); in south-west, extensive cracking clay soils, Koolatah (Ug5.5), Yanko (Ug5.24), gilgaied in places, Gilbert (Ug5.24); minor texture-contrast soils, Gamboola (Dy3.42) and Stewart (Dy3.43), and structured alkaline brown soils, Waterhole (Gn3.93)	Savannah of paperbark (*M. viridiflora*) and box (*E. microtheca*) over rather dense cover (Cyperaceae, *Eriachne burkittii*, *Panicum decompositum*, *Sorghum*, *Oryza*, *Dichanthium superciliatum*); some paperbark scrub (*M. foliolosa*) and evergreen mixed scrub
3 3 obs.	5% Throughout	Depressions; subcircular, 5–20 ft deep, 100–1000 yd across; contain water for much of the year; also old drainage floors with no active stream incision	Mainly texture-contrast soils, acid to alkaline hard mottled subsoils, Gamboola (Dy2.42), Stewart (Dy3.43), and Hanna (Dy3.41); some leached grey and brown earths with acid hardpan, Staaten (Gn2.85)	Paperbark woodland; where waterlogged dense *M. saligna*, *M. stenostachya* with ground cover scanty or lacking, elsewhere open *M. viridiflora* with some box (*E. microtheca*) and dense ground cover of *Eriachne burkittii*, *Panicum decompositum*, *Sorghum*, *Schizachyrium*, *Aristida*, Cyperaceae
4 1 obs.	5% Sporadic	Shallow incised valleys; scalded and dissected areas common on weathered clay and siliceous hardpan; streams incised 5–20 ft into hardpan with frequent waterholes	Probably texture-contrast soils and leached grey and brown earths	Paperbark scrub (*M. foliolosa*)

* Similar to the Miranda land system of the Leichhardt–Gilbert area.

(15) Ninda Land System (1160 sq miles)

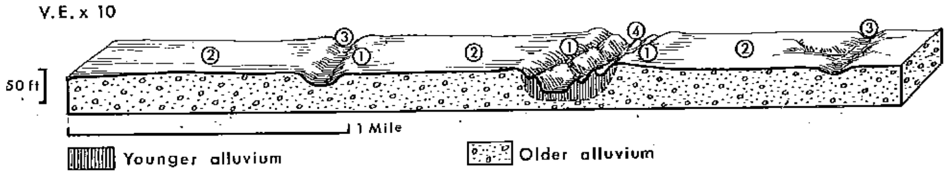
Colluvial and alluvial aprons and fans; texture-contrast soils; mostly paperbark woodland but very variable.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 7 obs.	30% Throughout	Alluvial fans; slopes ½–3%; ¼–4 miles wide; generally sand or fine-textured material; micro-relief of levees, channels, and back plains; partly subject to flooding	Uniform medium-textured alluvial soils, Helenvale (Um4.2), on levees; texture-contrast soils, Gamboola (Dy3.41, 3.42) and Alice (Dy3.43, Db1.43), minor leached grey earths, Staaten (Gn2.42), and uniform fine-textured alluvial soils, Bosworth (Uf1.43) on back plains	Variable; paperbark woodland (*M. viridiflora*, *M. nervosa*, some *M. acacioides*), box woodland (*E. microtheca*, *E. leptophleba*, *E. normantonensis*), and mixed eucalypt woodland (*E. alba*, bloodwood, *Erythrophleum*, *Alstonia*, *Coelospermum*, *Petalostigma*, paperbark, and ground cover *Imperata*, *Themeda australis*, *Heteropogon contortus*)
2 1 obs.	30% Throughout, except for Cooktown area	Colluvial aprons; slopes 1–5%; ¼–4 miles wide; stony in upper parts; some gullying and sheet erosion	Texture-contrast soils, Gamboola (Dy3.42); minor loamy yellow earths, Kalinga (Gn2.94), and uniform sandy soils, Bathurst (Uc2.20)	Variable; paperbark woodland, deciduous scrub (*Petalostigma* present), and mixed eucalypt woodland (bloodwood, *E. shirleyi*, *E. cullenii*, *Erythrophleum*, *Petalostigma quadriloculare*, *Xanthorrhoea*, and ground cover *Themeda australis*, spinifex)
3 0 obs.	20% Mainly in north-east	Dissected older colluvial aprons; slopes probably 2–10%; ¼–2 miles wide; gullying and sheet erosion; probably fairly deeply weathered	Mainly sandy and loamy yellow earths, Clark and Kalinga (Gn2.74); minor red earths, Coleman (Gn2.14), and texture-contrast soils, Gamboola (Dy3.41)	Gum woodland
4 0 obs.	20% Cooktown area	Colluvial aprons and plains; slopes ½–5%; 2–4 miles wide; mainly stony clay	Texture-contrast soils, Gamboola and Hanna (Dy3.41); minor loamy red earths, Coleman (Gn2.11)	Gum woodland

(16) Radnor Land System* (1520 sq miles)

Stable alluvial plains largely above flood level; texture-contrast soils; grassland or savannah.

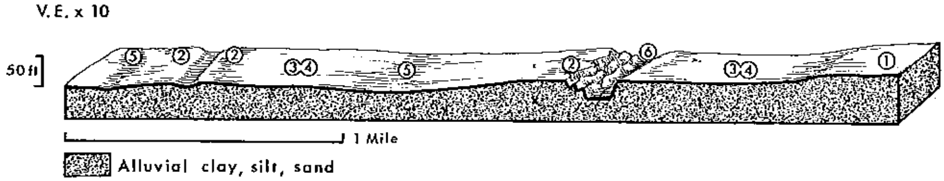


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 6 obs.	30% Mainly on lower Mitchell	Levees; 2–10 ft high, 100–500 yd wide; slopes ½–2%; silt and sand; minor areas with severe sheet and gully erosion	Mainly texture-contrast soils with thin and thick surface horizons and strongly alkaline to neutral subsoils, Alice (Dy2.33), Stewart (Dy3.23), and Hanna (Db1.12); minor loamy red earths, Coleman (Gn2.14)	Grassland or savannah, fairly dense *Aristida*, *Schizachyrium*, *Iseilema*, Cyperaceae, *Heteropogon contortus*, scattered bloodwood, box, *Bauhinia*, *Terminalia;* some mixed eucalypt woodland; some bloodwood–stringybark woodland
2 9 obs.	60% Throughout	Alluvial plains; slopes 0–½%; ¼–3 miles wide; clay and silt, possibly flooded in part	Mainly texture-contrast soils with thin sandy or loamy surface soils and strongly alkaline subsoils, Alice (Dy2.33); extensive areas of alkaline cracking clay soils, Koolatah (Ug5.25, 5.5), occasionally acid, Yanko (Ug5.5), and structured brown loams, neutral to alkaline, Wyaaba (Gn3.12) and Waterhole (Gn3.93)	Grassland or savannah as for unit 1, with added *Eriachne burkittii*, *Bothriochloa*, *Vetiveria*, *Sorghum;* some deciduous scrub (no *Petalostigma*)
3 1 obs.	5% Throughout	Old channels; 5–30 ft deep, 20–200 yd wide; flooded in wet season; some form permanent water-holes	Alkaline cracking clay soil with linear or rounded depressions 1–2 ft deep, Koolatah (Ug5.16)	Box woodland (*E. microtheca*), *Excoecaria*, dense mid-height grass (*Eriachne burkittii*, *Panicum*, *Brachyachne*), Cyperaceae
4 0 obs.	5% Throughout	Younger alluvial complex; channels, levees, and narrow back plains; all flooded in wet season	Recent alluvial soils	Very variable; paperbark woodland mainly (*M. leucadendron*, *M. argentea*), eucalypts on levees

* Similar to Miranda land system of the Leichhardt–Gilbert area.

(17) Cumbulla Land System* (2890 sq miles)

Alluvial plains in part actively forming and largely flooded in the wet season; texture-contrast soils; paperbark woodland.

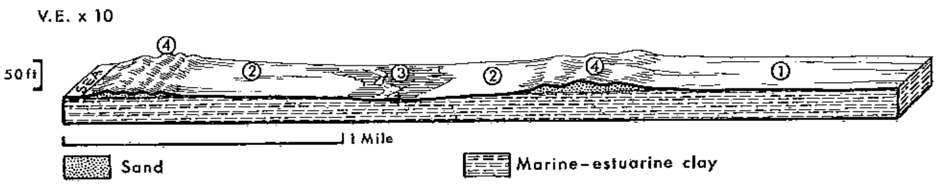


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 7 obs.	10% Throughout	Higher, old stable alluvial plains and terraces; silt and clay; 100–2000 yd wide	Structured brown soils, Wyaaba (Gn3.05) and Waterhole (Gn3.93), cracking clay soils, Koolatah (Ug5.16), and uniform fine-textured soils, Mimosa (Uf6.33)	Mixed eucalypt woodland on levees (bloodwood, *M. nervosa*, *Grevillea*, *Erythrophleum*); paperbark woodland (*M. viridiflora*) or evergreen mixed scrub (*Excoecaria*, box) on flood-plains and back plains; ground cover very variable
2 6 obs.	35% Throughout	Levees, not flooded; mainly sand and silt; 50–1000 yd wide	Mainly texture-contrast soils, Alice (Dy2.33, 3.43); some red and yellow earths, Coleman (Gn2.14) and Kalinga (Gn2.82); minor uniform medium- and fine-textured soils, Helenvale (Um4.2 on sand) and Bosworth (Uf1.43)	Mixed eucalypt woodland (bloodwood, box, *Excoecaria*, *M. nervosa*, *Terminalia*, *Coelospermum*, *Canarium*) over dense *Heteropogon contortus*, *Iseilema*, *Schizachyrium*, *Chrysopogon fallax*, *Capillipedium*; some paperbark woodland (*M. viridiflora*, *M. nervosa*)
3 2 obs.	20% Mainly on lower Mitchell	Plains and level terraces; partly flooded; mainly silt and clay; 100–500 yd wide	Texture-contrast soils, mainly with alkaline subsoils, Stewart (Dy3.43) and Alice (Dy3.13); minor Gamboola (Dy3.11)	Savannah of box (mainly *E. microtheca*) or paperbark (*M. viridiflora*) over *Eriachne burkittii*, *Schizachyrium*, *Sorghum*, Cyperaceae, *Panicum decompositum*
4 6 obs.	20% Mainly on middle Mitchell	As for unit 3 but more continuous; 500–2000 yd wide	Cracking clay soils with strongly alkaline subsoils, Koolatah (Ug5.16, 5.5); minor uniform medium-textured alluvial soils, Helenvale (Um4.2)	Grassland (*Eriachne burkittii*, *Schizachyrium*, *Sorghum*, Cyperaceae, *Panicum decompositum*); some scattered trees as in unit 3
5 5 obs.	10% Throughout	Depressions and older channels, frequently flooded; mainly clay; 10–500 yd wide, 2–20 ft deep	Cracking clay soils, Koolatah (Ug5.16, 5.24) and Yanko (Ug5.24)	Varied; bloodwood–stringybark woodland, paperbark woodland (*M. viridiflora*), box woodland (*E. microtheca*, *Excoecaria*), or grassland (*Heteropogon triticeus*, *Eriachne burkittii*, Cyperaceae, *Brachyachne*, *Chloris*, *Panicum*, *Vetiveria*, *Oryza*)
6 2 obs.	5% Throughout	Active channels; mostly dry in dry season; bed load mainly sand; up to 1200 yd wide, 5–50 ft deep; narrow fringe of silty ridges and channels along major rivers; liable to flooding	Uniform coarse- to medium-textured alluvial soils, Morehead (Uc2.12) and Helenvale (Um5.5)	Varied; usually bare, with fringe of *M. argentea* or *M. leucadendron*

* Similar to parts of Miranda and Gilbert land systems of the Leichhardt–Gilbert area.

(18) Inkerman Land System* (1180 sq miles)

Coastal clay plains with low sandy beach ridges; saline–alkaline cracking clay soils; grassland, some mixed evergreen scrub.

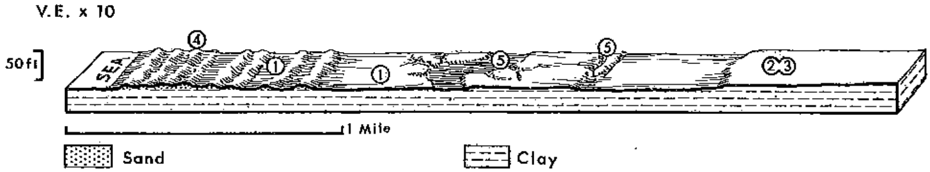


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 1 obs.	30% Throughout	Clay plains slightly higher than unit 2; mainly old lagoonal clay now above sea level; width variable up to 3 miles	Alkaline cracking clay soils, Koolatah (Ug5.28); minor texture-contrast soils, Hanna (Dy3.41)	Grassland (*Bothriochloa*, *Schizachyrium*, *Brachyachne*, *Eriachne burkittii*, *Vetiveria*, *Dichanthium*) with robust Cyperaceae; some paperbark woodland (*M. viridiflora*)
2 2 obs.	40% Throughout	Clay plains slightly lower than unit 1; mainly old lagoonal clay now above sea level; width variable up to 5 miles	Saline–alkaline cracking clay soils with slight gilgai microrelief (6–24 in.), Marina (Ug5.16, 5.28)	As for unit 1, with added *Sporobolus virginicus*, *Panicum decompositum*, *P. trachyrachis*
3 1 obs.	10% Throughout	Mud flats and swamps flooded by rivers in wet season and by highest tides; 50–500 yd wide	Saline mud	Bare, or mangrove scrub
4 1 obs.	20% Throughout	Low parallel sand ridges and intervening clay swales; ridges 3–10 ft high and 50–250 yd wide; swales 50–500 yd wide; quartz sand and shell sand; generally form belts ½–2 miles wide and 2–10 miles long parallel to the coast	Uniform fine well-sorted brown sands, Dinah (Uc1.21)	Mixed eucalypt woodland of bloodwood and box, with shrubs and varied non-eucalypt trees and grasses; sometimes without eucalypts to form open evergreen mixed scrub with tall grass and occasional palms

* Similar to part of Carpentaria land system in the Leichhardt–Gilbert area.

(19) Battersea Land System* (890 sq miles)

Coastal mud flats; saline–alkaline cracking clay and uniform fine-textured soils; patchy salt-marsh vegetation alternating with large bare areas.

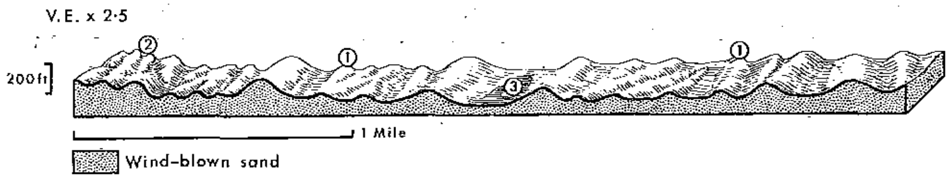


Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 1 obs.	60% Throughout	Bare saline mud flats probably flooded in wet season and covered by highest tides; 100–5000 yd wide	Saline–alkaline cracking clays, Carpentaria (Ug5.4), and uniform fine-textured soils, Nassau (Uf6.61); puffy flocculated salt layer at surface	Bare
2 1 obs.	15% Throughout	Clay plains slightly above unit 1; 100–1000 yd wide	Cracking strongly alkaline clay soils, Marina (Ug5.16); slightly gilgaied in places	Salt-marsh vegetation of short Cyperaceae with some *Sporobolus virginicus*, *Iseilema*, and *Sesbania*
3 2 obs.	5% Throughout	Similar to unit 2	As for unit 1	Salt-marsh vegetation of *Arthrocnemum*
4 1 obs.	10% Throughout	Low parallel sand beach ridges and intervening swales; quartz and shell sands; locally modified by wind action	Uniform fine well-sorted sands, Dinah (Uc1.13, 1.21), on ridges	Mixed eucalypt woodland of bloodwood and box, with shrubs and varied non-eucalypt trees and grasses; sometimes without eucalypts to form open evergreen mixed scrub with tall grass and occasional palms
5 1 obs.	10% Throughout	Tidal channels and swamps	Miscellaneous land, saline mud, permanently moist to wet	Mangrove scrub

* Similar to part of Carpentaria land system of the Leichhardt–Gilbert area.

(20) Flattery Land System (280 sq miles)

Dunes largely stabilized by vegetation; uniform sandy soils; evergreen mixed scrub.



Land Unit	Area and Distribution	Land Forms	Soils	Vegetation
1 0 obs.	75% Throughout	Stable dunes forming linear ridges 50–300 ft high	Probably uniform fine sandy soils, Dinah (Uc1)	From photo pattern, similar to unit 4 of Inkerman land system—mixed eucalypt woodland or open evergreen mixed scrub
2 0 obs.	15% Throughout	Unstable dunes subject to blowing; loose quartz sand		Mainly bare
3 0 obs.	10% Throughout	Swamps and lakes between dunes	Probably texture-contrast soils	From photo pattern, salt-marsh vegetation

PART III. CLIMATE OF THE MITCHELL–NORMANBY AREA

By R. H. Gunn*

I. Introduction

On the basis of rainfall and temperature, the area has a subhumid to humid tropical climate with marked wet and dry seasons. During the dry season the intertropical convergence zone is well to the north of the continent and prevailing winds are from the south. Dry, relatively cool weather and only very occasional light rainfalls occur during this period from May to October. With increasing temperatures and proportions of winds from the north and north-east, local convectional thunderstorms occur at the beginning of the wet season in November. In December and January the intertropical convergence zone moves south and the influx of moist air masses brings heavy rain to the area, particularly along the east coast where winds meet steep mountain barriers rising to above 1000 ft. A further important climatic control is the incidence of tropical cyclones which occur regularly in the area and cause torrential rain. These disturbances usually originate in the Coral Sea between latitudes 8° and 15°S. and move slowly in a westerly direction. Many re-curve near the coast and pass southward, but others may continue inland and occasionally move westward across northern Australia or re-curve in the interior and move eastward across southern Queensland (Bureau of Meteorology 1940). The following frequency of occurrence of cyclones over a 10-yr period has been shown by Brunt and Hogan (1956): December 0–1, January 2–3, February 1–3, March 1–3, April 0–1.

II. General Climatic Characteristics

(*a*) *Rainfall*

Average annual rainfall increases from about 35 in. in the south of the area to more than 70 in. along the north-eastern coast in the vicinity of Cooktown. Considerably higher rainfall occurs on the coastal slopes of the eastern highlands. A small part in the north-west has rainfall in excess of 50 in., which is probably associated with cyclones originating in the north and west over the Gulf of Carpentaria. According to Dick (1958), the variability of annual rainfall is 20–25% (mean deviation expressed as a percentage of average rainfall). The mean annual isohyets are shown in Figure 4.

A most striking feature of the rainfall is its marked seasonal distribution. With the exception of Cooktown where 40 out of an average of 120 rainy days a year occur from May to October, about 95% of rainfall at other stations in the area occurs from November to April. The average number of rainy days during the dry season is about 7 and rainfall in this period is generally less than 2 in. The months of highest rainfall are January to March. Although no data are available regarding

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rainfall intensities on an hourly basis, falls from 10 to nearly 14 in. in 24 hours have been recorded at Coen, Musgrave, Palmerville, and Walsh River. The general characteristics of the annual rainfall regime are given in Tables 1–3.

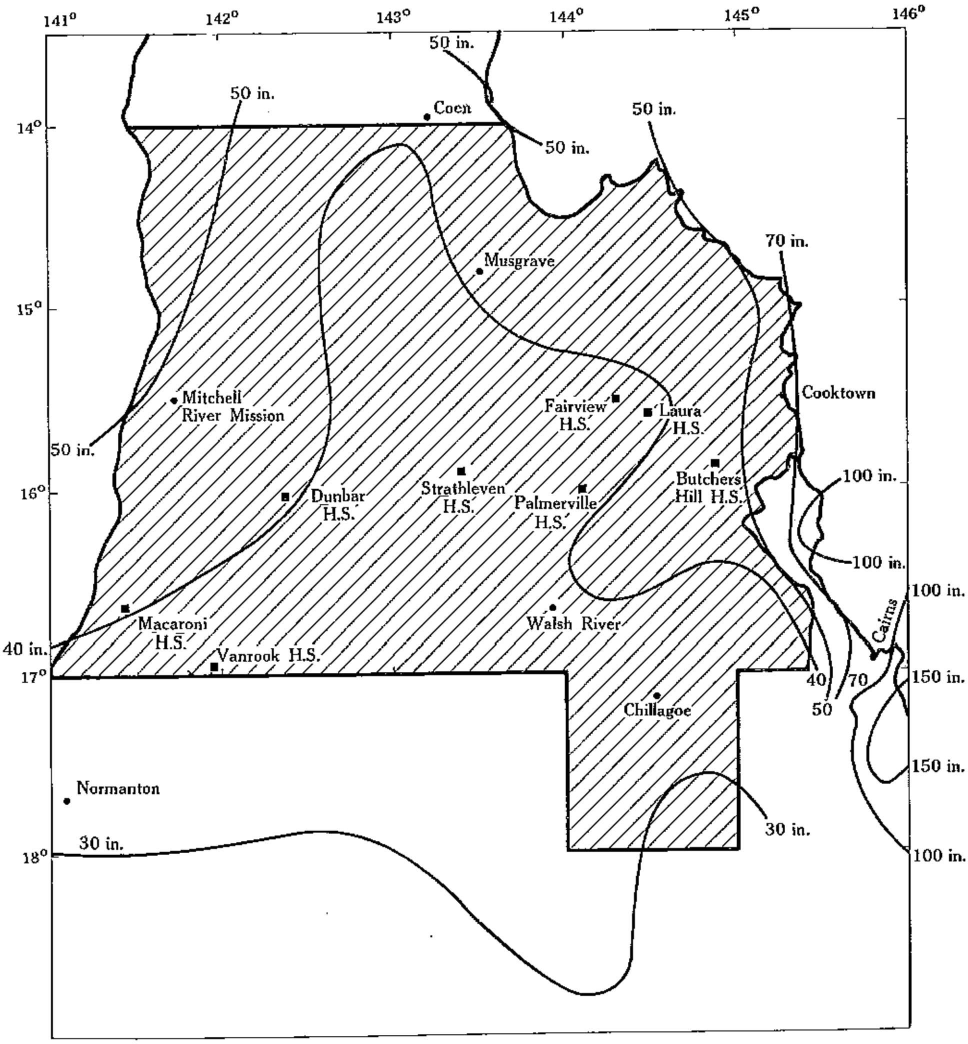

Fig. 4.—Isohyets of mean annual rainfall.

(*b*) *Temperature*

Temperature data are available for a few stations in the area and are shown in Table 4. On the basis of these figures temperature conditions appear to be fairly uniform throughout the area. At Coen just outside the northern boundary of the area, mean maximum temperatures range from about 82°F in June and July to 92°F in December. Mean minimum temperatures range from about 61°F in July to 72°F

TABLE 1
MEAN MONTHLY AND ANNUAL RAINFALL* (IN.)

Station	No. of Years	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Annual
Butchers Hill	14	0·32	0·23	0·05	1·05	1·97	5·20	11·02	10·82	10·87	1·59	0·51	0·40	44·03
Chillagoe	30	0·27	0·16	0·19	0·54	2·20	5·63	8·29	9·55	5·21	1·09	0·45	0·52	34·10
Coen	30	0·21	0·16	0·12	0·39	2·10	5·98	9·76	9·95	9·43	3·39	0·36	0·32	42·17
Cooktown	30	1·11	1·26	0·59	0·63	2·01	5·30	14·80	14·41	15·26	7·54	2·54	1·93	67·37
Dunbar	42	0·22	0·11	0·27	0·78	2·22	6·38	10·26	11·85	7·29	1·42	0·22	0·24	41·26
Fairview	30	0·12	0·06	0·19	0·65	1·97	5·95	11·02	8·87	7·23	1·74	0·28	0·43	38·51
Laura	78	0·15	0·13	0·16	0·71	2·04	5·31	9·03	9·54	6·93	1·22	0·26	0·38	35·86
Macaroni	19	0·07	0·13	0·30	0·16	2·51	5·28	9·53	11·31	7·66	1·05	0·06	0·52	38·58
Mitchell River	53	0·09	0·18	0·14	0·54	2·09	7·02	12·79	13·93	9·26	2·30	0·39	0·26	48·99
Musgrave	17	0·19	0·14	0·07	0·48	2·19	6·88	10·99	10·51	9·14	2·92	0·59	0·42	44·52
Palmerville	76	0·25	0·14	0·37	0·77	2·36	6·13	10·38	10·10	7·15	2·02	0·53	0·47	40·67
Strathleven	16	0·23	0·06	0·08	0·32	2·03	6·90	8·90	8·26	6·95	1·56	0·29	0·34	35·92
Vanrook	26	0·21	0·22	0·07	0·61	2·16	4·69	9·42	9·87	7·30	1·00	0·21	0·52	36·28
Walsh	78	0·26	0·10	0·16	0·61	2·21	5·98	8·85	8·53	6·65	1·30	0·36	0·39	35·40

* Unpublished and published data of the Bureau of Meteorology (1940, 1956, 1966).

in December and January. At Palmerville in about the centre of the area, mean maximum temperatures range from 86°F in June to about 96°F in November. Mean minimum temperatures range from 57°F in July to 73°F in January. According to Foley (1945) most of the area is frost-free but occasional light frosts have been recorded from June to August in the more elevated areas in the south.

TABLE 2

MEAN ANNUAL AND SEASONAL RAINFALL (IN.)

Station	Annual Mean	Summer (Nov.–Apr.)	Winter (May–Oct.)	Mean Summer Rainfall as Percentage of Mean Annual
Butchers Hill	44·03	41·47	2·56	94
Chillagoe	30·94	29·11	1·83	94
Coen	45·06	43·39	1·67	96
Cooktown	67·87	59·79	8·08	88
Dunbar	41·26	39·42	1·84	95
Fairview	38·51	36·78	1·73	95
Koolatah	42·67	40·69	1·98	95
Laura	35·86	34·07	1·79	95
Macaroni	38·28	37·34	1·24	97
Mitchell River	48·99	47·39	1·60	97
Mt. Mulligan	30·85	29·31	1·54	95
Musgrave	44·52	42·63	1·89	96
Palmerville	40·67	38·14	2·53	94
Strathleven	35·92	34·60	1·32	97
Vanrook	36·28	34·44	1·84	95
Walsh	35·40	33·52	1·88	95

TABLE 3

MEAN NUMBER OF RAIN DAYS*

Station	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Year
Chillagoe	1	0	0	2	4	9	13	12	10	3	1	1	56
Coen	2	1	1	1	3	11	16	16	15	7	2	3	78
Cooktown	7	6	4	4	5	11	16	17	18	13	10	9	120
Laura	1	1	0	1	3	9	14	14	12	3	1	1	60
Palmerville	1	0	1	2	6	11	18	17	15	6	3	2	82
Walsh	1	0	0	1	4	9	13	12	9	2	1	1	53

* Day with 0·01 in. or more of rain.

(c) *Humidity and Evaporation*

Available data on relative humidity are shown in Table 4 and Figure 5. There is clearly a close relationship between distance from the coast and relative humidity. The 9 a.m. values at Coen, situated about 30 miles from the coast with an annual rainfall of 45 in., are on average about 17% higher than at Palmerville, situated further inland with an annual rainfall of about 41 in.

TABLE 4

AVERAGE MEAN TEMPERATURE, HUMIDITY, AND ESTIMATED EVAPORATION* AT FOUR STATIONS

Element	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Year
					Coen								
Temperature—Maximum (°F)	81·5	82·8	86·2	89·4	91·4	91·9	89·5	87·8	86·9	85·6	83·6	82·2	86·6
Mean (°F)	71·2	72·4	75·3	78·7	81·1	82·0	80·7	79·6	78·9	77·2	74·6	72·4	77·0
Minimum (°F)	60·8	61·9	64·4	68·0	70·7	72·1	71·9	71·3	70·9	68·8	65·5	62·6	67·4
9 a.m. relative humidity (%)	76	72	69	66	67	74	81	84	83	80	79	77	76
Evaporation (in.)	4·09	4·81	5·61	6·88	7·47	7·32	5·52	4·42	4·12	3·66	3·53	3·51	60·94
					Musgrave								
Temperature—Maximum (°F)	85·0	87·0	90·9	93·8	95·4	94·4	91·5	90·6	89·6	89·0	86·9	85·0	89·9
Mean (°F)	70·9	72·0	75·7	79·6	82·3	83·4	82·5	81·9	80·9	78·7	74·8	72·2	77·9
Minimum (°F)	56·8	56·9	60·5	65·3	69·2	72·4	73·5	73·1	72·1	68·3	62·6	59·4	65·8
9 a.m. relative humidity (%)	66	62	59	55	56	64	73	76	76	71	69	68	66
3 p.m. relative humidity (%)	42	37	34	36	39	48	59	60	60	53	49	47	47
Evaporation (in.)	5·21	6·11	7·32	8·87	9·18	8·25	6·05	4·82	4·74	4·59	4·65	4·44	74·23
					Fairview								
Temperature—Maximum (°F)	82·9	85·1	89·4	92·8	94·5	93·6	91·2	90·1	88·8	88·4	85·8	83·6	88·8
Mean (°F)	72·1	73·4	71·7	80·0	82·1	83·0	82·1	81·3	80·1	78·8	75·9	73·4	78·2
Minimum (°F)	61·2	61·7	64·0	67·2	69·7	72·4	73·0	72·4	71·4	69·2	66·0	63·1	67·6
9 a.m. relative humidity (%)	66	65	63	61	64	70	75	78	77	69	67	67	68
Evaporation (in.)	5·39	6·08	7·56	9·15	9·45	8·77	7·00	5·60	5·43	5·46	5·33	4·92	80·14
					Palmerville								
Temperature—Maximum (°F)	85·6	87·7	91·9	95·2	96·1	94·7	92·0	90·7	90·1	89·6	87·9	85·4	90·6
Mean (°F)	71·4	72·8	76·8	80·7	83·0	83·6	82·6	81·7	80·6	78·4	75·2	72·3	78·3
Minimum (°F)	57·2	57·8	61·7	66·1	69·8	72·4	73·1	72·6	71·0	67·2	62·4	59·1	65·9
9 a.m. relative humidity (%)	63	58	53	51	54	63	72	75	73	67	64	66	63
3 p.m. relative humidity (%)	38	32	29	29	33	42	57	58	56	49	44	44	43
Evaporation (in.)	5·83	6·98	8·46	10·11	9·93	8·93	6·60	4·98	5·18	5·43	5·64	5·13	83·20

* Estimated by method of Fitzpatrick (1963) from mean maximum temperature, vapour pressure, and day length. Other data derived from Bureau of Meteorology (1940).

No evaporation data are available for the area, but estimates of mean monthly and annual evaporation from the Australian standard tank based on the method of Fitzpatrick (1963) are given in Table 4.

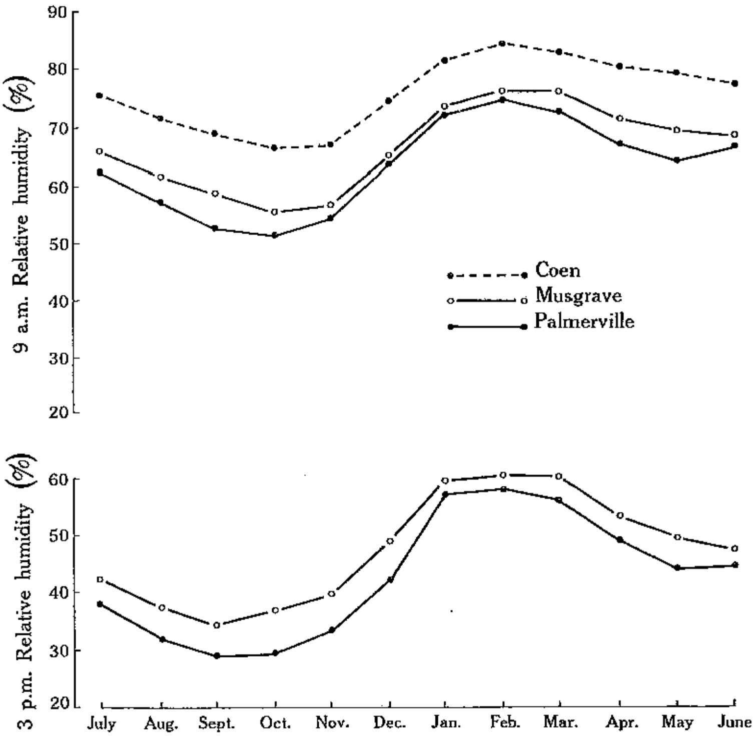

Fig. 5.—Mean monthly 9 a.m. and 3 p.m. relative humidity.

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PART IV. GEOLOGY AND RELIEF OF THE MITCHELL–NORMANBY AREA

By R. W. GALLOWAY*

I. INTRODUCTION

Rocks, in the broad sense of all solid and unconsolidated materials underlying the area, largely determine the nature of the country, and consequently the geology forms a convenient framework for regional description. Ten major types of rock are delineated on the coloured geology map. In this Part these types are briefly discussed and some account is given of the associated relief. The broad relationship between geology, relief, and land systems is summarized in Table 5.

This highly generalized account of the geology and relief is based on the maps and publications of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics (in association with the Queensland Geological Survey), on study of the air photographs and topographic maps, and on field work. Readers seeking fuller information are referred to the following publications: Amos and de Keyser (1964); Best (1962); de Keyser and Wolff (1964); Lucas and de Keyser (1965*a*, 1965*b*).

II. GEOLOGY AND LAND FORMS

(*a*) *Volcanics and Granite*

These Palaeozoic rocks occupy some 7% of the area, mainly in the south-east. They are highly resistant and parts have been uplifted in Cainozoic time. Consequently, they form rugged country with extensive areas of outcrop, narrow rocky valleys aligned along structural weaknesses, and scanty soil cover. The highest part of the Mitchell–Normanby area, rising to 4400 ft above sea level, occurs on the granite. Somewhat deeper soils are probably found in a small area in the extreme south-east where the rainfall is greater and vine forest predominates. Rapid erosion has removed any traces of Tertiary deep weathering or detrital deposits and the rocks are essentially unweathered except in the heavy-rainfall areas near the east coast. Alluvium is practically absent even along the major streams which have irregular regimes owing to the seasonality of the rainfall and the rapid run-off from steep slopes with much bare rock.

Starcke land system (unit 1) and part of Rumula land system occur on these rocks.

(*b*) *Quartz Sandstone*

Resistant quartz sandstone and related conglomerate, siltstone, and minor shale cover some 4% of the survey area and occur in two main localities. In the east and north-east, Jurassic and Lower Cretaceous sandstone are strongly unconformable on folded greywackes and dip gently west or north-west towards Princess Charlotte Bay. In the south is a small syncline of Triassic quartz sandstone and a somewhat

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Table 5

GEOLOGY AND RELIEF OF THE LAND SYSTEMS

Percentage of Area	Predominant Geology	Predominant Relief	Land Systems
7	Volcanics and granite: Palaeozoic; resistant; unweathered	Massive, extremely rocky mountains	Starcke (unit 1), part of Rumula
4	Quartz sandstone: Mesozoic; resistant; little weathered; gently warped or unfolded	Dissected tablelands	Starcke (unit 2)
10	Greywacke and other sediments: Palaeozoic; resistant; unweathered; folded and faulted	Steep, broken, closely dissected mountains and hills Undulating lowlands, low hills	Starcke (unit 3), Maytown, part of Rumula Hodgkinson
10	Metamorphics and granite: Precambrian and Palaeozoic; fairly resistant; little weathered; thin cover of gravelly or sandy detritus in places	Undulating lowlands and low hills, outcrop common	Arkara, minor parts of Starcke
0·5	Basalt: Tertiary; moderately resistant; fairly deeply weathered in part; unfolded	Plains, low stony plateaux	Lukin
6	Shale, claystone, siltstone: Cretaceous; unresistant; deeply weathered in part; gently warped or unfolded; locally covered by gravel or sand	Plains and gently undulating lowlands	Maple, Annaly, Brixton, part of Mottle
31	Weathered terrestrial deposits: Tertiary; unresistant; deeply weathered; unfolded	Slightly dissected extensive plains, low plateaux	Koolburra, Balurga, part of Mottle
19·5	Older alluvium and colluvium: Plio–Pleistocene; weathered in part	Extensive plains, colluvial foot slopes	Leinster, Dunbar, Ninda
8	Younger alluvium: Pleistocene to Recent	Alluvial plains	Radnor, Cumbulla, part of Mottle
4	Coastal sediments: Pleistocene to Recent	Tidal mud flats, clay plains, sand ridges, dunes	Battersea, Inkerman, Flattery

more extensive sheet of Cretaceous sandstone dipping very gently westwards towards the Gulf of Carpentaria.

The sandstone in the east and north-east forms a deeply dissected plateau mostly rising to between 500 and 1500 ft above sea level. Narrow flat-topped ridges, deep valleys, bluffs, and rocky benches are the rule. On the more extensive ridge tops ironstone gravel and traces of laterite are preserved. Where the sandstone dips down to the plains round Princess Charlotte Bay local relief is less and the country is undulating with deep sand fill in the valleys.

The Cretaceous sandstone in the south forms lower less dissected tablelands at 500–1000 ft above sea level, probably capped by weathered rock and laterite or by deep sand.

Starcke (unit 2) is the land system developed on these sandstones.

(*c*) *Greywacke and Other Sediments*

In the south-east lies an extensive area of folded Upper Silurian to Lower Carboniferous sedimentary rocks. While greywacke is the dominant rock type, other sediments such as conglomerate, sandstone, shale, limestone, and chert are present and vein quartz is locally abundant. Altogether these rocks cover 10% of the Mitchell–Normanby area. They are highly folded with some faulting and local mineralization and have probably been affected by uplift in the Tertiary. There are few signs of Tertiary deep weathering or detrital cover, probably on account of the relatively rapid erosion and considerable relief energy. Furthermore, extensive areas have been exposed to weathering and erosion only in later Cainozoic times after stripping of a former cover of basalt or Cretaceous sediments.

The relief ranges from steep mountains rising to over 3000 ft above sea level (Starcke land system unit 3 and part of Rumula land system) to undulating lowlands (Hodgkinson land system) carved out along the upper Mitchell and other major rivers and on less resistant sediments in the Chillagoe area. Most of the relief, however, consists of low hills with local relief 50–300 ft (Maytown land system) and closely spaced narrow valleys giving rise to short steep slopes with an intricate drainage pattern. In the Chillagoe area limestone beds form spectacular rocky ridges rising abruptly 100–300 ft above their surroundings. Soils are generally shallow and stony on the middle and upper slopes and somewhat deeper on the restricted colluvial cover of the lower slopes. Alluvium is practically absent.

(*d*) *Metamorphics and Granite*

Precambrian metamorphic rocks crop out in a meridional belt running through the centre of the area and extending over some 5500 sq miles (10% of the area). The rocks include schist, gneiss, quartzite, serpentinite, amphibolite, and granite. On the east the belt terminates at a powerful fault zone, while to the west it is overlain by Cretaceous sediments. The fault zone has been repeatedly active during an immense period of time extending up to the latter part of the Tertiary. The strike of the metamorphics is dominantly NNW.–SSE. but locally swings around granitic intrusions. In places the rocks are partially obscured by a thin cover of weathered detrital sand and gravel; the weathered zone may penetrate through the cover into the basement in these areas. However, most of the metamorphics are little weathered and soils are generally shallow and outcrops frequent. On some of the granitic rocks, on the other hand, the micas and feldspars have been leached out, leaving deep residual quartz sand.

Although these rocks are fairly resistant they have been subjected to such prolonged erosion in both pre-Cretaceous and post-Cretaceous times that they have generally been worn down to a gently undulating erosion surface between 500 and 1000 ft above sea level, rising to 1500 ft in the extreme south. More broken relief is found on the eastern margin of the metamorphics where there has been comparatively recent uplift along the boundary fault zone; elsewhere particularly resistant beds form ridges a few score to a few hundred feet high.

In the southern part of the area some Palaeozoic granites have given rise to types of country that are similar but locally diversified by numerous rocky tors. Throughout both the metamorphic belt and granites, alluvium is of very restricted extent; it is probably sandy and subject to flooding. Over most of the metamorphics the vegetation is open eucalypt woodland and on the air photographs a rather weakly developed linear arrangement of trees parallel to the strike can be discerned, though it is not readily apparent on the ground.

Apart from minor parts of Starcke land system (unit 1), Arkara is the sole land system on these rocks.

(*e*) *Basalt*

This is the least extensive rock type, occupying only 0·5% of the area. It forms Lukin land system which consists of undulating plains or low rocky mesas with either fairly deep red soils or stony brown loams and clay soils.

(*f*) *Shale, Claystone, and Siltstone*

These sediments of Cretaceous age probably underlie the entire western half of the area as well as extensive tracts of the Laura plains. However, they are largely obscured by younger Cainozoic deposits and are actually exposed over only 6% of the area, mainly in the north-east, north-west, and south. They are horizontal or dip very gently seawards and are unresistant and not deeply dissected. Consequently they form plains and gently undulating lowlands with deep soils and slopes rarely exceeding two degrees. They have been deeply weathered but the weathered zone has been partially or completely stripped in some places; elsewhere mottled and pallid zones survive and are exposed in low breakaways or creek incisions. Thin patches of Tertiary sand and gravel overlie the Cretaceous sediments in places, particularly at Fairview in the north-east, and have protected the underlying weathered shale or claystone from erosion.

Maple, Brixton, Annaly, and parts of Mottle are the land systems associated with these rocks. Broadly speaking, these land systems comprise four types of country in varying proportions: cracking clay soils with deciduous scrub and grassland, box woodland on loamy soils, bloodwood–stringybark woodland on earth soils, and paperbark woodland on texture-contrast soils. The deciduous scrub and grassland are associated with unweathered shale and claystone; the paperbark and box woodland are found partly on siltstone and partly on a very thin Tertiary sand cover. The bloodwood–stringybark occurs where this cover is thicker. The cracking clay soils form the best pastoral country and have considerable potential for cultivation but they occupy only less than 1% of the Mitchell–Normanby area.

(*g*) *Weathered Terrestrial Deposits*

These deposits form by far the most extensive rock type, occupying 31% of the area mainly in the north and centre. They consist of a mantle of detrital sediments from a few feet to a few score feet thick, ranging from gravel to clay but mainly sandy or loamy. They were laid down in Tertiary times (presumably by streams or sheet floods) over the planed-off surface of older rocks or the upper surface of Cretaceous marine sediments. The deposits are deeply weathered and their formation has been intimately associated with the development of a laterite profile. Actually, consolidated laterite is rarely exposed but it is possibly widespread. Silcrete (grey billy) was found *in situ* only in the driest part of the area occupied by these rocks where the rainfall is barely 35 in.

The surface of the terrestrial deposits is level or very gently undulating in keeping with its depositional origin and, where undissected, forms extensive sandy or loamy plains on major divides and on low plateaux, notably "The Desert" in the north-centre of the area. This is Koolburra land system.

For the most part, however, the weathered terrestrial deposits have been shallowly dissected by wide valleys with flat floors and gently sloping sides with gradients rarely exceeding three degrees and often less than one degree. These widely spaced shallow valleys and broad undissected interfluves form Balurga land system which covers nearly one-quarter of the entire Mitchell–Normanby area. The upper reaches of the valleys usually have no channel and erosion is practically at a standstill although the presence of a siliceous hardpan implies active solution and redeposition of silica. Downstream, shallow channels 1–5 ft deep cut into the floor and often expose the siliceous hardpan. On the gently sloping sides of the valleys a catenary arrangement of soils and vegetation is clearly developed, passing from bloodwood–stringybark woodland on deep earths or sands on the upper parts to texture-contrast soils with paperbark or grassland on the lowest parts.

Thousands of shallow subcircular closed depressions up to 500 yd across occur in Balurga land system, particularly in the north-west. They usually have seasonally flooded clay floors 2–10 ft below the surrounding sandy plains. While some are formed through damming of old watercourses by drifting sand, the origin of others, particularly those on the interfluves, is obscure. They may be deflation or solution features.

On the margins of Balurga land system superficial stripping and alluviation give rise to plains with paperbark scrub and small patches of eucalypt woodland often on very slight rises mapped as part of Mottle land system. Possibly this stripping has removed the weathered detrital sediments entirely in places and the landscape may be developed on the underlying Cretaceous siltstone.

(*h*) *Older Alluvium and Colluvium*

In the south-west of the area an immense alluvial plain was laid down in Plio–Pleistocene times by the Mitchell, Gilbert, and smaller streams. The plain is about 100 miles wide and rises gradually from the Gulf of Carpentaria to about 250 ft above sea level at its inland margin where it grades into, or abuts against, the dissected older deposits forming Balurga land system. Coarser material naturally tends to predominate in the upper, inland portions whereas finer material is more common in the distal parts. Smaller spreads of similar material occur on the lower Normanby River in the north-east. Colluvial and alluvial fans and aprons below hill and mountain masses in the east are also believed to be of similar age and origin though of much more restricted extent.

Within the older alluvium and colluvium three types of landscape have been recognized. The first is a monotonous plain with very shallow widely spaced valleys and a uniform pattern on the air photographs, which has been mapped as Leinster land system. The material is often cemented by silica, particularly in the valleys, to form a hard sandstone or fine conglomerate into which streams such as the Staaten River are incised 5–30 ft. These incised streams contain long permanent water-holes in many places. The slopes of some of the larger valleys have scalded areas and low breakaways where weathered profiles believed to be younger than those of Balurga land system are exposed. In the south of the area Leinster land system grades into part of Mottle land system, from which it is not always readily distinguishable as paperbark woodland tends to predominate on both.

The second type of country on the older alluvium and colluvium comprises Dunbar land system. It consists of more diverse plains than those of Leinster land system, with old levees and channels of former distributaries of the Mitchell and seasonally flooded depressions. It is probably more subject to flooding than Leinster land system but both must have much surface water at times on account of the heavy rainfall in the wet season and the low gradients. The materials and soils of Dunbar land system are finer-grained than those of the Leinster land system and box woodland is more common. Dunbar land system often grades into Leinster land system and into land systems on younger materials so that its delineation on the map is only approximate.

The third type of country consists of Ninda land system which occurs on alluvial and colluvial fans and aprons at the foot of steep hill country from Cape Melville south to Mareeba. The material is probably highly variable, ranging from coarse gravel to clay, and of varying ages and degrees of weathering. The situation below steep ranges suggests that extensive flooding is likely.

(*i*) *Younger Alluvium*

Alluvial deposits of Pleistocene to Recent age cover about 8% of the area. Alluvium is very restricted along the middle and upper reaches of even the larger rivers but forms extensive spreads along the lower Mitchell, Gilbert, and Normanby Rivers and north-west of Princess Charlotte Bay. On the basis of air-photo patterns and field observations, at least two generations of younger alluvium have been identified. However, differences between the two generations are not always clear-cut and their mapping is consequently only an approximation.

Both generations have a well-developed system of channels, levees, back plains, and back swamps. The channel pattern becomes progressively more intricate downstream as the number of distributaries increases and the elements of the relief consequently tend to become smaller and more closely juxtaposed.

The earlier generation has been mapped as Radnor land system. It tends to have deep mature soils and in middle reaches of the major valleys it forms a distinct terrace. Channels and back swamps have clay floors and form quiet backwaters in the wet season or permanent lagoons. Levees are silt or fine sand and subject to scalding and badland erosion. The back plains are often above present floods but parts are probably under standing water at times in the wet season because of low gradient and high rainfall.

The later generation of alluvium forms Cumbulla land system. Most of it is seasonally flooded and the soils are less mature than those of Radnor land system. The channels have a bed-load of sand or gravel and are fringed by minor terraces and linear depressions under gallery forest. The levees are sandy while the back plains are mainly clay.

(j) *Coastal Sediments*

Coastal sediments of Recent or Pleistocene age fringe the entire west coast, occupy an extensive area round Princess Charlotte Bay, and occur sporadically on the east coast. Their area amounts to some 2250 sq miles. The inner margin of the coastal sediments is marked by an old beach ridge system almost certainly of interglacial age. Contrary to what has been observed in many other parts of the world, there is no evidence that the sea was ever more than a few tens of feet above its present level during the Pleistocene.

The sediments consist of clay or sand. The clay forms tidal mud flats, mapped as Battersea land system, which are either bare or have a scanty cover of halophytic vegetation. Some clay flats are inundated at every tide while others are affected only by occasional high spring tides. Winding tidal creeks fringed by mangroves occur particularly at river mouths.

In slightly higher situations the clay now forms sedge- or grass-covered plains above tide level, often gilgaied and subject to flooding from rivers and from heavy rainfall in the wet season. These higher clay plains probably originated as tidal and lagoonal flats. On the lower Normanby River it has not been possible to delimit accurately the break from coastal clay plains to alluvial clay plains built up by the river.

The sand element of the coastal sediments occurs as low beach ridges running more or less parallel to the coast or as parabolic dunes aligned south-east to north-west parallel to the prevailing dry-season winds. The beaches are usually built of quartz sand but shell sand also occurs in places. The inner ridges are older and less clear-cut, their form having been modified by wind, erosion, and soil formation. The beach ridges together with the higher clay plains form Inkerman land system.

The parabolic dunes form Flattery land system which is confined to the east coast principally in the Cape Flattery–Cape Bedford area. They form linear ridges up to 200 ft high rising above swampy or lake-filled hollows. Several generations of dunes can be recognized on the air photographs. The older ones have deep soils and are covered by dense vegetation but are still subject to local blow-outs, probably after fires. The younger dunes have shallower soils and the youngest, close to the present beach, are still accumulating.

III. History of the Landscape

Prolonged erosion in early Mesozoic times formed a level to gently undulating surface cut across deformed older rocks. During the Jurassic and Cretaceous periods, seas invaded the land and deposited sandstones, shales, and claystones on both eastern and western sides of the Cape York Peninsula. The maximum extent of these deposits is not known but they may have covered all but the highest parts of the area. Sedimentation was interrupted in the south-east by uplift, which caused erosion to strip the Mesozoic cover and bite deeply into the underlying older formations; sedimentation was terminated by withdrawal of the sea at the close of the Cretaceous period.

During the Tertiary, erosion was active on the higher areas of the centre and south-east, with concomitant deposition of thin terrestrial sediments over enormous areas in the west and round Princess Charlotte Bay. Deep weathering of these deposits took place and limited areas of basalt were poured out over older rocks in the south-east and on the coastal plain near Cooktown. Later, the extensive plains formed by the Tertiary sediments were dissected by shallow valleys.

In late Tertiary times two phases of renewed deposition, associated with deep weathering, laid down extensive alluvial plains on the lower Mitchell and Normanby Rivers and locally on foot slopes below steep ranges in the east.

At least two further phases of alluviation occurred in the Pleistocene giving rise to plains with an intricate relief of levees, channels, and back plains. In the Pleistocene, interglacial and post-glacial marine transgressions formed several generations of shoreline features near the coast. The large dune complex in the Cape Flattery area was probably also formed in response to Pleistocene climates.

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PART V. SOILS OF THE MITCHELL–NORMANBY AREA

By R. H. Gunn*

I. Introduction

Owing to wide variations in environmental conditions in the area there is correspondingly great diversity in soil-forming factors. Of greatest importance have been the influence of past climatic and hydrologic regimes and the effects of weathering, erosion, and deposition over wide areas. Parent rock lithologies vary considerably and relief ranges from the nearly level coastal plains slightly above sea level to mountains rising above 4000 ft along the eastern border. Altitude, distance from the sea, and prevailing winds influence the amount and distribution of rainfall which ranges from 70 in. in the north-east to about 30 in. in the extreme south. Variations in rainfall and drainage conditions affect the distribution of vegetation and soil fauna, and consequently affect profile development.

Three major soil zones can be distinguished in the area. Most extensive is a catenary sequence of red and yellow earths, uniform sandy soils, and texture-contrast soils. This occurs in the western and Laura plains physical regions (Fig. 2) on strongly weathered variously dissected terrestrial sediments in the centre and north-east of the area. Sandy highly leached soils with low levels of fertility predominate. The second zone comprises leached grey and brown massive earths and alkaline and saline fine-textured soils in the lower Mitchell and coastal plains regions. Most of these soils are poorly drained and liable to flooding, and some are affected by salinity or siliceous hardpan. The third zone consists mainly of shallow sandy, gravelly, or rocky soils in the eastern highlands and central uplands regions.

The southern boundary of the area is contiguous with that of the Leichhardt–Gilbert area surveyed in 1953–54 (Perry *et al.* 1964). The soils of the adjoining land systems in that area are described by Sleeman (1964) but, for reasons given in Part I of this report, correlations between the two areas are poor, and only the solonchak soils of the coastal plains and the skeletal soils of hills and mountains are coincident. Other previous soil studies in or near the area were limited to the observations on lateritic soils by Simonett (1957) and a mineralogical examination of soils on basalt in the Cairns–Atherton region by Simonett and Bauleke (1963).

The scope of the soil investigation reported in this Part was a very broad rapid reconnaissance based on the examination of aerial photographic patterns and 220 field observations. A soil survey of the Cape York Peninsula for the Atlas of Australian Soils was carried out concurrently with the survey reported here by Mr. R. F. Isbell, of the CSIRO Division of Soils, using the factual key of Northcote (1965). Most of the field observations made by Mr. Isbell have been incorporated in this report, and his generous assistance and cooperation are gratefully acknowledged.

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TABLE 6

SOIL GROUPS AND FAMILIES

Major Group	Family	Brief Description	Appropriate or Approximate Equivalent Names	Principal Profile Form (Northcote 1965)
Alluvial soils	Morehead	Uniform coarse-textured soils	Alluvial soils (Stephens 1962)	Uc2.12, 2.21
	Helenvale	Uniform medium-textured soils		Um4.2, 5.5
	Bosworth	Uniform fine-textured soils		Uf1.43
	Nassau	Saline, uniform, fine-textured soils	Solonchak (Stephens 1962)	Uf6.61
Cracking clay soils	On marine clays			
	Carpentaria (Sleeman 1964)	Saline dark grey soils	Solonchak (Stephens 1962)	Ug5.4
	On old fluvial–marine clays			
	Marina	Dark grey and greyish brown saline alkali soils	Grey and brown soils of heavy texture (Stephens 1962)	Ug5.16, 5.28
	Alluvial materials			
	Kooltah	Dark greyish brown strongly alkaline soils		Ug5.16, 5.24, 5.5
	Yanko	Brown and greyish brown acid soils		Ug5.24
	Gilbert	Gilgaied, dark brown and greyish brown alkaline soils		Ug5.24, 5.34
	Sedentary on shales			
	Wrotham	Black to very dark greyish brown alkaline subsoils	Black earths (Stephens 1962)	Ug5.12, 5.14, 5.16
Texture-contrast soils	Gamboola	Thick sandy surface soils; acid to mildly alkaline subsoils	Soloths (Stephens 1962)	Dy3.41, 2.42, 2.81
	Stewart	Thick sandy surface soils; strongly alkaline subsoils	Solodized solonetz and solodic soils (Stephens 1962)	Dy 3.43, 3.23, 2.83
	Hanna	Thin sandy or loamy surface soils; acid to mildly alkaline subsoils	Soloths	Dy3.41, Db1.12
	Alice	Thin sandy or loamy surface soils; strongly alkaline subsoils	Solodized solonetz and solodic soils	Dy3.43, Db1.43

Massive earths	Kimba	Sandy red earths	Lateritic red earths (Stephens 1962)	Gn2.14, 2.15
	Coleman	Loamy red earths		Gn2.14, 2.15
	Clark	Sandy yellow earths	Yellow earths (Stephens 1962)	Gn2.25, 2.22, 2.62
	Kalinga	Loamy yellow earths; acid to neutral subsoils		Gn2.22, 2.25, 2.85
	Welcome	Loamy yellow earths; strongly alkaline subsoils		Gn2.23, 2.56, 2.86
	Brooklyn	Shallow gravelly earths		Gn2.24, 2.14, 2.82
	Staaten	Leached grey and brown acid to neutral earths	*Grey lateritic soils* (Simonett 1957)	Gn2.94, 2.85
	Crowbar	Leached grey and brown earths with hardpan		Gn2.94, 2.85
	Lorraine	Leached grey and brown alkaline earths		Gn2.66, 2.86, 2.93
Structured red and brown soils	Springvale	Gradational or uniform red loams and clays; acid to neutral	Krasnozems (Stephens 1962)	Gn3.11, 3.12, Uf6.31
	Wyaaba	Gradational brown loams; acid to neutral subsoils		Gn3.05, 3.25
	Waterhole	Gradational or uniform brown loams; strongly alkaline subsoils		Gn3.93, Uf6.33
Uniform medium- to fine-textured soils	Frazer	Deep red and brown acid loams and clays		Uf4.2
	Mimosa	Deep brown and yellowish brown alkaline clays		Uf6.41
	Maitland	Shallow gravelly acid loams and clays		Um4.1, Uf4.1
Uniform sandy soils	Healy	Deep red and reddish brown soils	Brown soils of light texture (Stephens 1962)	Uc2.12, 2.21
	Bridge	Deep brown and yellowish brown soils		Uc2.21
	Bathurst	Deep grey and greyish brown soils		Uc2.12, 2.21
	Dinah	Deep, fine, well-sorted beach sands	Aeolian sands (Stephens 1962)	Uc1.21
	Cardwell	Shallow gravelly soils		Uc2.12, 4.11
Shallow rocky soils	Mungana	Uniform coarse-textured soils	Skeletal soils (Stephens 1962)	Uc1.21, 4.11
	Emu	Uniform medium-textured soils		Um1.41, 4.1

II. Soil Groups and Families

The soils of the area have been arranged in 8 major groups and 36 families as shown in Table 6. The major groups are differentiated partly on a textural basis following the uniform, gradational, and duplex primary profile forms of Northcote (1965) and partly according to the nature and mode of formation of parent materials. They are generally broader than great soil groups. The families are distinguished according to differences in texture and thickness of surface horizons, reaction, parent material, colour, depth, and salinity. They have been given geographic names from the area and related to appropriate or approximate equivalent names where possible.

III. Descriptions of the Soils

The following soil descriptions are based on the examination of profiles by 2-in. and 3-in. auger borings. Sites were selected according to photographic patterns distinguished mainly by differences in land form and vegetation, and wherever possible profiles were examined to depths of 36 in. or more. The terms used to describe the soils are those of the Soil Survey Manual (United States Department of Agriculture 1951). Samples for analysis were collected from 15 profiles that were later allocated to 9 families and the few analytical data are included in the descriptions.

(*a*) *Alluvial Soils*

The soils of this group occur on recent alluvial deposits and show little or no profile development apart from humic staining at the surface. These soils are widespread but occur in relatively small areas that cannot be shown on the accompanying soils map. They are clearly distinguishable from soils formed from older alluvial materials in which soil-forming processes have given rise to changes in texture, structure, colour, and other properties not present in the original materials. They occur on alluvial flats and fans in process of construction, often in association with older soils with well-developed horizons. The group comprises four families differentiated according to variations in texture and salinity.

(i) *Morehead*.—The soils of this family are medium sands that are either uniform to depths of 4 ft or more or underlain by layered finer-textured materials and gravel at about 2 ft. They occur on levees or in old channels and support woodlands of bloodwood. Colours are dark brown or grey at the surface and grade to brown or yellowish brown beneath. They are structureless and reaction is slightly acid throughout.

(ii) *Helenvale*.—These soils are uniform sandy to silty clay loams or loams and are generally underlain by layered materials of mainly coarser textures at about 2 ft. Some have uniform textures to depths of $3\frac{1}{2}$ ft or more. They occur mainly in Cumbulla and Ninda land systems under woodlands of Timor white gum, Moreton Bay ash, bloodwood, blue gum, or grassland, and are subject to flooding. Colours are dark brown to black at the surface and grade to brown, yellowish brown, or reddish brown. Soil reaction is slightly to moderately acid throughout.

(iii) *Bosworth*.—These soils are uniform silty or light clays throughout, sometimes with a thin silty overlay at the surface. They occur in Cumbulla land system and support woodlands of cabbage gum or grassland. They are dark brown at the surface and grade to yellowish brown at about 12 in. Structure is massive, consistence is firm, and reaction is slightly acid throughout. They are probably subject to overflow.

(iv) *Nassau*.—The soils of this family are solonchaks with crusty or puffy salt-encrusted surface soils. They are deep uniform olive to olive-grey light to medium clays which are massive and strongly alkaline throughout and prominently mottled below the surface layer. They have formed on fluvial–marine deposits in Inkerman land system on the coasts and are either bare of vegetation or support scattered patches of samphire. They are probably flooded seasonally by overflow or by high tides in places and are permanently moist or wet below the surface few inches. They occur in association with the soils of Carpentaria and Dinah families.

(*b*) *Cracking Clay Soils*

The soils of this group are moderately deep to very deep medium to heavy clays with marked shrinking and swelling properties and imperfect to impeded drainage. They have formed mainly on fine-textured fluviatile and/or marine alluvial deposits south of Princess Charlotte Bay, near the Gulf coast, and on old flood-plains of the larger rivers and creeks. There are some extensive though rather scattered occurrences of sedentary soils developed on materials derived from Cretaceous shales in the south and north-east of the area.

On the basis of 31 observations the soils have been placed in four subgroups according to differences in parent materials and six families on the basis of differences in soil reaction, microrelief, soluble salt content, and colour (Table 6). Most of these soils are grey and brown soils of heavy texture (Stephens 1962).

(i) *Carpentaria* (Sleeman 1964).—These soils are dark strongly alkaline medium to heavy clays with a soft flocculated salty layer at the surface when dry. They occur on the coastal plains in Battersea land system and are either barren or support a sparse cover of samphire. They are liable to flooding by rain or overflow during the wet season and possibly also by high tides. In places they occur in association with low sandy beach ridges and kitchen middens. Large cracks form in the surface soils when they are dry but subsoils probably remain moist permanently.

Colours are very dark grey to olive-grey at the surface and there is a gradual change to dark greyish brown, greyish brown, and light grey with increasing depth. There are many large prominent brown mottles below 12 in. The soft flocculated puffy surface layer of 1–2 in. has abundant very fine crystals of sodium chloride, and below this there is a firm subangular blocky horizon of about 4 to 6 in. The underlying soil is massive. In the three profiles examined the soils were moist at shallow depths and became very moist to wet and very plastic and sticky at about 2 ft. About 10% soft carbonate occurred in one profile at 2–5 in. and there were numerous shell fragments and occasional large carbonate concretions below 24 in. The soils are generally calcareous and strongly alkaline throughout.

(ii) *Marina*.—These soils occur on plains inland from the coastal plains of Battersea land system and have formed on older marine clays and/or fine-textured alluvial deposits in Inkerman land system. They have slightly developed gilgai microrelief (6–12-in. interval between mound and depression), support a grassland vegetation of salt-water couch and sedges, and are probably subject to seasonal flooding by rain or overflow. They are very dark grey to dark greyish brown medium to heavy clays that gradually become greyish brown and olive-grey with many prominent brown or yellow mottles below 2–3 ft. Two profiles examined to depths of 60 in. near the eastern coast contained 10–15% carbonate in the form of soft accumulations or hard concretions in the upper 2–3 ft and shell fragments were numerous at depths below 3 ft. These profiles were slightly to moderately calcareous and reaction was strongly alkaline below the surface few inches. In one other profile near the Gulf coast about 10% fine gypsum crystals occurred below 3 ft and carbonate was absent. In this profile, reaction increased gradually from slightly acid at the surface to strongly alkaline below 4 ft. Structure and consistence in the three profiles were medium to coarse blocky and firm to hard to depths of 2–3 ft, and massive, soft, and plastic in the very moist subsoils.

Analytical data in respect of two profiles, one in the east and one in the west of the area, indicate that these soils have moderate to high contents of soluble salts (0·53–0·98%) and exchangeable sodium percentages exceeding 15 (range 25–41). Cation exchange capacities are moderately high (17–20 m-equiv./100 g soil) and the soils are 100% base saturated. Magnesium is the dominant metal ion and sodium and calcium ions occur in about equal proportions. Values for exchangeable potassium are about 1 m-equiv./100 g throughout the profiles to 60 in. depth. Clay mineral analyses indicate that montmorillonite, illite, and kaolin are present in about equal proportions. Amorphous material with properties possibly between montmorillonite and illite was present in significant amounts in the sample from the eastern site.

(iii) *Koolatah*.—The soils of this family are very deep dark grey to brown clays with strongly alkaline mottled subsoils. They occur mainly on alluvial plains adjacent to the larger rivers and creeks in Cumbulla and Radnor land systems under grassland or, less commonly, box and gutta-percha or paperbark woodlands. Most areas of these soils are probably subject to seasonal or occasional flooding.

There is commonly a silty clay overlay of 6–9 in. at the surface and underlying textures are medium to heavy clays. Colours at the surface are very dark grey to very dark greyish brown grading to dark yellowish brown, brown, or olive-brown at depth where many prominent yellowish brown mottles generally occur. Structure is medium to coarse angular blocky throughout or becomes massive at depths below 3–4 ft and consistence is firm to very hard. Small to moderate amounts of carbonate concretions are commonly present below 3 ft. Soil reaction is moderately acid at the surface and gradually becomes strongly alkaline at depth.

Analytical data on three profiles indicate that the soils contain only small quantities of soluble salts (up to 0·2%) at depths below 2 ft but exchangeable sodium percentages generally exceed 30 below the surface few inches (range 19–54). Exchange capacities are rather variable but are low to medium (6·4–13·4 m-equiv./100 g soil) in surface soils and medium (more than 12 m-equiv.) in subsoils. Exchangeable sodium is the dominant metal ion below the first foot and magnesium and calcium ions occur in about equal proportions. Exchangeable potassium is low in the surface soil (range 0·08–0·26 m-equiv./100 g soil) and increases slightly at depth. Clay mineral analysis of samples from the three profiles indicated that illite was the dominant mineral in one with amorphous material subdominant and kaolin accessory. In the second profile kaolin was dominant, illite subdominant, and amorphous material accessory (<20%). In the third profile montmorillonite, illite, and kaolin were present in about equal proportions.

(iv) *Yanko*.—These soils have developed on old alluvial plains in Leinster and Radnor land systems and in some rounded depressions in Balurga land system, and differ from those of Koolatah family in having slight to medium acid reactions throughout and commonly extremely hard consistence in subsoils. The common vegetation is paperbark woodland with some box including coolibah. The surface soils are dark greyish brown to brown light to medium clays that grade to brown or grey medium clays in the subsoils. Prominent yellowish brown mottling occurred throughout four of the five profiles examined and indicated that these soils are subject to seasonal flooding or waterlogging. Structure is angular blocky and consistence is firm to hard in the upper 2–3 ft and extremely hard beneath. Soil reaction is slightly to moderately acid throughout. Flakes of blackened organic material are common on the surface and at two sites in Leinster land system there was evidence of subsurface erosion in the form of numerous small depressions and tunnels.

Analytical data in respect of one profile indicate a remarkably low exchange capacity for a clay soil (6·3–7·1 m-equiv./100 g soil). Calcium is dominant in the upper 2 ft and magnesium is dominant below that depth. Soluble salts and exchangeable sodium are present in negligible amounts. Clay mineral analysis on samples from two profiles indicated that illite was dominant or co-dominant with kaolin.

(v) *Gilbert*.—These soils are deep medium to heavy clays with moderately developed melon-hole gilgai microrelief. The vertical intervals between mounds and depressions are about 1–2 ft and large arcuate cracks commonly occur in the depressions. Of the three profiles examined two occurred on plains in Dunbar land system and one in an alluvial situation in Hodgkinson land system. Paperbark woodland or open box and gutta-percha woodlands occur in these areas. Colours at the surface are brown to dark greyish brown and grade to yellowish brown at 2–3 ft. These profiles had many prominent brown and yellowish brown mottles throughout, indicating impeded drainage and seasonal flooding or waterlogging. Structure is subangular to angular blocky and consistence firm to hard. Soil reaction at the surface is slightly acid and gradually becomes strongly alkaline at depths below 2 ft where small amounts of hard carbonate concretions occur.

Analytical data on two samples taken between 2 and 5 ft in one profile in Dunbar land system indicate that the soil is only slightly affected by soluble salts (0·17%) and exchangeable sodium (17%) below 3 ft. The cation exchange capacity ranged from 15·1 to 16·6 m-equiv./100 g in the two samples and calcium and magnesium were the dominant and subdominant metal ions respectively. Clay mineral analysis on a sample taken at a depth of 2–3 ft from one profile indicated that illite, kaolin, and amorphous material were present in about equal proportions.

(vi) *Wrotham*.—The soils of this family are very dark moderately deep to very deep cracking clays developed on Cretaceous shale materials in Maple and Brixton land systems near Wrotham Park and Fairview. The relief is very gently undulating to nearly level with slopes mainly 1–2%, occasionally up to about 4%. Linear gilgais occur in some areas. Grassland or deciduous scrub is characteristic but open woodlands of box occur in some areas. Eight profiles were examined. The soils are uniform medium to heavy clays that develop deep wide cracks when dry. Colours at the surface are black to very dark greyish brown and grade to dark grey or greyish brown below 2 ft. Prominent mottling occurs in the lower profiles in some poorly drained situations. Structure in the upper 2–3 in. is mainly medium subangular blocky but is granular in some well-drained sites where there is a tendency to form a self-mulching surface layer. The underlying soil has medium to very coarse blocky structure and firm to very hard consistence. Soil reaction at the surface is slightly acid to neutral and grades to strongly alkaline at depths of 4 ft or more. Slight to moderate amounts (up to 10%) of carbonate concretions are commonly present in the lower parts of profiles and small amounts of gypsum are sometimes present. A gravelly phase occurs where residuals of deeply weathered Tertiary sandstone which once formed a complete cover occur upslope of these soils.

Analytical data on samples collected at three sites indicate that these soils are not affected by soluble salts and exchangeable sodium percentages are generally very low. In one profile in a sample taken at a depth of 3–4 ft, exchangeable sodium comprised 13% of the exchange capacity. Cation exchange capacities are high to very high (range 27–57 m-equiv./100 g soil). In one profile calcium was the dominant metal ion and it was codominant with magnesium in the second. In the third profile magnesium was dominant and calcium subdominant. In the surface soils exchangeable potassium values ranged from 0·5 to 1·12 m-equiv./100 g soil. Clay mineral analyses on samples from the three profiles indicate that amorphous material, with properties possibly between montmorillonite and illite, was dominant (>50%). In two profiles kaolin was subdominant or accessory and in the third illite and quartz were both accessory (<20%).

(c) *Texture-contrast Soils*

This group comprises all soils with sandy or loamy surface horizons and abrupt boundaries to clayey subsoils. Bleached subsurface horizons are generally present, subsoils are mainly greyish brown to yellowish brown and prominently mottled, and reaction ranges from strongly acid to very strongly alkaline. Structure of surface soils ranges from single-grained to massive and in subsoils from massive to blocky or occasionally columnar. Similar soils are widespread in other parts of Queensland. On the basis of their morphological characteristics most are considered to be solodized solonetz, solodic soils, or soloths formed under the influence of high levels of exchangeable sodium and/or magnesium leading to dispersion and illuviation of clay in parent materials. Some are probably polygenetic soils formed by the deposition of coarse-textured materials over older clays. Almost all these soils are poorly drained and subject to seasonal flooding or waterlogging.

These soils have formed in a wide range of parent materials but mainly in alluvial and colluvial deposits in Cumbulla, Radnor, Leinster, Mottle, Balurga, and Ninda land systems. Most commonly they have developed on nearly level alluvial plains, gently sloping colluvial land, and in drainage depressions in areas of denuded Tertiary weathered zones. They occur throughout the area under varying rainfall and drainage conditions. In the high-rainfall area in the east they tend to have acid reaction throughout, but some with strongly alkaline subsoils occur in parts that receive 50 in. or more a year.

On the basis of 36 observations the group is subdivided into four families according to differences in the combined thickness of surface and subsurface horizons and reaction of subsoils. A somewhat arbitrary depth of 10 in. has been taken as the boundary between thick and thin surface soils but there is a broad correlation between the families and the plant communities they support.

(i) *Gamboola*.—The soils of this family have sand to sandy loam surface horizons 20 in. thick on average (range 12–28 in.) over greyish brown to yellowish brown, generally mottled, sandy clay to heavy clay medium acid to neutral subsoils. The humic-stained surface soils are dark greyish brown to black and about 4 in. thick. They have single-grain to massive structure, soft to hard consistence, and slight to medium acid reaction. There is a gradual boundary to the subsurface horizons which are generally bleached light grey or pale brown and occasionally contain quartz gravel or concretionary ironstone.

The subsoils are generally sandy or light clays (range sandy clay loam to heavy clay) and there is an abrupt boundary with the overlying material. Colours are mainly greyish brown or yellowish brown with many prominent red or yellow mottles. Structure is angular or subangular blocky, occasionally columnar or massive, and consistence is hard to extremely hard. Soil reaction is medium acid to mildly alkaline.

These soils were found mainly on gentle lower slopes in Balurga, Mottle, and Leinster land systems, and woodlands of paperbark either in pure stands or mixed with box occurred at 11 of the 14 sites examined. At the other sites were grassy woodlands of box. Large termite mounds, commonly the "magnetic" type, were frequently present in areas of these soils.

(ii) *Stewart*.—These soils are similar to those of Gamboola family but reaction in subsoils is strongly to very strongly alkaline. Surface soils are mainly dark grey to dark greyish brown loamy sands to sandy loams, occasionally silty loams. They have massive structure, firm consistence, and set hard when dry. Thickness of surface horizons in ten profiles averaged 20 in. (range 11–38 in.). Subsurface horizons are mainly bleached light grey or brownish grey.

Subsoils are light to medium clays with blocky structure and hard to extremely hard consistence. Columnar structure was noted in one profile. Colours are mainly greyish brown or brown and prominent yellowish brown or reddish brown mottles commonly occur. About 5% hard concretionary carbonate was noted in one profile.

These soils have formed mainly in old alluvial materials in Cumbulla, Radnor, Leinster, Mottle, and Balurga land systems, but they have also developed on materials derived from metamorphic and other rocks. Large termite mounds are common and "tussock mounds" up to 4 in. high, formed by earthworms around grass tussocks, occur in some areas subject to flooding and waterlogging. Open grassy woodlands of box occurred at five of the ten sites examined, paperbark occurred at four sites, and grassland at one site.

(iii) *Hanna*.—Thin sand to sandy loam, occasionally silty clay loam, surface soils and light to medium clay acid to mildly alkaline subsoils separated by an abrupt boundary are the most important characteristics of this family. The average thickness of surface horizons is 8 in. There is a very thin humic-stained dark brown to greyish brown surface horizon underlain by a bleached light grey subsurface horizon. The clay subsoils are grey to yellowish brown and prominent mottling is usual. Subsoil structure is blocky and consistence hard to very hard. Paperbark woodlands or grassland with scattered box are typical.

(iv) *Alice*.—Profile characteristics are similar to those of Hanna family but subsoil reaction is strongly to very strongly alkaline. The average thickness of the sandy or loamy surface horizons in eight profiles examined was 9 in. Subsurface horizons are mainly bleached, but occasionally only sporadically, and in one profile an A_2 horizon was absent. Subsoils are grey to brown or yellowish brown and prominent mottling was present in three profiles. Structure is generally angular to subangular blocky but coarse columnar structure occurred in two profiles. Grassy woodlands of box predominate.

(*d*) *Massive Earths*

This group of soils is the most extensive and widespread in the area. Their main characteristics are gradational texture profiles in which the clay content gradually increases with depth, massive structure, and earthy porous fabric in the subsoils. Some members are similar to the strongly leached soils that are widespread in many other parts of Australia, generally with moderately acid to neutral reaction, kaolinoid clay minerals, high sesquioxides, and varying amounts of concretionary ironstone. Subsoil colours range from red to yellowish brown to grey. Many of the soils have pale-coloured subsurface (A_2) horizons and prominent mottling is common in the subsoils of some families.

The group comprises eight families differentiated according to variations in texture, colour, reaction, consistence, and depth as shown in Table 6. The term "sandy", used in respect of the red and yellow earths, denotes sandy loam or coarser textures to a depth of 2 ft or more and "loamy" denotes sandy clay loam or finer textures at depths of less than 2 ft in the profiles. The group includes the lateritic red earths and yellow earths of Stephens (1962) and, in part, the grey lateritic soils of Simonett (1957).

The soils have formed on a wide range of parent materials but are most extensive in Koolburra and Balurga land systems on deeply weathered quartz-rich terrestrial sediments and in Leinster and Dunbar land systems on old alluvial plains of weathered materials stripped from the adjoining uplands and spread over denuded weathered zones. In the first situations, the families of red and yellow earths predominate where they generally occur on well-drained upper and middle slopes in a catenary sequence (Fig. 6). In Leinster and Dunbar land systems the leached grey and brown earths with imperfect drainage are most extensive. The loamy yellow earths and leached grey and brown earths with strongly alkaline subsoils do not appear to be very widespread but have been given independent status. They occur mainly in Radnor and Leinster land systems. Descriptions of the soils of the eight families based on 94 observations follow.

(i) *Kimba*.—The soils of this family have sand to sandy loam textures to depths of 24 in. or more and there is a gradual increase in clay content to sandy clay loam or light clay in the subsoils. They are more than 50 in. deep and are well drained. They occur mainly on the slightly to moderately stripped Tertiary land surface on tablelands and the crests and upper slopes of gently undulating land mainly in Koolburra and Balurga land systems and infrequently in Mottle land system. Slopes range from about 1 to 3%, occasionally up to 5%, and the characteristic vegetation is tall woodland of bloodwood and stringybark. Colours at the surface range from dark greyish brown to grey and grade to paler colours of brown, yellowish brown, yellowish red, or light brownish grey in the subsurface and red in subsoils. Concretionary ironstone was absent in the six profiles examined but abundant gravel of subangular ferruginized sandstone was present in one profile. A surface wash of pale coarse quartz sand is common. Soil reaction is moderately acid to neutral throughout the profiles.

(ii) *Coleman*.—These soils have sand to sandy loam surface horizons that grade to sandy clay loam at depths of less than 2 ft and clay loams or light clays at depths of 3 ft or more. They occur on crests, upper slopes, and plains on strongly weathered materials derived from Tertiary sandstones, metamorphic rocks, or alluvium in Balurga, Arkara, and Cumbulla land systems. Woodlands of bloodwood, stringybark, and ironbark are characteristic. Abundant gravel is commonly present where these soils have formed on metamorphic rocks. Concretionary ironstone was present in two of six profiles examined, in one of which small amounts were present near the surface and increased to about 30% at 50 in. depth and in the other as an underlying horizon or layer at 42 in. Colours range from dark grey or dark greyish brown to reddish brown at the surface grading to dark brown, brown, or yellowish red in subsurface horizons and red or reddish brown in subsoils. Structure is massive, subsoils have an earthy porous fabric, and consistence is firm to slightly hard. Soil reaction is slightly acid to neutral throughout.

(iii) *Clark*.—These soils are similar to those of Kimba family but subsoils are yellowish brown or brownish yellow. They are more than 3 ft deep and occur on upper and mid slopes in Koolburra and Balurga land systems and on low rises or old levees in Mottle and Leinster land systems. Woodlands of bloodwood, stringybark, or paperbark occur. Surface soils are loose soft dark greyish brown to dark brown sands and loamy sands that grade to massive firm yellowish brown sandy clay loams or light clays below 24 in. A few soils with pale brown to light brownish grey subsurface horizons are included. In 11 profiles examined, hard mottled red and grey sandy clay or light clay with abundant concretionary ironstone occurred at depths of 3 ft or more. Soil reaction is slightly acid to neutral throughout.

(iv) *Kalinga*.—These soils have dark grey or dark greyish brown sandy or loamy surface soils that grade to sandy clay loam or finer textures before 24 in. and to yellowish brown light clay in the subsoils. A few of the soils have pale subsurface horizons and mottling is occasionally present in subsoils. They are more than 3 ft deep and occur in nearly level to gently undulating areas with slopes up to about 5% in Mottle, Leinster, Brixton, and other land systems. They have formed on upper and mid slopes on materials derived mainly from deeply weathered Tertiary rocks. Of ten profiles examined five contained varying amounts (5–60%) of concretionary ironstone. Several different vegetation communities are found on these soils, most commonly mixed woodlands of bloodwood, stringybark, and paperbark but also box, poplar gum, and yellowjack. Soil reaction is slightly to moderately acid throughout.

Analytical data from one profile indicate a very low cation exchange capacity (<6 m-equiv./100 g), the dominant metal ions being calcium in the surface soil and magnesium beneath. Kaolin was the dominant clay mineral in one subsoil sample.

(v) *Welcome*.—Three profiles very similar to those of Kalinga family but with strongly alkaline yellowish brown subsoils are placed in this family. They have formed on old alluvial materials in Leinster and Radnor land systems and on what are possibly colluvial materials on Cretaceous sandstone in Brixton land system. They are probably not extensive. The vegetation at two sites was a mixed woodland of paperbark and box and at the other it was grassland. Soil reaction is moderately acid at the surface, gradually increases with depth, and quite abruptly becomes strongly alkaline at about 3 ft.

(vi) *Staaten*.—The soils of this family have dark grey or dark greyish brown sandy or loamy surface soils, commonly bleached A_2 horizons, and grey to brown massive clay subsoils that are generally mottled and have firm to hard consistence. The surface soils grade to sandy clay loam or finer textures at depths of 24 in. or less. Most of the 13 profiles in this family were examined to depths of 3–4 ft and a few to 5 ft. Rock was encountered in only one profile at a depth of $3\frac{1}{2}$ ft. Varying amounts (5–40%) of concretionary ironstone occurred in four profiles and quartz gravel was present in four profiles. These soils occur extensively on nearly level plains and gently undulating areas mainly in Leinster, Dunbar, Mottle, and Balurga land systems. Slopes rarely exceed about 3%. Woodlands of bloodwood and paperbark, and less commonly stringybark, either mixed or in pure stands, are characteristic. Soil reaction is slightly acid to neutral throughout or becomes medium acid in the lower parts of profiles.

(vii) *Crowbar*.—These soils are similar to those of Staaten family but have hardpan horizons generally at depths between 12 and 24 in. from the surface (range 4–42 in.). They occur mainly on the extensive old alluvial plains of Leinster and Dunbar land systems and less commonly on lower slopes in Mottle and Balurga land systems. Woodlands of silver-leaved paperbark occurred at 10 of 14 sites examined and mixed bloodwood and paperbark at the remainder.

Textures at the surface are sands to sandy clay loams and grade to light or medium clays at depths of 2–3 ft. In some profiles loamy sand to sandy loam textures occurred below the gradational upper profile. Colours are dark greyish brown to dark grey at the surface and grade to brown, yellowish brown, or light brownish grey in subsurface horizons. Subsoils have brown, greyish brown, or grey colours with many prominent yellow and/or red mottles. Soil reaction is slightly to moderately acid (pH 6·5–5·7) throughout. The hardpan horizons have hard to extremely hard consistencies and in many cases could not be penetrated by an auger. Concretionary ironstone in varying amounts (5–20%) was present in the hardpan in five profiles and occurred as a layer above it in one profile.

Stripped weathered zones consisting of mottled- and pallid-zone materials sometimes overlain by a thin ferruginous zone were exposed in eroded areas near some of the sites. These materials may possibly constitute the hardpan horizon in some cases where younger materials have been deposited on denuded weathered zones. In most profiles, however, the hardpan is considered to be a silica-cemented horizon.

(viii) *Lorraine*.—These soils have very similar profile characteristics to those of Staaten family but subsoils have strongly alkaline reactions. They occur on very gentle slopes on stripped Tertiary weathered zone and materials derived therefrom or on alluvium under woodlands of paperbark, or less commonly bloodwood. Reaction at the surface is slightly acid and gradually increases to strongly alkaline in the mottled, massive, and generally very hard clay subsoils.

(ix) *Brooklyn*.—These are shallow soils underlain by rock or gravel at depths of less than 2 ft. Textures grade from sands or loams at the surface to light or medium clays in subsoils, and eight of the ten profiles examined contained varying amounts (5–80%) of fine to coarse gravel. Subsoil colours range from red to yellowish brown to greyish brown and some have well-developed A_2 horizons. They occur on materials derived from rocks of widely varying lithologies on gentle to steep slopes. The vegetation is also very varied.

(*e*) *Structured Red and Brown Soils*

The soils of this group have gradational occasionally uniform texture profiles and varying grades of smooth-ped structure either throughout the profiles or in subsoils. They have formed mainly on old alluvial plains and on materials derived from weathered basalt, metamorphic, and other rocks in gently undulating areas in Leinster, Radnor, Lukin, and Hodgkinson land systems. They are probably not extensive. On the basis of 16 observations the group is subdivided into three families according to differences in subsoil colour and reaction.

(i) *Springvale*.—These soils have dark reddish brown to dark brown clay loam surface soils that grade to reddish brown, yellowish red, or red medium to heavy clay subsoils. Similar soils that have uniform light to medium clay textures throughout are included in this family. Structure in surface soils is generally moderate grade fine to medium subangular blocky, occasionally massive, and in the subsoils moderate to strong grade medium subangular blocky with smooth-faced peds. Consistence is firm to slightly hard and soil reaction is moderately acid to neutral throughout. The soils are well drained and are usually more than 2 ft deep, but a shallow phase occurs on steep slopes of about 10%. These soils predominate in the gently undulating basalt areas in Lukin land system near Butchers Hill and north of Cooktown, under an average annual rainfall of 45–70 in. They have also formed on materials derived from limestone near Chillagoe with a rainfall of 30 in. Woodlands of box, bloodwood, or narrow-leaved ironbark are typical.

(ii) *Wyaaba*.—The soils of this family have dark greyish brown loamy surface soils that grade to brown or yellowish brown light to medium clays. Prominent mottling in the subsoils is common and indicates somewhat poor internal drainage. Surface soils have massive or subangular blocky structure and subsoils have blocky smooth-faced peds and firm to very hard consistence. The soils are more than 3 ft deep and soil reaction is either neutral throughout or medium acid in the subsoils.

They have formed mainly in alluvial materials on plains or very gently undulating land under woodlands of paperbark and/or box, and bloodwood.

(iii) *Waterhole*.—Three profiles formed in old alluvial materials in Radnor and Leinster land systems were placed in this family. The soils have dark brown to dark greyish brown slightly acid silty clay loam surface soils that grade to yellowish brown strongly alkaline clay subsoils. Prominent yellow or red mottling in subsoils indicates poor internal drainage and iron-manganese staining was noted in one profile. Small to moderate amounts (5–15%) of hard carbonate concretions were present below 2 ft. Structure at the surface is massive and grades to angular blocky smooth-faced peds with hard to very hard consistence. The soils occur on nearly level land under open woodland or grassland with scattered box, paperbark, or *Bauhinia*.

Analytical data on one profile 15 miles south-east of Galbraith indicate that the cation exchange capacity is low (6–12 m-equiv./100 g) and sodium is the dominant metal ion below 12 in. The exchangeable sodium percentage below the surface 6 in. ranged from 29 to 65 and the soil is slightly affected by soluble salts (0·2%) below 12 in. depth. Clay mineral analysis of one sample from the subsoil indicates that montmorillonite is dominant and illite subdominant, and there were traces of kaolin and quartz.

(*f*) *Uniform Medium- to Fine-textured Soils*

The soils of this group are uniform loams or clays. They have formed in a wide range of parent materials derived mainly from sedimentary, metamorphic, or volcanic rocks, and also colluvial and/or alluvial deposits. The group is subdivided into three families according to differences in texture, reaction, and depth.

(i) *Frazer*.—These are deep uniform light clay soils with thin dark greyish brown surface horizons, thick brown to yellowish red subsurface horizons, and red subsoils. They have weak fine subangular blocky structure in the surface soil and are massive beneath. They are well drained and have an earthy porous fabric and firm consistence. Soil reaction is medium acid throughout. The soils have developed in strongly leached materials derived from granite and metamorphic rocks on steep mountain slopes of up to 45%. They occur under vine forest in the east of the area where the average annual rainfall is 50 in. or more. Analytical data in respect of one profile in a forest clearing near Rumula indicate that cation exchange capacities are low to very low (8·0 m-equiv./100 g in the humic surface soil decreasing to 2·7 at a depth of 3½ ft). Calcium is the dominant exchangeable metal ion and decreases with depth in phase with the exchange capacity.

(ii) *Mimosa*.—These soils are deep uniform light to medium clays with mottled blocky structured subsoils. They occur on very gentle slopes under box woodland in Brixton, Annaly, and Cumbulla land systems. They have formed on materials derived mainly from strongly weathered Cretaceous shales or fine-textured alluvium. Reaction is slightly to moderately acid throughout. Colours at the surface are dark brown to dark grey and grade to yellowish brown in the subsurface and greyish brown with prominent red or yellowish brown mottling in subsoils.

(iii) *Maitland*.—These are shallow gravelly uniform medium- to fine-textured soils. They occur mainly on steep to very steep slopes and have formed either *in situ* on metamorphic and weathered Tertiary rocks in Maytown and Annaly land systems or on colluvial aprons and fans in Ninda land system. Woodlands of narrow-leaved ironbark and, less commonly, box, or lancewood and paperbark scrub are characteristic. Textures range from sandy clay loams to light clays and varying amounts (10–50%) of gravel are present throughout the profiles. A surface strew of gravel is common and frequent rock outcrops occur in places. Depth to rock varies from about 15 to 24 in. Colours are brown to dark greyish brown occasionally reddish brown at the surface and grade to brown, yellowish brown, or yellowish red beneath. Reaction is slightly to moderately acid throughout.

(g) *Uniform Sandy Soils*

The soils of this group are widespread throughout the area and probably almost as extensive as the sandy massive earths (Section (*d*)). They have uniform sand to loamy sand textures, single-grain to massive structure, and medium acid to neutral reaction. They occur mainly on lower slopes, sometimes on crests, in Balurga land system and on low rises and old levees in Mottle, Leinster, and Dunbar land systems. They have formed mainly in materials derived from deeply weathered coarse Tertiary terrestrial deposits either *in situ* or on reworked soils on colluvial–alluvial slopes. In these situations they commonly occur in a catenary sequence with red and yellow earths on crests and upper slopes and texture-contrast soils in valley bottoms (Fig. 6).

The group comprises five families differentiated according to variations in subsoil colour, depth, and mode of formation as follows.

(i) *Healy*.—These soils are dark greyish brown to reddish brown sands or loamy sands at the surface and grade to reddish brown, yellowish red, or red in the subsoils. They are more than 2 ft deep, commonly much deeper, and are underlain by sandstone or massive laterite. A pale-coloured subsurface (A_2) horizon is present and in one of the four profiles examined it was bleached. About 10–30% subangular quartz gravel to 1½ in. diameter occurred in the lower part of one profile. Soil reaction is slightly acid to neutral throughout. These soils occur on slopes of up to 4% in gently undulating areas and support woodlands of stringybark and bloodwood, or paperbark.

(ii) *Bridge*.—The soils of this family have dark greyish brown to grey medium to fine sand surface soils, yellowish brown or light grey, commonly bleached, subsurface horizons, and brown, yellowish brown, or reddish yellow sand or loamy sand subsoils. Prominent mottling in the lower parts of some profiles indicates seasonal waterlogging. The soils are generally more than 5 ft deep but some are underlain by rock or weathered-zone materials at depths below 3½ ft. Varying amounts (5–30%) of fine quartz gravel (to ½ in. diam.) and ironstone concretions were present in 9 of 18 profiles examined. Soil reaction is slightly acid at the surface and generally becomes medium acid at depth. A thin surface wash of white coarse quartz sand commonly occurs. The soils have either single-grain structure and soft loose consistence throughout or the subsoils become massive and firm. They occur on gentle slopes of up to about 4% and stringybark, bloodwood, woollybutt, and paperbark woodlands are characteristic. Commonly associated arenaceous genera are *Acacia*, *Grevillea*, *Petalostigma*, *Alphitonia*, and *Pandanus*. The family includes one example of a tropical podzol at a site east of Princess Charlotte Bay under mixed *Acacia*–paperbark woodland where the average annual rainfall is about 50 in. This soil had a fine sand texture throughout to 60 in., a black humic extremely acid surface horizon 8 in. thick, a thick (28 in.) bleached light grey subsurface horizon, and a medium acid dark reddish brown upper subsoil grading to brown in the lower profile.

(iii) *Bathurst*.—These soils are similar to those of Bridge family but have grey or brownish grey colours in the subsoils. Subsurface horizons are pale coloured or occasionally bleached. Textures are sands to loamy sands throughout and varying amounts (5–40%) of fine quartz gravel (to 1 in. diam.) and concretionary ironstone were present in three of five profiles examined. Structure is single-grained or massive and consistence soft to firm. The soils are generally more than 3 ft deep and are underlain by rock or massive laterite. Soil reaction is slightly acid to neutral. Woodlands of paperbark and/or bloodwood with associated arenaceous shrubby species are characteristic.

(iv) *Dinah*.—These are aeolian regosols which occur on dunes and old wind-sorted beach ridges in Inkerman, Battersea, and Flattery land systems near the coasts. On the basis of one observation only, they are deep uniform fine sands and show little or no profile differentiation apart from humic staining in the surface soil. Colours at the surface are very dark to dark brown and grade to pale brown at about 12 in. They have single-grained structure and loose to soft consistence. Soil reaction is neutral to mildly alkaline. On old dunes in the high-rainfall parts of the area it is probable that podzols have developed.

(v) *Cardwell*.—This family comprises uniform sands to loamy sands 12–24 in. deep on rock, laterite, or gravel. They contain varying amounts (10–60%) of gravel, subangular to rounded and up to 3 in. in diameter. Structure is single-grained to massive and consistence soft to firm. Soil reaction is slightly acid throughout. These soils occur in Balurga, Arkara, Hodgkinson, and Annaly land systems and support woodlands of stunted stringybark and bloodwood, or paperbark.

(*h*) *Shallow Rocky Soils*

The soils of the group are very shallow (< 12 in.) and show little or no profile development. They generally contain stones and gravel and occur with frequent rock outcrops in hilly or mountainous terrain. Since they are nowhere dominant their distribution is not shown on the soils map. They are, however, largely concentrated in the areas shown as rocky land. Two families are distinguished according to differences in texture.

(i) *Mungana*.—These soils have uniform coarse textures and are derived mainly from granite and sandstone materials. They are dark brown or greyish brown at the surface and grade to brown or pale brown beneath. Reaction is slightly to moderately acid. Mixed eucalypt woodlands are characteristic.

(ii) *Emu*.—These soils have uniform loamy textures and are derived mainly from metamorphic rocks. They generally contain abundant gravel. They have thin dark humic-stained surface soils which grade to lighter colours beneath. Reaction is moderately acid to neutral throughout. Ironbark woodlands predominate.

(*i*) *Miscellaneous Land*

Two categories of land are included in this group. The first comprises the saline mud flats and tidal swamps in Battersea land system. The saline permanently moist to wet muds are either barren or support mangroves. The second is rocky land consisting mainly of rock outcrop with little or no soil which occurs mainly in Starcke land system.

IV. Occurrence and Origin of the Soils

In this section some of the more important factors which have influenced soil distribution and formation in the area are considered broadly.

(a) *Distribution of the Soils*

The distribution of the soils in the 20 land systems into which the area has been mapped is indicated in Table 7 and in the soil map. The map was compiled by using the land system boundaries and soil associations as mapping units. Table 7 shows the estimated occurrence of the 36 soil families in groups of land systems arranged according to geology and relief. The most extensive group comprises Koolburra, Balurga, and Mottle land systems covering about 19,170 sq miles on variously denuded weathered terrestrial sediments. The dominant soils are massive earths which occur in association with uniform sandy soils and, in Mottle land system only, texture-contrast soils in bottom lands. Second in importance according to extent is the group consisting of Maytown, Starcke, and Rumula land systems covering 10,400 sq miles of hills and mountains. Shallow rocky or gravelly soils predominate in the first two and uniform fine-textured soils and structured red loams occur in Rumula land system. A third important group comprises Dunbar, Leinster, and Ninda land systems on 7900 sq miles of old alluvial plains and colluvial foot slopes. The dominant soils in these land systems are massive grey and brown earths, cracking clays, and texture-contrast soils respectively.

(b) *Past Climatic and Geomorphic Influences*

Extensive deposition of terrestrial sediments derived from the weathering and erosion products of sandstone, granite, and metamorphic rocks formed a gently undulating landscape during the Tertiary. They now cover most of the western plains and Laura basin physical regions. The sediments are predominantly quartz sandstones and grits but contain more clayey material in places. Deep weathering occurred probably under climatic conditions different from those of the present and laterite profiles developed with a surface cover of highly leached red and yellow earths underlain by ferruginous, mottled, and pallid zones. In parts the weathering extended into the underlying older rocks. Subsequent erosion of the weathered mantle left more or less intact remnants of the old surface on high ground mapped in Koolburra land system in which red and yellow earths predominate. At lower levels are gently undulating moderately dissected areas on weathered zones on which a catenary sequence of soils has developed widely. These are mapped in Balurga land system which generally has red and yellow earths on ridges and upper slopes, deep uniform sands on lower slopes, and solodized texture-contrast soils in valleys. In parts, possibly where the Tertiary deposits were derived from quartz sandstones, uniform red, yellowish brown, and grey sandy soils entirely cover ridges, slopes, and valleys. Where the weathered mantle was strongly denuded, only small residual rises of sandy soils occur and texture-contrast soils and leached grey and brown earths with hardpan

TABLE 7

ESTIMATED OCCURRENCE OF SOILS IN LAND SYSTEMS

Percentage area of each land system

Soil Group and Family	Alluvium: Plains and Flats		Coastal Sediments: Plains, Ridges, and Dunes			Old Alluvial–Colluvial Deposits: Plains and Foot Slopes			Weathered Terrestrial Sediments: Plains and Plateaux			Basalt: Plains and Mesas	Mixed Tertiary Cretaceous Rocks: Undulating Lowlands		Fresh Cretaceous Shale: Undulating Lowlands	Metamorphics and Granite: Lowlands and Hills		Volcanics and Granite: Hills and Mountains		
	Cumbulla	Radnor	Inkerman	Battersea	Flattery	Dunbar	Leinster	Ninda	Mottle	Balurga	Koolburra	Lukin	Annaly	Brixton	Maple	Arkara	Hodgkinson	Maytown	Starcke	Rumula
Alluvial soils																				
Morehead	5	<5								<5										
Helenvale	10	<5						5		<5										
Bosworth	<5	<5						<5		<5										
Nassau				30																
Cracking clays																				
Carpentaria				35																
Marina			40	15																
Koolatah	15	20	25			5						10								
Yanko	5	5				5														
Gilbert						10											<5			
Wrotham														20	90					
Texture-contrast soils																				
Gamboola	10				10	10	<5	40	10	<5			20	10		10		10		
Stewart	10	10				10	<5		5	<5						<5		5	5	
Hanna		10	5			<5		5							<5	10				
Alice	25	40						10	10	<5										

Massive earths																				
Kimba								5	5	25	60									
Coleman	5	5						5			10					5				
Clark							5	10	5	20	15					10				
Kalinga	5						5	15	10					40	5	15	10			
Welcome							5													
Staaten						40		<5	5	<5			30			10	<5			
Crowbar						10	55		25				30							
Lorraine	5						5			<5										
Brooklyn													10	5			15		5	
Structured red and brown soils																				
Springvale												55					<5	<5		45
Wyaaba	<5	5					15						10				<5	<5		
Waterhole	<5	5				5														
Uniform medium- and fine-textured soils																				
Frazer																				45
Mimosa	<5						<5							20	5					
Maitland													<5				55	75		
Uniform sandy soils																				
Healy										15	5					5				
Bridge						5			10	15	5		<5			5				
Bathurst								<5	15	5	5					5	10			
Dinah			20	10	90															
Cardwell										10				5		20			20	
Shallow rocky soils																				
Mungana																		5	10	
Emu												35							10	
Miscellaneous land																				
Saline mud flats			10	10																
Rocky land																5			50	10

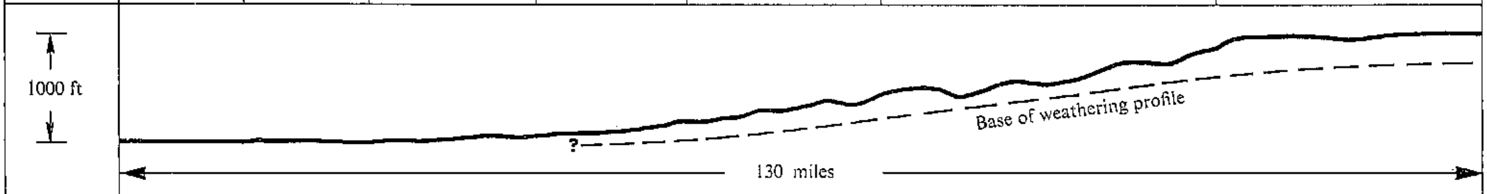
Land form	Depositional Coastal plains and flats		Depositional Old alluvial plains		Erosional–depositional Plains and rises	Erosional, moderately dissected Gently undulating land	Intact or slightly denuded Plains and plateaux
Land system	Battersea	Inkerman	Dunbar	Leinster	Mottle	Balurga	Koolburra
Vegetation	Mainly barren, some salt marsh and mangroves	Grassland	Paperbark and box woodlands	Paperbark woodland	Bloodwood–stringybark woodland on rises; paperbark woodland on plains	1 Bloodwood–stringybark woodland 2 Paperbark woodland 3 Short grassland	Bloodwood–stringybark woodland
							
Soils	Saline cracking clay and fine-textured soils (Carpentaria, Nassau)	Saline–alkaline cracking clay soils (Marina, Koolatah)	Leached grey and brown earths (Staaten), some cracking clay soils (Koolatah, Gilbert, Yanko)	Leached grey and brown earths (Crowbar)	Yellow earths (Kalinga) and uniform sandy soils (Bathurst, Bridge) on rises; leached grey and brown earths (Staaten, Crowbar) and texture-contrast soils (Alice, Gamboola) on plains	Catenary sequence: 1 Red and yellow earths on rises and upper slopes (Kimba, Clark) 2 Uniform sandy soils on lower slopes (Bridge, Healy) 3 Texture-contrast soils in valleys (Gamboola, Stewart, Alice)	Red and yellow earths dominant (Kimba, Clark, Coleman); uniform sandy soils associated (Healy, Bridge)

Fig. 6.—Distribution of soils and associated vegetation in topographic sequence in the west-central part of the area.

have developed on gently sloping intervening plains (Mottle land system). In the west and south-west of the area in the lower Mitchell and coastal plains regions most of the mantle has been stripped off and old alluvial plains occur. Leached grey and brown earths and structured brown soils predominate in Leinster and Dunbar land systems. These lands merge with the saline–alkaline clays of Inkerman and Battersea land systems on the coastal plains and flats. The topographic sequence is illustrated in Figure 6.

In Brixton land system near Wrotham Park and Fairview the weathered mantle has been severely denuded and entirely removed in places to expose the underlying fresh shales. Yellow earths with abundant concretionary ironstone occur on the remaining thin weathered cover, uniform fine-textured soils have developed on partly weathered shales in transitional areas, and cracking clays have formed on fresh shales.

(*c*) *Lithology and Relief*

In the eastern highlands and central uplands physical regions soil type and distribution are controlled mainly by the lithology of parent rocks and relief. The greater part of these hilly to mountainous areas consists of resistant sandstones, granite, and metamorphic rocks. Soil formation is influenced mainly by steep slopes, high run-off rates, and erosion and shallow gravelly soils with frequent outcrops predominate in Starcke, Maytown, and Hodgkinson land systems. An exception is Rumula land system under vine forest where deep strongly weathered massive and structured soils of Frazer and Springvale families have developed on materials derived from granite, greywacke, and other sediments. In the relatively small Lukin land system on basalt, deep structured red soils have developed on plains in association with shallow rocky soils on low hills and mesas. Maple land system on plains and undulating lowlands on fresh shales has mainly cracking clay soils.

Land form and the nature of source materials largely determine soil distribution in the two alluvial land systems of Cumbulla and Radnor. The largest occurrences of Cumbulla land system are on the alluvial plains near the mouths of the Mitchell and Gilbert Rivers. In these areas there is an intricate pattern of old and active channels, levees, back slopes, and back plains and the resulting soil pattern is also very complex. Texture-contrast soils are most extensive and massive earths, alluvial soils, and cracking clay soils occur in about equal proportions. In the plains of the Stewart, Annie, and Normanby Rivers in the north-east texture-contrast soils with bleached subsurface horizons and strongly alkaline subsoils predominate. In older alluvial plains of Radnor land system texture-contrast and alkaline cracking clay soils are most extensive.

(*d*) *Salinity*

Apart from the saline–alkali soils on the coastal plains in Inkerman and Battersea land systems that are affected by sea salts, soil formation in other parts of the area has also been influenced by salts, the source of which is not so obvious. Soils with solodized solonetz morphology and cracking clays with very high proportions of exchangeable sodium occur in several land systems, notably Cumbulla, Radnor, and Dunbar on alluvial plains and Ninda, Mottle, and Annaly land systems on colluvial foot slopes and weathered Tertiary rocks. In addition to possible atmospheric accessions of salts in areas near the coast, alternative local sources are the mottled and pallid zones of denuded laterite profiles. Analytical data on a few samples of pallid-zone materials indicate salt contents of up to 2%, consisting mainly of sodium chloride but with appreciable magnesium and sulphate ions in places. The presence of these salts in the weathered zones may account for the formation of solodic soils in drainage floors of Balurga and Mottle land systems. Solution of the salts by seepage and their transport in run-off and river flow may have influenced the development of similar soils in alluvial and colluvial situations.

(*e*) *Climate*

Combined with other factors climate has a broad overall control on soil formation, but it is almost certainly of lesser importance than the past history of weathering, lithology of parent rocks, and relief. Although the average annual rainfall over most of the area exceeds 35 in., almost all occurs during the period November–April. Dry conditions during the remainder of the year combined with high temperatures and evaporation rates tend to offset the effects of a moderately high seasonal rainfall. In small areas under vine forest on high ranges in the east with rainfall of 50 in. or more there is a moderate accumulation of organic matter but over most of the area the organic content of the soils is very low. Also in the high-rainfall belts, sandy soils low in clay and bases tend to accumulate acid raw humus at the surface and to develop podzol morphology with the seasonally intense leaching and translocation of iron and humus compounds.

The most noticeable effects of the seasonal high rainfall are the intense leaching of sandy soils in gently undulating areas and the mottling and poor drainage conditions evident in most of the fine-textured soils of plains and bottom lands. The development of well-defined often bleached A_2 horizons is particularly marked in the group of massive earths. This feature is the result of leaching and translocation of iron compounds to the lower parts of profiles and is absent or less pronounced in some drier parts of Queensland. Mottling is also more common particularly in the soils of the clay plains and in low-lying situations where seasonal flooding or water-logging occurs. The hardpan horizons in the soils of Crowbar family, although not confirmed by analysis, are believed to be cemented by silica leached from the acid strongly weathered soils on high ground and transported in run-off and seepage.

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PART VI. VEGETATION OF THE MITCHELL–NORMANBY AREA

By R. STORY*

I. INTRODUCTION

(a) *General Remarks*

With respect to other surveys done by the Division of Land Research, the vegetation has affinities with that of the Leichhardt–Gilbert (Perry and Lazarides 1964) on the one hand and of the Adelaide–Alligator (Story 1969) on the other, but is distinct from each. The Leichhardt–Gilbert is the driest of the three, as reflected in the rainfall figures and in the vegetation, where the prominence of annual short grasses, low woodland, *Triodia*, and *Aristida* point to long periods of water stress. The Mitchell–Normanby area is intermediate, with short grasses and low woodland less common and *Triodia* and *Aristida* rare and occasional respectively. Mid-height grasses are dominant. In the Adelaide–Alligator area, the wettest of the three, short grasses and low woodland are comparatively scarce, *Triodia* is rare, and *Aristida* was not recorded. Tall and mid-height grasses are about equally common.

(b) *Main Features of the Vegetation and Environment*

The two major vegetation regions that occur in the Mitchell–Normanby area are vine forest and woodland of *Eucalyptus* or *Melaleuca* (paperbark).

The vine forest, by far the smaller of the two regions, forms a narrow strip along the eastern coastal mountains and seaward of them, mainly where the peaks rise to about 3000 ft and where the annual rainfall is between 50 in. and the maximum of about 160 in., which has been recorded in the mountains south of Cooktown (Whitehouse 1947). Most of the rain falls in summer but some places have appreciable winter rain, e.g. at Cooktown, which is on the margin of the vine forest region, about 8 in. (12%) falls in winter. The floristics and structure of the forest vary according to the rainfall and fuller information may be obtained from several papers by Webb (1959, 1965, 1968). In general the forest forms an even cover, and the boundary between it and the woodland is fairly definite. In detail, many localized deviations are found, e.g. both eucalypt and paperbark woodland occur in the vine forest region on sandy soils of low fertility, swampy areas, etc.

The larger botanical region is a mosaic (sometimes a mixture) of eucalypt woodland and paperbark woodland over mid-height grass, extending from the shores of the Gulf of Carpentaria to the Pacific coast between Princess Charlotte Bay and Cooktown, with summer rainfall ranging from 35 to 50 in. and winter rainfall negligible. Tongues of woodland extend also up the wider valleys of the vine forest region. The eucalypts are about 40 ft high and comprise mainly stringybark and bloodwoods in level well-drained country, ironbarks in rugged mountainous country,

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box on the lowlands, often on soils of heavy texture, and gum in the valleys of the vine forest region. Paperbark woodland is of *Melaleuca*, about 30 ft high and at first sight floristically uniform. Closer examination reveals many slight differences in vegetative characters, e.g. leaves narrow or broad, aromatic or not, green or glaucous, hairy or glabrous, bark loose or papery, and to this extent at least several species may be represented. Both eucalypt and paperbark woodlands at times open out into a savannah with widely scattered trees or thicken with added shrubs into a fairly dense scrub, and both are evergreen.

The grasses are mostly perennial, mid-height, and tussock-forming. In wooded country they are usually scanty and mixed, without recognizable recurrent communities in the generally accepted sense of the word. In open country they often do form communities, sometimes characteristic of a particular habitat and sometimes with an apparently random distribution. With few exceptions they are dormant and dry during the winter.

This simple breakdown into two major vegetation regions is subdivisible into a great variety of constituent vegetation types, but for the purposes of this survey 16 have been recognized. They are listed under the next heading, with their dominants or with a diagnostic note, and are treated in the same order in the more detailed section that follows. Their structure and distribution are given in Tables 8 and 9.

TABLE 8

STRUCTURE OF VARIOUS VEGETATION TYPES

Community	Height of Tallest Trees (ft)		Diameter of Largest Trees (in.)		No. Trees/ac ≤3 in. Diameter		Visibility at Eye Level (yd)	
	Range	Average	Range	Average	Range	Average	Range	Average
Box woodland	30–60	41	12–18	16	32–154	83	300–800	467
Ironbark woodland	30–40	35	15–18	16	64–192	96	400–500	450
Gum woodland	40–60	45	13–24	18	54–144	96		300
Bloodwood–stringybark woodland	20–80	48	6–30	14	32–288	147	80–400	230
Mixed eucalypt woodland	25–50	44	3–30	13	48–324	200	100–200	125
Paperbark woodland	20–30	18	3–9	3	16–288	238	100–300	170
Paperbark scrub	15–20	18		3	32–216	108	100–400	200
Evergreen mixed scrub	15–50	31	3–14	8		80	60–200	115
Deciduous scrub	12–20	16	7–10	9	77–216	128	200–350	300
Savannah	20–50	34	4–19	12	16–48	28	400–1000	500

(c) *Diagnostic Plants and Features of the Vegetation Types*

(1) *Box woodland.—E. leptophleba, E. microneura, E. microtheca, E. normantonensis*, and *E. argillacea*.

(2) *Ironbark woodland.—E. cullenii* or *E. shirleyi*.

(3) *Gum woodland.—E. alba*.

(4) *Bloodwood–stringybark woodland.—E. polycarpa, E. dichromophloia*, or *E. tetrodonta*.

TABLE 9

RELATION OF VEGETATION TYPES TO LAND SYSTEMS

Area (sq miles) in each land system

Vegetation Type	Annaly	Arkara	Balurga	Battersea	Brixton	Cumbulla	Dunbar	Flattery	Hodgkinson	Inkerman	Koolburra	Leinster	Lukin	Maple	Maytown	Mottle	Ninda	Radnor	Rumula	Starcke	Total
Box woodland		570			370	70						160	170	5	1380		120	80		820	3755
Ironbark woodland		1130							560						1420					2130	5240
Gum woodland															670		460				1130
Bloodwood–stringybark woodland	330	1560	9490		40	70	320				1425	430		5		860		90			14720
Mixed eucalypt woodland		1420		70		820		105	130	180						860	230	180		765	4760
Paperbark woodland	330	990	1580		30	440	530			210	40	3250			90	2320	230	80		765	10690
Paperbark scrub	40						610					60									810
Lancewood scrub	40																				40
Evergreen mixed scrub			1580	20		115	400	105		60		430				730				765	4205
Deciduous scrub					60				240					150			120	180		1310	2060
Mangrove scrub				90						60											150
Grassland and savannah			670		70	1230	2390			620	40		100	70		120		910			6220
Salt-marsh vegetation				180				30													210
Vine forest																			320		320
Gallery forest																					
Bare areas				530		145		40		60											775
Total	740	5670	13320	890	570	2890	4250	280	930	1190	1505	4330	270	230	3560	4890	1160	1520	320	6565	

(5) *Mixed eucalypt woodland.*—Mixed eucalypts other than those listed above, usually with abundant non-eucalypt trees and shrubs.

(6) *Paperbark woodland.*—Broad-leaved *Melaleuca.*

(7) *Paperbark scrub.*—Narrow-leaved *Melaleuca.*

(8) *Lancewood scrub.—Acacia shirleyi.*

(9) *Evergreen mixed scrub.*—Evergreen shrubs, rare eucalypts, and *Melaleuca.*

(10) *Deciduous scrub.—Bauhinia, Terminalia,* or *Petalostigma.*

(11) *Mangrove scrub.*—Tidal strips of dense evergreen trees up to 15 ft high.

(12) *Grassland.*—Short or mid-height grasses.

(13) *Savannah.*—Short or mid-height grasses with scattered trees.

(14) *Salt-marsh vegetation.—Arthrocnemum* and *Sporobolus virginicus.*

(15) *Vine forest.*—Broad-leaved, mostly evergreen non-eucalypts up to 100 ft high.

(16) *Gallery forest.*—Riverine strips of broad-leaved evergreen and deciduous non-eucalypts up to 100 ft high.

Where only the generic name is given it refers to the genus in general, or to one particular species if only one is listed in Appendix I.

The available common names of the plants mentioned are listed in Appendix I.

E. is used throughout for *Eucalyptus,* and *M.* for *Melaleuca.*

Trees, shrubs, and grasses are listed alphabetically if they are equally common, otherwise the commonest come first.

Ground and helicopter observations were used together in writing the vegetation part and in drawing up the land system descriptions.

II. Description of the Vegetation Types

(*a*) *Box Woodland*

The species represented (*E. leptophleba, E. microneura, E. microtheca, E. normantonensis,* and *E. argillacea*) have roughly similar ecological requirements, being found along gullies, on alluvial flats, on gentle slopes, and in low-lying country generally, mostly on soils of heavy texture. They form a rather open woodland, usually with scattered bloodwoods and sometimes with *Melaleuca* (commonly *M. viridiflora*) or elements of deciduous scrub. The bloodwoods do not appear to become dominant in these low-lying sites, but the *Melaleuca* and deciduous scrub elements do and as they become increasingly common the box woodland grades into paperbark woodland or deciduous scrub, with box subordinate. *E. tetrodonta* was very rarely found in association with box but the other common trees did not appear to be restricted in this way.

The structure is given in Table 8.

One of the boxes (probably *E. normantonensis*), exceptional in having almost a mallee habit, forms a low and rather dense woodland. It was recorded a few miles south of Mount Carbine in communities a mile or so across, and sporadically elsewhere.

Apart from the deciduous scrub elements shrubs are rare. The ground cover is fairly dense, commonly of *Eriachne, Sorghum, Themeda australis, Heteropogon contortus, Aristida, Heteropogon triticeus, Chrysopogon fallax, Schizachyrium,* and Cyperaceae.

(*b*) *Ironbark Woodland*

Outside the vine forest region ironbark woodland covers most of the rugged country (Plate 1, Fig. 2). It is a rather open vegetation type with few shrubs or small trees. The structure is given in Table 8.

The commonest ironbark is *E. cullenii* (narrow-leaved and sometimes deciduous), the glaucous *E. shirleyi* and occasionally *E. melanophloia* being mainly on wash slopes and along drainage lines, and much less common. Bloodwoods are scattered throughout or are locally dominant, *E. dichromophloia* being the most common. Thinly scattered *M. viridiflora*, *Hakea*, *Erythrophleum*, and deciduous scrub species constitute the remainder of the trees commonly found in this community, with a little *E. alba* towards the east coast.

Themeda australis is dominant in a fairly dense ground cover, next in order being *Schizachyrium*, *Heteropogon triticeus*, *H. contortus*, *Sorghum*, *Aristida*, *Arundinella setosa*, *Chrysopogon fallax*, and *Alloteropsis*.

(*c*) *Gum Woodland*

The gums (nearly all *E. alba*) were recorded only near the east coast. From west to east they are at first scattered and eventually dominant both in the coastal valleys and on the lower coastal hills that are not under vine forest. They form a rather lush woodland of spreading and somewhat massive trees (Table 8). Those observed were evergreen, although *E. alba* is deciduous or semi-deciduous in parts of the Northern Territory. The woodland is lower and more open on the hills.

Other large trees include bloodwoods (mostly *E. polycarpa* recorded, occasional *E. tessellaris* and *E. dichromophloia*), box, *Erythrophleum*, rare *E. tereticornis*, and ironbark where this woodland grades into ironbark woodland. Smaller trees are commonly *Melaleuca*, *Acacia*, *Alphitonia*, *Petalostigma*, *Coelospermum*, and *Pandanus*, some of which occur in shrub form as well.

The grasses vary widely. The wetter areas have a good cover from a rank growth of *Arundinella*, *Imperata*, *Coelorachis*, *Aristida*, *Themeda*, and *Heteropogon*, or with heavy stocking a dense sward of *Chrysopogon aciculatus*. Drier areas are often under *Themeda australis* and *Schizachyrium*, especially where this woodland borders ironbark woodland, and under *Schizachyrium* and secondary annuals where stocking is heavy.

The only two soil records in this community were of an alluvial red earth and a structured brown soil. Other records (L. J. Webb, personal communication) indicate that the soils are usually solodic.

(*d*) *Bloodwood–Stringybark Woodland**

This covers a greater area than any other vegetation type. In general, it is a woodland of tall trees with a rather dense canopy over scattered smaller trees and shrubs and scanty mid-height grass (Plate 3, Fig. 2). The structure is given in Table 8. The diagnostic character is the dominance of *E. tetrodonta* (50% of the records) or of bloodwoods (33%), or of a mixture of the two (17%). Occasionally *E. tetrodonta*

* The bloodwood recorded as *E. polycarpa* in this vegetation type is not that species. Its identity is still in doubt.

is missing, and very occasionally so are all the bloodwoods. As these differences were discontinuous and could not be correlated with the habitat or the subordinate vegetation, they have been looked upon as chance variation and disregarded for diagnostic purposes. Only two of the nine species of bloodwoods were recorded as dominants, namely *E. polycarpa* and *E. dichromophloia*, in roughly equal proportions. The others were uncommon.

The canopy is broken and made up mostly of the dominant *E. tetrodonta* and bloodwoods, the only other (but minor) constituent being *Erythrophleum*, constantly present but never in abundance. Other large trees occurring singly or in small groups here and there are *E. cullenii*, *Parinari*, and *Eugenia eucalyptoides*.

Of the smaller trees, those that are uncommon generally but common where found are *Acacia leptocarpa*, *Alphitonia*, *Pandanus*, *Xanthorrhoea*, *Melaleuca*, and *Thryptomene*. Single trees regularly but widely scattered are *Hakea*, *Persoonia falcata*, and *Grevillea pteridifolia*.

Shrubs are sparse. They are represented by occasional patches of *Petalostigma banksii* or the rarer *P. quadriloculare* and scattered single plants of *Brachychiton paradoxum*, *Grewia*, and *Coelospermum*.

The ground cover is mainly of short and mid-height grasses, with annuals and perennials in roughly equal proportions. The records have been summarized as follows: *Schizachyrium* (abundant and often dominant); *Chrysopogon fallax*, *Thaumastochloa*, *Aristida*, and *Eriachne* (widespread and frequent); *Alloteropsis*, *Themeda*, and *Heteropogon* (widespread but uncommon); spinifex (rare, dense in patches); *Panicum*, *Setaria*, and *Eragrostis* (rare).

The only fairly common tall grasses are *Sorghum* and *Heteropogon triticeus*. The main non-grasses are short Cyperaceae and *Drosera*, ubiquitous and fairly common.

The canopy and floristics change little throughout the range of this vegetation type but the trees vary in size. In the wetter eastern parts they are up to 80 ft high and 2 ft in diameter, but in the west they are somewhat dwarfed and much more slender, *E. tetrodonta* especially. In some dry and hot places it had a maximum height of 40 ft and a maximum diameter of 9 in., with a reddish tinge to the foliage.

Bloodwood–stringybark woodland is characteristic of the low-level tablelands and plains of weathered Tertiary sediments (Balurga and Koolburra land systems) and of the sandy levees of former streams in Dunbar land system. It is widespread also as a fringe along channelled drainage lines, particularly in Radnor land system.

(*e*) *Mixed Eucalypt Woodland*

This type was called into being to cater for various communities that are too small to be considered as types in their own right. The main ones are given below. Their only common diagnostic character is the dominance of the eucalypts.

(i) *The Bloodwood–Stringybark–*E. phoenicea *Community*.—This (the only record of *E. phoenicea*) was sampled on deep sand about 20 miles ENE. of Laura, and a similar aerial photo pattern is found in a discontinuous band for about 50 miles towards the west, characterized under the stereoscope by level surfaces and shallow valleys that are respectively dark and even, and pale (almost white). *E. dichromophloia* is the dominant tree, with *E. phoenicea* and *E. tetrodonta* subdominant. The canopy is about 50 ft high, maximum diameter is about 18 in., and visibility about 100 yd, with a little over 100 trees to the acre. *Erythrophleum* was not recorded. Smaller trees are *Hakea*, *Persoonia*, *Grevillea*, and *Acacia leptocarpa*. Shrubs are abundant and varied (*Lamprolobium*, *Alyxia*, *Hibbertia*, *Pouteria*), the ground cover sparse and floristically poor (spinifex, *Schizachyrium*, Cyperaceae).

(ii) *The Bloodwood–Stringybark–*E. miniata *Community*.—*E. miniata*, which is closely related to *E. phoenicea*, was likewise rare over most of the survey area. The community was sampled only once and was found to have several points of similarity with the bloodwood–stringybark–*E. phoenicea* community. It was on sand about 20 miles SW. of Wrotham Park and was also recorded about half way between Wrotham Park and Chillagoe, again on sandy soil. *E. tetrodonta* was dominant, with *E. miniata* and *E. dichromophloia* subdominant. Like the foregoing community, it was characterized by abundant shrubs and a sparse ground cover.

(iii) *The* E. brevifolia *Community*.—*E. brevifolia* is dominant on rocky hills in the neighbourhood of Nymbool. It forms a low (25 ft) open woodland of almost mallee-habit trees with 200 and more trunks to the acre. Other trees include *Callitris*, *E. cullenii*, *E. shirleyi*, *Casuarina*, *E. dichromophloia*, and *E. similis*. Shrubs are uncommon and ground cover sparse (*Themeda*, spinifex, *Schizachyrium*, *Cymbopogon*). *Xanthorrhoea* is abundant and widespread.

(iv) *The* E. tereticornis *Community*.—Except near the coast, *E. tereticornis* was rare in the survey area. One example of this community was seen near Molloy, *E. tereticornis* about 70 ft high being the only tree making up the canopy. *E. tessellaris*, *E. alba*, and *E. polycarpa* were frequent but much shorter. Small trees included *Melaleuca*, *Tristania*, *Coelospermum*, and *Alphitonia*. Among the grasses, *Imperata*, *Themeda australis*, and *Chrysopogon aciculatus* were about equally common, and formed a dense and matted cover.

(v) *Eucalypts with Shrubs*.—There is little consistency in this mixture and no specific dominance among the eucalypts. They include *E. tetrodonta*, bloodwoods, ironbarks, and boxes, the commonest subordinate species being *Canarium*, *Syzygium*, *Ficus*, *Pandanus*, *Hakea*, *Acacia*, *Melaleuca*, *Excoecaria*, *Casuarina*, *Erythrophleum*, *Alphitonia*, *Grevillea*, and *Cochlospermum*. Shrubs are usually common, and like the grass cover are very variable.

Such nondescript patches are to be found in most of the land systems. They appear to be normal chance assemblages that are not related to the environment in any way.

(*f*) *Paperbark Woodland*

It was not possible to determine the species of *Melaleuca* (paperbark) in the field, and merely to differentiate between them was a laborious, exacting, and repetitive task. It is probable, therefore, that many features were missed, and the account of paperbark woodland should be considered against this background.

It is the second largest vegetation type and the most widespread, dominating most of the lowlands west of the Great Dividing Range, particularly on foot slopes, valley floors, and low-lying level country which is flooded for at least part of the rainy season. It is made up of slender silvery broad-leaved trees about 20 ft high, with rather twisted stems that branch towards the top (Plate 4, Fig. 1; Table 8). Stem diameter of mature trees is about 3 in. and there are a little over 300 trees of all sizes to the acre. The density, however, varies greatly, for the woodland at one extreme grades into savannah and at the other forms dense communities that would more fittingly be classified as scrub. For the sake of convenience the term *scrub* is reserved for the communities of narrow-leaved *Melaleuca* that are dealt with in Section II(*g*).

In nearly half the sample areas more than one species of *Melaleuca* were recorded; and this may have been the case more often than the records show, for the species were sometimes very closely alike.

The most common dominant was *M. viridiflora* which covered many miles throughout the survey area, sometimes on gravelly or sandy rises but mostly on low seasonally flooded plains and billabong floors. Others recorded on the seasonally flooded plains, but less commonly, were *M. saligna*, *M. nervosa*, and *M. stenostachya*. *M. leucadendron* and *M. argentea* were recorded along the sandy banks of larger rivers. *M. symphyocarpa* was frequent along billabong margins.

Almost invariably these woodlands have a scattering of emergent eucalypts and almost invariably these are bloodwood and box. In addition, though still dominantly under *Melaleuca*, some areas have concentrations of bloodwoods in irregular narrow bands. Habitat differences in these bands and outside them, as far as survey observations go, are barely perceptible. The bands appear to be very slightly higher and have a deeper topsoil with a more clayey subsoil. The subsoil in both is extremely hard, a feature that was shared by a great many of the sample areas in paperbark woodland.

Other common trees in order are *Grevillea*, *Petalostigma banskii*, *Hakea*, *Acacia leptocarpa*, *Erythrophleum*, and *Alphitonia*, of which the first three are usually and the last three sporadically present. A little *Grewia* occurs but shrubs are generally uncommon.

On the whole, the ground cover is sparse and stalky, *Schizachyrium* being the most widespread and common plant in the ground cover and the most usual dominant. The three species recorded were *S. fragile*, *S. obliqueberbe*, and *S. pachyarthrum*, but they were usually too fragmentary to be distinguished. Other plants, roughly in order, are *Sorghum*, small Cyperaceae, *Thaumastochloa*, *Chrysopogon fallax*, *Eriachne*, *Aristida*, *Drosera*, *Heteropogon triticeus*, *Themeda australis*, and *Alloteropsis*.

(*g*) *Paperbark Scrub*

This comprises the narrow-leaved and ericoid species *M. acacioides*, *M. tamariscina*, and *M. foliolosa*.

(i) *The* M. acacioides *Community*.—It is a little doubtful whether this merits consideration as a community for, apart from the dominant *M. acacioides*, the constituent plants vary greatly from place to place. The most common subordinate woody plants are coolibah (*E. microtheca*), bloodwoods, *M. viridiflora*, and deciduous scrub species. Ground cover varies from dense and tall to sparse and short, and is of many species. No consistent pattern or dominant could be discerned for the community as a whole.

The seven records are all from low situations (colluvial foot slopes or alluvial plains).

(ii) *The* M. tamariscina *Community.*—*M. tamariscina* was recorded only from the pallid and mottled zones below terrestrial sandstone. It forms a compact and uniform community about 12 ft high, often mixed with and eventually giving way to lancewood scrub upslope. It contains virtually no emergents but does include a number of smaller shrubs (*Bossiaea, Grevillea decora, Jacksonia ramosissima, J. thesioides, Calytrix, Fenzlia* sp.). The ground cover is very scanty (*Aristida caput-medusae, Cymbopogon, Schizachyrium, Thaumastochloa*).

The patches seldom cover more than a few acres, but are useful and easily recognizable indicators of Annaly land system (occurring on unit 2). In the dry season at least they are a characteristic brown.

(iii) *The* M. foliolosa *Community.*—This community usually occurs in low-lying areas. Like the foregoing community, it is about 12 ft high and in patches of a few acres, but it is often mixed with box, bloodwood, and *M. viridiflora* (occasionally with *M. acacioides* and *Excoecaria*) and is then more open with an orchard-like appearance and visibility from 100 to 400 yd. The trees are bushy towards the top and dark green. Shrubs are rare and ground cover poor and usually short (Cyperaceae, *Schizachyrium, Drosera, Aristida*).

It is widespread but never very common. Its main occurrences are in Dunbar (units 2 and 4) and Leinster (unit 4) land systems.

(*h*) *Lancewood Scrub*

Lancewood (*Acacia shirleyi*) was recorded only from weathered terrestrial sediments, usually on or near low cliffs or outcrops. It is dense, has a deep canopy, and is about 30 ft high, with very few shrubs or other trees and only occasional wiry grasses below (*Aristida caput-medusae, Cymbopogon bombycinus, Eragrostis, Schizachyrium, Thaumastochloa*).

It is of little importance except for diagnostic purposes, for it is virtually confined to Annaly land system (unit 2).

(*i*) *Evergreen Mixed Scrub*

The diagnostic characters are a dense and low mixed community in which deciduous trees, eucalypts, and paperbarks, though often present, are never dominant. The canopy is uneven and broken and most trees are under 3 in. diam. breast height, those 3 in. and over being only about 80 to the acre (Table 8), sometimes mixed, sometimes with one or two species dominant. Besides eucalypts and paperbarks these trees and shrubs were noted: *Acacia, Alphitonia, Banksia, Bossiaea, Coelospermum, Erythrophleum, Erythroxylum, Excoecaria, Gardenia, Grevillea, Hakea, Pandanus, Persoonia, Petalostigma,* and *Thryptomene.*

Evergreen mixed scrub is vague, heterogeneous, and fragmented, and more a repository than a vegetation type. It is found in thickets rather than patches and is measurable in acres rather than in square miles. In sandy places it is usually associated with *Grevillea* and in clayey low-lying places with *Excoecaria,* but apart from these two examples no correlations were observed. The grasses have little uniformity except in their sparseness.

(*j*) *Deciduous Scrub*

Most deciduous scrub is on soils of heavy texture, with woody constituents *Terminalia*, *Bauhinia*, *Dendrolobium*, box, bloodwood, *Grewia*, *Acacia bidwillii*, and rare *Carissa* and *Gardenia vilhelmii*. *Acacia bidwillii* tends to form communities of its own but the rest are usually mixed. Cover is variable, with abrupt or very gradual transitions into patches of savannah or grassland, and with more shrubby and dense areas along the edges of gullies. Boxes are fairly frequent, bloodwoods occasional, they and some of the *Acacia bidwillii*, which is semi-deciduous, being the only evergreen members of the community. The structure is given in Table 8. Because the trees and shrubs were bare during the survey, figures for visibility are higher than they would be in summer and not comparable with those of the other vegetation types.

On cracking clays derived from calcareous shale the ground cover is usually rather dense and dominated by grasses 3–4 ft high, of which the commonest are *Dichanthium*, *Themeda australis*, *Heteropogon contortus*, *Sorghum*, *Chrysopogon fallax*, *Aristida ingrata*, *A. latifolia*, *Pennisetum basedowii*, and *Panicum*. Below this top cover is a sparser layer of Cyperaceae and short annual grasses (*Aristida*, *Urochloa*, *Schizachyrium*, *Iseilema*), with small twining legumes fairly frequent.

A variant of the deciduous scrub is made up principally of *Petalostigma banksii* with some *P. pubescens* and evergreen trees (*Alphitonia*, *Grevillea*, *Hakea*). It occurs nearly always on sandy soils with sparse and variable usually short grasses below, and few legumes.

A third variant is found on outcrops. It is the deciduous microphyll vine thicket of Webb (1959), locally known as "turkey scrub". It is floristically richer with a canopy 15–30 ft high, and thorny shrubs and swollen stems (e.g. "bottle trees") are conspicuous life forms. Common trees are *Erythrina vespertilio*, *Gyrocarpus americanus*, *Cochlospermum gillivraei*, *Gardenia ochreata*, *Brachychiton paradoxum*, *B. australe*, *Terminalia*, *Strychnos lucida*, *Clerodendrum cunninghamii*, *Ficus*, *Diospyros ferrea*, and *Pouteria sericea*. The grass cover is negligible.

The edges of these patches are often infiltrated by sclerophyll forest species, e.g. *E. dichromophloia*, *E. confertiflora*, *E. papuana*, *E. tetrodonta*, *E. tessellaris*. These seral mixtures are to be seen as different stages of recovery of the vine thicket margin after past catastrophic fires.

The main occurrences of deciduous scrub are in units 4 of Brixton, 2 and 4 of Maple, and 2 of Radnor land systems (in all of which *Petalostigma* is unusual) and (with *Petalostigma*) in units 4 of Arkara, 4 of Hodgkinson, 2 of Ninda, and on outcrops generally.

(*k*) *Mangrove Scrub*

Ten species of mangrove were recorded of which seven were determinable, namely *Myoporum acuminatum*, *Aegialitis annulata*, *Lumnitzera racemosa*, *Excoecaria agallocha*, *Avicennia marina* var. *resinifera*, *Ceriops tagal* var. *australis*, *Rhizophora ?stylosa*.

They occur mainly along the east coast where they line the tidal creeks and cover the lower tidal mud flats of unit 5 of Battersea land system. The scrub is in the usual form of 12–15-ft dense trees with an unbroken canopy and a bare and regularly inundated floor. No records were made of the floristic distribution or ecology.

(l) Grassland and Savannah

The presence or absence of scattered trees is the key character that distinguishes grassland from savannah. For practical purposes the two are best considered together, for the distinction is subjective and in any case relative rather than absolute.

Occasional small areas of grassland and savannah, apparently without any consistent correlation with the habitat, are found in most land systems. They appear to be normal chance variations too small for consideration in this survey. The areas to be dealt with here, on the other hand, do show a fairly close correlation with the habitat for they are nearly all connected with clayey soils, drainage depressions, and/or alluvial plains. Those on clayey soils are *Heteropogon contortus* with scattered bloodwood on soils derived from basalt, mixed grasses with scattered deciduous scrub species and box on soils derived from calcareous shale, and mixed grasses and coarse sedges on coastal sediments. Those on drainage depressions are *Eriachne burkittii*, fine sedges, and scattered paperbark. Those on alluvial plains are mixed grasses and scattered paperbark.

(1) *Heteropogon contortus* with scattered bloodwood on soils derived from basalt is a limited community (Lukin land system) because basalt occupies only a small part of the survey area. *Heteropogon contortus* is usually dominant, in some places forming virtually pure communities, in others with *Themeda australis* or *Dichanthium*, less commonly with *Coelorachis* and *Heteropogon triticeus*. *Aristida latifolia* is widespread but thinly scattered.

(2) Mixed grasses with scattered deciduous scrub species and box on soils derived from calcareous shale is identical with the community described for shale in Section II(*j*) except that the scrub species are widely scattered. The general effect is of an even and dense 3–4-ft stand of flowering culms with a complex tangle of leaves and twiners nearer the ground. As a rule, the deciduous scrub elements tend to scatter in clumps rather than to form a parkland of individuals. *Grewia latifolia* is an exception. It is often present and is fairly evenly distributed. This vegetation is found mainly on Brixton and Maple land systems.

(3) Mixed grasses and coarse sedges on coastal sediments form a community in which the grasses are a mixture or a mosaic of short and mid-height species, which in many places alternate with small pure communities of a robust sedge, probably *Cyperus exaltatus*. The cover is usually dense and grasses with runners are frequent (*Cynodon*, *Sporobolus virginicus*, *Brachyachne*). The common grasses besides the three mentioned are *Eriachne burkittii*, *Arundinella setosa*, *Vetiveria*, *Schizachyrium*, *Panicum decompositum*, *P. trachyrachis*, *Bothriochloa*, *Chrysopogon fallax*, *Chloris*, *Sorghum*, *Iseilema*, *Themeda arguens*, *Oryza*, *Dichanthium fecundum*, and *D. superciliatum*. Fine sedges are scattered throughout. Gilgai hollows are present in some areas, usually dominated by Cyperaceae, *Eriachne burkittii*, or *Oryza*. Only a little widely scattered *M. viridiflora* occurs, and other trees are rarer still. This vegetation is found on Inkerman land system, with small outliers on Battersea.

(4) Communities of the drainage depressions have *Eriachne burkittii* as the commonest grass (six records of dominance), the rest being *Sorghum*, *Bothriochloa*, *Ischaemum*, *Aristida* sp., and *Arundinella setosa* (one record each of dominance) and *Eriachne humilis*, *E. squarrosa*, *Themeda avenacea*, *Pseudoraphis*, *Schizachyrium*, *Vetiveria*, *Alloteropsis*, *Ectrosia*, *Panicum decompositum*, and *Panicum* spp. (frequent

but not dominant). Cover is dense and fine Cyperaceae are common throughout. The trees consist of widely scattered *M. viridiflora* and occasional thickets of *M. foliolosa* near the edges of the depressions. It is self-evident that the communities are widespread throughout most land systems.

(5) Communities of the alluvial plains are best considered as a complex because changes in the grass flora, though abrupt and often striking, could not be correlated with any habitat factor. The diversity of the vegetation is illustrated by the following list of dominants, each of which was recorded only once: *Aristida* sp. (annual), *Bothriochloa*, Cyperaceae, *Heteropogon contortus, Iseilema, Schizachyrium, Sorghum, Eriachne burkittii*, and *Vetiveria*. Other fairly common grasses are *Chrysopogon fallax, Panicum, Heteropogon contortus*, and *Brachyachne*.

This complex covers many miles of country in Radnor, Cumbulla, and Dunbar land systems and is associated with scattered paperbark.

(*m*) *Salt-marsh Vegetation*

This is a patchwork of low usually rather uniform herbaceous communities alternating with bare scalds. Those communities with the greatest aggregate cover are of *Arthrocnemum*. All the salt-marsh vegetation is within reach of at least the spring tides, and usually includes slightly higher areas of the mixed grasses and coarse sedges of the coastal sediments. It occurs only in Battersea land system.

(*n*) *Vine Forest**

Closed forest vegetation characterized by an abundance of woody vines and a high proportion of deciduous and low-branched trees, and composed of species of Indo-Malesian affinity, occupies a relatively small area in relation to the dominant sclerophyll vegetation. It belongs to the so-called "tropical rain forest" element which is largely restricted to the humid coastal regions of north-eastern Australia. The vine forest vegetation (nomenclature follows Webb 1959) is generally confined to well-drained soils of high fertility† (derived from basalt, limestone, granodiorite, diorite, and other basic or sub-basic rocks), and, except in the humid coastal region, favours topographic fire-shadows (rocky outcrops, protected gullies) and well-drained alluvia fringing creeks and lagoons. The fire-sensitive vine forest species are able to maintain themselves only in situations topographically protected from bush fires or, where moisture is adequate, by the microclimate of well-integrated vine forests themselves. Some Indo-Malesian taxa, however, contain species that occur scattered in the sclerophyll formations and are tolerant of fire. Their presence is a striking feature of many of the types of eucalypt woodland, especially on well-drained reddish sandy soils and krasnozems, common genera being *Terminalia, Owenia, Brachychiton, Parinari, Canarium, Albizia, Adenanthera, Eugenia*, and *Pouteria*. It is evident that while generally the sclerophyll forests are secondary and have tended to replace the dry types of vine forests which now occur as small relict patches, there has been a long history

* This section and parts of (*j*) and (*o*) were written by Dr. L. J. Webb and Mr. J. G. Tracey, of the Division of Plant Industry, CSIRO.

† Vine forest has been recorded by Mr. R. F. Isbell (personal communication) on quite acid granites and adamellites, low-grade metamorphics, and greywacke. The soils derived from these rocks are very low in phosphorus, their only pretension to high fertility being the relatively high amounts of organic matter in the A horizon.

of co-adaptation of the Indo-Malesian and Australian floras. The absence of a well-developed deciduous (tropophilous) element in the Australian flora is notable: equivalent monsoonal areas in south-east Asia and India are dominated by deciduous formations, but in Australia by mainly evergreen sclerophyllous types. These sclerophyllous types presumably reflect long adaptation to oligotrophic conditions (Webb 1965, 1968). Accordingly, the vegetation patterns of the region are to be interpreted not only in terms of the primary influence of rainfall distribution and soil drainage but also in terms of soil nutrient availability and topography in relation to the influence of wild fires.

The following structural types of vine forest occur in the survey area (nomenclature follows Webb 1959, 1968).

Mesophyll vine forest, either complex or mixed, is found where rainfall is greater than 80 in. This type grades into mixed and simple notophyll vine forest, often with *Agathis*, on the wet granodiorite coastal mountains above approximately 2000 ft. These two types are poorly represented in the survey area.

Semi-deciduous mesophyll vine forest, found where rainfall is approximately 60–80 in., is a moist monsoonal type 70–100 ft high characterized by scattered deciduous emergent and canopy species, e.g. *Terminalia sericocarpa*, *Ficus racemosa*, *Bombax malabaricum*, and *Gmelina fasciculiflora*.

Semi-deciduous notophyll vine forest, sometimes with *Araucaria cunninghamii* (see below), is a drier type, found where rainfall is approximately 45–60 in. The canopy level averages 40–60 ft with emergents, and common trees are *Argyrodendron* sp. (probably *trifoliolatum*), *Alangium villosum*, *Buchanania arborescens*, *Randia cochinchinensis*, *Endiandra glauca*, *Dysoxylum oppositifolium*, *Blepharocarya involucrigera*, *Ganophyllum falcatum*, and *Terminalia sericocarpa*.

Araucaria cunninghamii (hoop pine) occurs in a few patches of a low notophyll vine forest fringing the hind-dunes on the coast north of Cooktown. The distribution of this conifer is presumably relict throughout the Peninsula: the most extensive vine forest with *A. cunninghamii* is on the McIlwraith Range just north of the survey area.

Brass (1953, p. 154) notes that the 150-mile stretch of country between Cooktown and the McIlwraith Range is the driest of all the east coastal fall from the base of the Peninsula to Cape York. (This cannot be confirmed from available records.) There is vine forest to the north and south, but little within it, and it is probably the most important gap in the present-day distribution of vine-forest fauna and flora in north-eastern Australia.

Along the eastern coast of the Peninsula in the north-east of the survey area, patches of a low semi-deciduous vine forest also occur in the lee of the sand dunes and as narrow strips fringing mangroves. A more open type of vine forest with low-branched trees and a grassy floor also occurs on the low calcareous sand ridges (local relief less than 6 ft) separating extensive grassland corridors south of the Archer River. Occasional lagoons fringed by *Barringtonia gracilis* are typical throughout this region, which is in Inkerman land system.

(*o*) *Gallery Forest*

Thin strips occur sporadically in alluvial terraces and levees along some of the bigger streams. They consist of a mixture of deciduous and evergreen trees up to 100 ft high festooned with lianes and with an understorey of lax or scrambling tall shrubs.

Leaf litter and annual grasses make up most of the ground cover. The non-eucalypt trees identified in the 30–40-in. rainfall zone were *Alstonia*, *Brachychiton*, *Erythrina*, *Ficus*, *Melaleuca*, *Parinari*, *Erythrophleum*, *Canarium*, and *Eugenia eucalyptoides*. Occasional eucalypts noted were *E. tetrodonta*, *E. microtheca*, *E. camaldulensis*, and bloodwoods. Typical gallery forest in the coastal area north of Cooktown has the common tree species *Bombax malabaricum*, *Terminalia sericocarpa*, *Ficus racemosa*, *Eugenia tierneyana*, *Nauclea orientalis*, *Ganophyllum falcatum*, *Aleurites moluccana*, *Cryptocarya triplinervis*, *C. hypospodia*, *Castanospermum australe*, *Celtis philippinensis*, *Dysoxylum pettigrewianum*, *Blepharocarya involucrigera*, *Vitex acuminata*, *Alstonia scholaris*, *Pseudocarapa nitidula*.

Gallery forest covers a very small proportion of the area, and has no connection with any particular land system.

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PART VII. LAND USE IN THE MITCHELL-NORMANBY AREA

By R. H. Gunn* and R. Story*

I. Introduction

The dominant land use in the area is extensive grazing of native pastures by beef cattle with low capitalization and very small returns per acre. Beef cattle production will continue to be dominant for the foreseeable future, but there is scope for some intensification of production and for other forms of land use, despite the difficult nature of the environment.

II. Climate and Land Use

Although the rainfall is considerable and fairly reliable it is almost entirely concentrated into the summer months, except for the coastal highlands which receive a little winter precipitation. Because of the marked seasonality of the rainfall, and the high evaporation, pastures die off soon after a period of rapid growth in summer and lose their nutritive value in the dry season. Seasonal flooding of fine-textured soils on coastal and alluvial plains is a further climatic hazard. The general climatic conditions are nevertheless suitable for growing a wide range of tropical crops during the wet season from November to April on appropriate soils.

III. Pastures and Land Use

It is emphasized that the grasses were seen under the worst conditions, at the end of the dry season when much of the annual cover had disintegrated and the perennial cover was almost completely dry. Even allowing for this, the impression gained was still of a poor country with little permanent water and with generally sparse and stalky grasses. It was noted also that edible non-grasses, whether trees, shrubs, or herbs, were uncommon. Whitehouse (1947) describes the great plains of the Mitchell River as bearing "a rubbishy vegetation", and though he is speaking specifically of the trees and shrubs he would have been unlikely to say this if it had been a country of lush pasture. The intrinsic poverty of the grasses is increased by the drop in value during the dry season, so that the environment is generally unattractive from the grazing point of view although there are limited areas of better pastures.

The area has been divided into six pasture lands, within each of which grazing conditions are broadly uniform (see pasture lands map). A seventh area, non-range country, is unsuitable for grazing. It is defined as country in which stable and economic grazing cannot be carried out. The definition is not precise, for a run of good or bad seasons, or skilled graziers, or communications, or beef prices could easily alter the situation.

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(a) *Pasture Land 1—Bloodwood–Stringybark Country*

Mediocre grazing from pastures of *Eriachne*, *Alloteropsis*, and *Chrysopogon fallax* characterize this pasture land which comprises Annaly, Balurga, and Koolburra land systems. The tree cover is mainly bloodwood–stringybark woodland. Water supplies on the whole are fair, particularly in Balurga land system where many billabongs occur. With heavy stocking accelerated erosion would be a risk because the landscape is somewhat dissected and cover rather poor, particularly on scarps and scalds where a scanty cover of *Eriachne*, *Aristida*, and *Cymbopogon* gives little protection.

This pasture land occupies 15,560 sq miles.

(b) *Pasture Land 2—Lowland Paperbark Country*

This pasture land comprises lowlands and plains, some of them seasonally flooded, with mainly short grasses and scattered clumps of tall grass, both under paperbark woodland.

In the east the fans and colluvial aprons of Ninda land system have a somewhat higher rainfall but are subject to gullying, sheet erosion, and shallow flooding. Common grasses are *Schizachyrium*, *Sorghum*, *Thaumastochloa*, *Themeda australis*, *Heteropogon contortus*, and *Aristida*, with a good proportion of more mesophytic and mostly taller grasses among them, namely *Imperata*, *Arundinella*, *Coelorachis*, and *Heteropogon triticeus*. Cyperaceae are widespread and common. The tree cover is on the whole dense and varied. Grazing is fair but water is scarce.

In the centre and west this pasture land occupies the gently undulating country and plains of Mottle and Leinster land systems. The mesophytic grasses of the east are replaced by *Eriachne*, *Alloteropsis*, and *Chrysopogon fallax* while the tree cover is mostly woodland. The grazing is poor and permanent water is restricted to pools along the major drainage lines. The boundary between pasture lands 2 and 4 is indefinite, for Leinster land system (in pasture land 2) consists mainly of paperbark woodland and grades imperceptibly into Dunbar (in pasture land 4) which has rather open paperbark woodland and less of it. Dunbar is also slightly lower, but again the transition is very gradual.

This pasture land occupies 10,380 sq miles.

(c) *Pasture Land 3—Rugged Ironbark Country*

This type of country comprises the hilly Maytown and Starcke land systems with extensive rocky areas. The sward is dominated by *Themeda australis*, *Schizachyrium* is widespread, and *Heteropogon contortus*, *Aristida*, and fine Cyperaceae are common. The tree cover is mainly ironbark woodland which, from the evidence of small clearings, does not influence the yield or composition of the ground cover. Permanent water is scarce. While this country is well grassed it requires the provision of watering points and more intensive management than is at present possible. Care would be needed to avoid accelerated erosion on the steep slopes, especially since the cover of *Themeda australis* is easily destroyed by continuous stocking.

This pasture land occupies 10,120 sq miles.

(*d*) *Pasture Land 4—Alluvial Plain Country*

This pasture land comprises alluvial plains with some seasonal flooding and embraces Inkerman, Dunbar, Cumbulla, and Radnor land systems. On the saline cracking clays of Inkerman land system there is a mixture of short grasses and tall somewhat rank grasses. Common constituents are *Cynodon*, *Sporobolus virginicus*, *Brachyachne*, *Eriachne burkittii*, *Arundinella setosa*, *Vetiveria*, *Schizachyrium*, *Panicum decompositum*, *P. trachyrachis*, and *Bothriochloa*. The trees consist mainly of widely scattered paperbarks. Cumbulla, Dunbar, and Radnor land systems have more soils of lighter texture and a different ground cover in which the common constituents are *Eriachne burkittii*, finer Cyperaceae, *Schizachyrium*, *Sorghum*, *Panicum decompositum*, *Heteropogon contortus*, *Iseilema*, *Chrysopogon fallax*, *Brachyachne*, *Aristida*, *Chloris*, *Heteropogon triticeus*, *Capillipedium*, *Oryza*, *Dichanthium superciliatum*, and *Bothriochloa*. The trees (mainly paperbark) are denser than in Inkerman land system. The flooding of this pasture land seems shallow and sluggish and is unlikely to be a hazard to stock. The resulting stored water should tend to maintain green feed well into the dry season, offsetting the disadvantage of earlier flooding. Indeed the flooded country might be kept as a reserve to prolong the overall period of useful grazing. Pools along the drainage lines and billabongs provide adequate watering points (see remarks in pasture land 2 on the indefinite boundary between 2 and 4).

This pasture land occupies 9840 sq miles.

(*e*) *Pasture Land 5—Central Ironbark Country*

This is undulating country comprising the Hodgkinson and Arkara land systems and has a fairly uniform pasture dominated by *Themeda australis* and *Schizachyrium*. Subordinate grasses are *Heteropogon*, *Sorghum*, *Aristida*, *Thaumastochloa*, *Chrysopogon fallax*, and *Arundinella setosa*, with Cyperaceae widespread and common among them. Ground cover is fairly good. The tree cover is mainly ironbark woodland and is too open to restrict grazing in any way.

This is one of the better pasture lands but it is rocky in parts and water supplies would be a problem once the rains had ceased.

This pasture land occupies 6600 sq miles.

(*f*) *Pasture Land 6—Shale and Basalt Country*

This pasture land comprises the grasses of the shale and basalt on open country of plains, lowlands, and low plateaux (Brixton, Lukin, and Maple land systems). Ground cover is fairly dense, mostly of mid-height grasses with a subordinate layer of short grasses, fine Cyperaceae, and twining legumes.

Common plants are *Heteropogon contortus*, *Dichanthium*, *Themeda australis*, *Schizachyrium*, *Aristida*, *Sorghum*, Cyperaceae, Leguminosae, *Iseilema*, *Alloteropsis*, and *Astrebla squarrosa*. The country has some thickets of deciduous scrub and eucalypts besides (mainly bloodwood and box), but is on the whole sparsely wooded.

Clayey soils, good ground cover, open country, lack of strong relief, and a proportion of non-grass feed make for comparatively stable and nutritious grazing, but permanent water is scarce.

This pasture land occupies 1070 sq miles.

(g) *Non-range Country*

Rumula is rugged country under rain forest, Battersea land system is mostly bare or under salt-marsh vegetation, and Flattery land system consists largely of dunes. Their use for grazing would at present be ill advised, and these land systems have accordingly not been considered from this point of view.

Non-range country occupies 1490 sq miles.

TABLE 10

LAND CLASSIFICATION

Land Class	Extent (sq miles)	Potential Land Use	Land Systems	Main Limitations
III	300	*Cultivation*	Maple, Lukin (in part)	High clay content workability, erosion
IV	20,000	Pasture improvement, limited cultivation	Koolburra, Balurga, Mottle, Brixton, Annaly	Erosion, low fertility, low water-holding capacities, poor physical properties of soils
V	14,000	Extensive grazing, pasture improvement	Dunbar, Leinster, Cumbulla, Radnor, Inkerman	Flooding, waterlogging, hardpan soils, salinity and alkalinity
VI	7800	Extensive grazing, forestry	Arkara, Ninda, Hodgkinson	Relief, erosion, shallow soils
VII–VIII	11,500	Limited grazing, forestry, water-shedding	Maytown, Starcke, Rumula, Battersea, Flattery	Relief, erosion, salinity

IV. Soils and Land Use

The eight soil groups described in Part V of this report vary widely in their suitability for pastoral and agricultural purposes. Since there is little or no experience of land use in the area other than extensive grazing of natural pastures and since the survey data can support only very broad generalizations, no detailed assessment of the potential land use is possible.

A tentative land classification of the area, based not only on soils but also on topographic and climatic conditions, is given in Table 10 and illustrated in Figure 7. The classes shown are similar to those defined by the United States Department of Agriculture (1958).

(a) *Alluvial Soils*

Three of the four families of this group (Morehead, Helenvale, and Bosworth) occur throughout the area but are most extensive in Cumbulla land system where they occur in a complex pattern with other soils. They do not occur in large uniform areas and are almost certainly liable to regular flooding of varying depth and duration. Consequently they are considered generally unsuitable for cultivation in all but small areas where the risk of flooding is slight. They support pastures that are suitable for grazing in the dry season and may be compared with some frontage country in the Leichhardt–Gilbert area to the south. The soils of the fourth family (Nassau) occur mainly in Battersea land system on the coastal plains. They are severely affected by sodium salts, are poorly drained and subject to flooding, and are suitable only for extensive dry-season grazing.

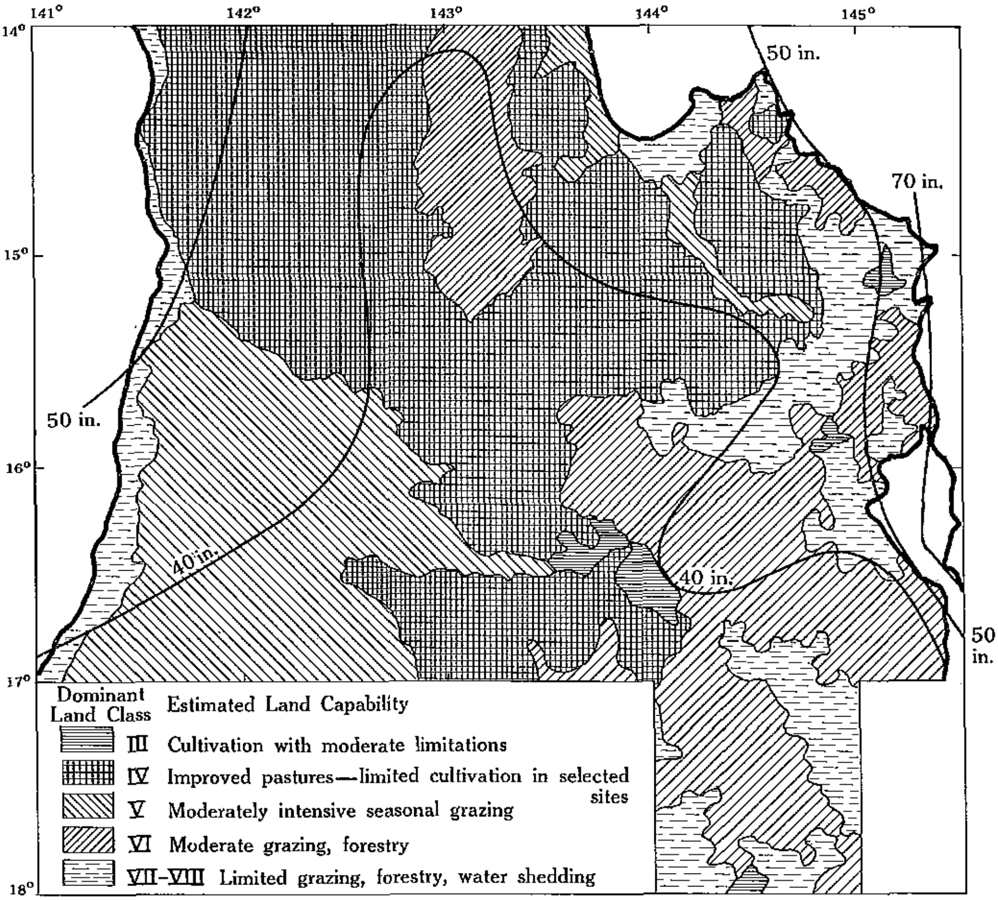

Fig. 7.—Land capability.

(*b*) *Cracking Clay Soils*

This group comprises six families. Carpentaria and Marina soils occur in Inkerman and Battersea land systems on the coastal plains and are moderately to severely affected by sodium salts and subject to regular flooding. They are suitable only for extensive grazing in the dry season. On the basis of very few analytical data, the soils of Koolatah family are only slightly affected by soluble salts but contain high proportions of exchangeable sodium. They are likely to have very slow permeability and are poorly drained. The soils of Yanko and Gilbert families appear to be only slightly affected by soluble salts but prominent mottling indicates seasonal flooding or waterlogging. The soils of Wrotham family in gently undulating areas formed on shales are considered suitable for cultivation except for the very stony phases and where they occur in drainage depressions. They cover about 300 sq miles in the area. No information is available regarding their fertility but they would probably give responses to phosphatic and nitrogenous fertilizers. The main problems concerning their use for cropping would be caused by their high content of montmorillonoid clay and the likelihood of a narrow range of soil moisture for optimum working.

(c) *Texture-contrast Soils*

The soils of this group are comparable with other very similar soils which are widespread in central Queensland. Many have the typical morphology of solodized solonetz and solodic soils with massive sandy surface horizons and hard intractable subsoils which restrict penetration of water and roots. They are generally considered to be best suited to pasture establishment, particularly those with thick surface horizons. Some with structured friable subsoils may be suitable for cultivation or forestry in selected areas.

(d) *Massive Earths*

The soils of the nine families in this group are best considered in terms of two subgroups. The first comprises the red and yellow earths of Kimba, Coleman, Clark, Kalinga, Welcome, and Brooklyn families which cover almost 10,000 sq miles in the area. These soils occur mainly in Koolburra, Balurga, Arkara, and Brixton land systems in well-drained very gently undulating areas generally under tall bloodwood and stringybark woodlands. They have formed on deeply weathered terrestrial sediments and are strongly leached. They have very low levels of fertility and generally low water-retaining capacities. These soils are considered to be best suited to pasture improvement with Townsville stylo. The shallow soils of Brooklyn family are suitable only for limited grazing use.

The second subgroup comprises the leached grey and brown massive earths of Staaten, Crowbar, and Lorraine families. These soils occur extensively in Dunbar, Leinster, Mottle, and Annaly land systems where they cover an estimated area of 7000 sq miles of plains or gently undulating lowlands under paperbark woodlands. They have poor internal drainage, and Crowbar soils have an extremely hard siliceous hardpan at depths of 1–2 ft. Pasture improvement with Townsville stylo or the growing of fodder sorghums may be feasible but extensive areas of these soils are probably liable to periodic flooding or waterlogging.

(e) *Structured Red and Brown Soils*

This group comprises three families. The structured red soils of Springvale family occur mainly in Lukin and Rumula land systems, under eucalypt woodland and vine forest respectively. In Lukin land system with gently undulating relief on basalt, the soils are well drained and probably have moderately high fertility. They are commonly very stony but some areas are free of stones and suitable for cultivation. Similar soils are found in Rumula land system with mountainous relief. These areas are generally too steep for cultivation, grazing, or forestry and the rainfall is 50 in.

or more. Conservation as water catchments would probably be the best use for such areas.

Wyaaba and Waterhole soils are similar to those of Springvale family only in respect of their gradational texture profiles and structured subsoils. In other respects they are more akin to the leached grey and brown massive earths and occur in similar situations. Pasture improvement may be feasible but flooding and waterlogging are probable hazards.

(*f*) *Uniform Medium- and Fine-textured Soils*

This group of three families is also rather heterogeneous but they have textural affinities. Frazer family has deep massive highly leached soils which occur under vine forest in Rumula land system and would best be conserved as watersheds. Mimosa soils occur most extensively in Brixton land system in gently undulating areas under box woodland. They are probably most suitable for pasture improvement but might be cultivated in selected areas.

The soils of Maitland family are shallow and gravelly and occur in the hilly to mountainous Hodgkinson and Maytown land systems. Their use for forestry in the more humid parts of these areas warrants investigation.

(*g*) *Uniform Sandy Soils*

The soils of the five families in this group are all characterized by uniform sandy textures. Healy, Bridge, and Bathurst soils are distinguished on the basis of differences in colour which probably reflect drainage conditions. They occur in similar situations mainly in Mottle, Balurga, Koolburra, and Arkara land systems where they cover an estimated area of 800 sq miles. They are very strongly leached with high contents of quartz sand and are consequently infertile. Available water-holding capacity is almost certainly very low.

The soils of Cardwell family are shallow and gravelly and like the deep dune sands of Dinah family have practically no agricultural value.

(*h*) *Shallow Rocky Soils*

These soils are widespread in the eastern half of the area on steeply sloping country. They have no agricultural value but can support useful timber in places.

(*i*) *Miscellaneous Land*

Saline mud flats, tidal swamps, and steep rocky land are virtually useless.

V. The Cattle Industry

(*a*) *Present Situation*

From figures supplied by the Bureau of Census and Statistics, W. F. Mawson (personal communication) estimates the present cattle population of the area at about 261,000. These cattle are distributed more or less equally throughout those parts of Cook, Mareeba, and Carpentaria Shires that occur in the area. Excluding the inaccessible or barren hilly and mountainous terrain, the overall present stocking rate in the area is therefore about 1 beast to 4 sq miles. The annual total turn-off rate is probably between 10 and 15% (Howard 1966).

According to Copeman and Mawson (1955), most of the cattle in the north-eastern part of the area were originally Shorthorns but were later crossed with Devon bulls. The resulting cross-bred animals were considered hardier and better able to withstand heat, ticks, and drought. In the west of the area Shorthorns are by far the most popular breed of cattle. There is a small proportion of Herefords and Brahman and Santa Gertrudis cattle are increasing (Howard 1966). In recent years the use of Zebu blood has increased and breeding programmes aim at developing animals that combine the beefing qualities of the British breeds with the adaptability of the Zebu (Donaldson 1963).

Owing to the short period of active growth and the generally low quality of native pastures in the area, the provision of adequate nutritious feed for stock during the dry season is a major problem. Copeman and Mawson (1955) also record that, except for the marine plains, phosphate or other mineral deficiencies in soils and pastures are evident from cases of bone-chewing. The low carrying capacity of the native pastures involves the use of large areas, which, together with the lack of fencing and watering facilities, results in poor control of herds. These factors in turn lead to difficulties in management with respect to the control of mating, weaning, and pests and diseases (Copeman and Mawson 1955; Donaldson 1963).

Cattle tick and buffalo fly are present almost throughout the area. Ticks are considered to cause the greatest economic loss to the industry and, directly or indirectly, are responsible for more deaths than any other factor. Tuberculosis causes losses of about 5% or higher in some herds. Infertility diseases such as vibriosis and leptospirosis are suspected of reducing calving rates in breeders and causing deaths in young calves. Contagious bovine pleuropneumonia is present in the area but is now under control as a result of vaccination programmes. Blight or ophthalmia affects mainly the British breeds but Zebu crosses appear to be immune. Dingoes cause losses in parts of the area. Various poisonous plants, e.g. heartleaf (*Gastrolobium*), Noogoora burr, and zamia occur in the area (Copeman and Mawson 1955; Howard 1966).

In addition to the problems listed above, the remoteness of the area and poor communications also cause management problems. Managers and stockmen on remote stations tend to drift to less isolated areas, and high transport costs and lack of readily available materials cause difficulties (Copeman and Mawson 1955). The nearest sale-yard and railhead is at Mareeba to the south-east. Some cattle from the south-west of the area are moved by sea from Burketown, Karumba, and the mouth of the Nassau River (Howard 1966). Most stock are walked to a railhead by recognized stock routes, but transport by barges to Cairns from loading bases in Princess Charlotte Bay is now being used and road transport is increasing.

(*b*) *Possible Improvements*

Copeman and Mawson (1955), Mawson (1956), Donaldson (1963), Burns (1964), and Howard (1966) suggest that improvements in feeding, breeding, and management are the primary essentials for improved cattle production.

The great problem in feeding is the decline in pasture quality during the dry season. Grazing management trials on unsupplemented native pastures in tropical and subtropical Australia have so far shown no practicable method by which the period of grazing can be lengthened. Much fodder is wasted because insufficient cattle can be carried through the dry season to graze the native pastures to capacity during their period of useful growth. Ways of meeting the difficulty include fertilizing, haymaking, ensilage, treatment of mature grass with urea and molasses, hand feeding, and strict paddocking, but these are all uneconomic under present conditions.

Results at Katherine Research Station (Norman 1966) indicate that the drop in liveweight during the dry season can be prevented and peak weight maintained for all but the leanest time if the cattle have access to some high-protein supplement during the dry season. The most promising so far has been *Stylosanthes humilis* (Townsville stylo). It can bring about a dramatic rise in carrying capacity, and recent work has shown that it can be fairly easily established in native pasture and that it has now spread to some very remote parts between Darwin and Arnhem Land. Townsville stylo was not recorded during the present survey but has been recorded in the Mitchell–Normanby area by other workers (Copeman and Mawson 1955). It does well under a variety of conditions and seems worth trying on many of the soil groups and pasture lands, particularly in the drier parts of the area. Soil nutrient deficiencies may have to be supplemented but climatic conditions seem suitable.

In the more humid coastal belt in the north-east of the area perennial grass–legume mixtures may prove more successful, as in more southerly coastal areas of Queensland.

Improvements in breeding with the introduction of Zebu blood result in increased reproduction and growth rates and crosses which are better able to withstand the effects of heat, ticks, and drought. Breeding programmes can only have limited effects without more advanced management techniques than are at present in use.

A practicable management technique at the present time would be to concentrate the stock on better-drained areas early in the wet season and to move them to lower and damper country after the rains. These damper areas would provide green feed when the grasses had dried out elsewhere, and with spelling during the wet season would not be damaged by puddling. Areas of Townsville stylo would best be utilized last of all, when the added protein would delay and lessen the final drop in liveweight.

Further improvements in management will require fencing and the provision of watering points in order to improve mating, weaning, and control of pests and diseases. The development of better roads will not only greatly facilitate movement of the stock to sale-yards but also may eventually help to reduce the isolation which is one of the prime factors in the drift of managers and stockmen to more accessible areas.

VI. Agriculture

(*a*) *Present Situation*

Apart from very limited areas of cultivation along the Endeavour River near Cooktown there is at present no agriculture in the survey area.

(*b*) *Possible Developments*

Climatic conditions are suitable for a wide range of tropical crops but poor soils, rugged relief, or risk of flooding severely restrict the opportunities. It is believed that trials of annual crops such as grain and fodder sorghums on the sedentary cracking clays near Wrotham Park have shown that they can be grown successfully. These cracking clay soils and the structured red soils of Lukin land system offer the best possibilities for cultivation.

Some of the massive earths and uniform sandy soils are similar to those near Mareeba where tobacco is grown and may be suitable for this purpose provided supplementary irrigation can be provided.

VII. Forestry

(a) *Present Situation*

Some commercial logging is carried out in parts of the eastern highlands. Local timbers are used to a minor extent throughout the area for construction purposes. Over the greater part of the area, however, the trees are not suitable for commercial exploitation.

(b) *Possible Developments*

The possibility of establishing exotic forest plantations in the humid eastern part of the area, particularly in Ninda land system, may warrant investigation with regard to suitable species and wind-throw and erosion hazards.

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APPENDIX I

Plants Mentioned in Text and Available Common Names

Acacia spp.	
A. bidwillii Benth.	One of two species known as corkwood wattle
A. flavescens Benth.	
A. leptocarpa Benth.	
A. shirleyi Maid.	Lancewood
Adenanthera abrosperma F. Muell.	
Aegialitis annulata R. Br.	Mangrove
Agathis	Kauri pines
Alangium villosum (Bl.) Wangerin	Canary muskheart
Albizia	
Aleurites moluccana Willd.	Candle nut
Alloteropsis semialata (R. Br.) Hitchc.	Cockatoo grass
Alphitonia excelsa (Fenzl) Benth.	Red ash
Alstonia actinophylla (A. Cunn.) K. Schum.	
A. scholaris R. Br.	Milky pine
Alyxia	
Araucaria cunninghamii Ait.	Hoop pine
Argyrodendron trifoliatum F. Muell.	Brown tulip oak
Aristida caput-medusae Domin	Wire grass
A. ingrata Domin	Wire grass
A. latifolia Domin	Feather-top wire grass
Arthrocnemum	Samphire
Arundinella nepalensis Trin.	Reed grass
A. setosa Trin.	
Avicennia marina (Forsk.) Vierb. var. *resinifera* (Forst. f.) Bakh.	Mangrove
Barringtonia gracilis (Miers) R. Kunth	Freshwater mangrove
Bauhinia cunninghamii (Benth.) Benth.	
Blepharocarya involucrigera F. Muell.	Northern bolly-gum
Bombax malabaricum DC.	Silk-cotton tree
Bossiaea	
Bothriochloa decipiens (Hack.) C. E. Hubb.	Pitted or bitter blue grass
Brachyachne convergens (F. Muell.) Stapf	Common native couch
Brachychiton australis (Schott) C. T. White	Broad-leaved bottletree
B. paradoxum Schott	
Buchanania arborescens Bl.	
Callitris sp.	Cypress pine
Calytrix sp.	
Canarium australianum F. Muell.	Scrub turpentine
Capillipedium parviflorum (R. Br.) Stapf	Scented-top grass
Carissa ovata R. Br.	Current bush, baroom bush
Castanospermum australe A. Cunn.	Moreton Bay chestnut, black bean
Casuarina torulosa Ait.	Forest oak
Celtis philippinensis Blanco	
Ceriops tagal (Perr.) C. B. Rob.	Mangrove
Chloris	
Chrysopogon aciculatus (Retz.) Trin.	Mackie's pest
C. fallax S. T. Blake	Golden-beard or blue leaf grass
Clerodendrum cunninghamii Benth.	Kapok
Cochlospermum gillivraei Benth.	
Coelorachis rottboellioides (R. Br.) A. Camus	
Coelospermum sp.	
Corypha elata Roxb.	
Cryptocarya hypospodia F. Muell.	Northern laurel
C. triplinervis R. Br.	Brown laurel
Cymbopogon bombycinus (R. Br.) Domin	Citronella grass
Cynodon dactylon (L.) Pers.	Couch grass
Cyperaceae	Sedges
Dendrolobium umbellatum Benth.	Horse bush
Dichanthium fecundum S. T. Blake	Gulf blue grass
D. superciliatum (Hack.) A. Camus	Tassel blue grass
Diospyros ferrea (Willd.) Bakh. var. *humilis* (R. Br.) Bakh.	Queensland ebony
Drosera sp.	Sundew
Dysoxylum oppositifolium F. Muell.	Pink mahogany
D. pettigrewianum F. M. Bail.	Scrub ironbark, Cairns satinwood
Ectrosia	Hare's-foot grass
Endiandra glauca R.Br.	Walnut

Eragrostis	Love grass (and other common names)
Eriachne spp.	Wanderrie grass (and other common names)
E. burkittii Jansen	
E. humilis Hartley	
E. squarrosa R. Br.	
Erythrina vespertilio Benth.	Bat's-wing coral tree
Erythrophleum chlorostachys (F. Muell.) Baill.	Cooktown ironwood
Erythroxylum ellipticum Benth.	Brown plum or Cooktown kerosene-wood
Eucalyptus alba Pl.	Poplar gum
E argillacea W. G. Fitzg.	
E. brevifolia F. Muell.	Snappy gum
E. camaldulensis Dehn.	River or river red gum
E. confertiflora F. Muell.	Broad-leaved carbeen
E. cullenii F. Muell.	Cullen's ironbark
E. dichromophloia F. Muell.	Red-barked bloodwood
E. leptophleba F. Muell.	Bastard gum-leaved box
E. melanophloia F. Muell.	Silver-leaved ironbark
E. microneura Maid. & Blakely	Georgetown box
E. microtheca F. Muell.	Coolibah
E. miniata Schau.	Melaleuca gum, woollybutt
E. normantonensis Maid. & Cambage	Normanton box
E. papuana F. Muell.	Cabbage or ghost gum, carbeen
E. phoenicea F. Muell.	Ngainggar or scarlet gum
E. polycarpa F. Muell.	Small-flowered bloodwood
E. shirleyi Maid.	Shirley's silver-leaved ironbark
E. similis Maid.	Yellowjack, desert yellow-jacket
E. tereticornis Sm.	Blue gum, forest red gum
E. tessellaris F. Muell.	Carbeen or Moreton Bay ash
E. tetrodonta F. Muell.	Darwin stringybark
Eugenia eucalyptoides F. Muell.	Native pear

E. tierneyana F. Muell.	
Excoecaria agallocha L.	Mangrove
E. parvifolia F. Muell.	Gutta-percha tree
Fenzlia	
Ficus	Fig
F. racemosa L.	
Ganophyllum falcatum Bl.	Scaly ash
Gardenia ochreata F. Muell.	
G. vilhelmii Domin	
Gmelina fasciculiflora Benth.	White beech
Grevillea decora Domin	
G. mimosoides R. Br.	
G. pteridifolia Knight	
Grewia latifolia Benth.	Dysentery plant
Gyrocarpus americanus Jacq.	Helicopter or shuttlecock tree
Hakea	
Heteropogon contortus Beauv.	Black or bunch spear grass
H. triticeus (R. Br.) Stapf	Giant spear grass
Hibbertia sp.	Guinea flower
Imperata cylindrica (L.) Beauv. var. *major* (Nees) C. E. Hubb.	Blady grass
Ischaemum sp.	
Iseilema	Flinders grass
Jacksonia ramosissima Benth.	
J. thesioides Benth.	
Lamprolobium	
Lumnitzera racemosa Willd.	Mangrove
Melaleuca acacioides F. Muell.	
M. argentea W. V. Fitzg.	Paperbark tea-tree
M. foliolosa Benth.	
M. leucadendron (L.) L.	Weeping or river tea-tree
M. nervosa (Lindl.) Cheel	
M. saligna Schau.	
M. stenostachya S. T. Blake	
M. symphyocarpa F. Muell.	
M. tamariscina Hook.	
M. viridiflora Gaertn.	Broad-leaved paperbark tea-tree
Myoporum acuminatum R. Br.	
Nauclea orientalis (L.) L.	Leichhardt tree
Oryza rufipogon Griff.	Wild rice
Owenia	
Pandanus	
Panicum spp.	
P. decompositum R. Br.	Native millet
P. trachyrachis Benth.	
Parinari nonda F. Muell.	Nonda tree

Pennisetum basedowii Summerh. & Hubb.	
Persoonia falcata R. Br.	Geebung
Petalostigma banksii Britten & S. Moore	
P. pubescens Domin	Quinine berry
P. quadriloculare F. Muell.	Quinine berry
Pouteria sericea (Ait.) Baehni	
Pseudocarapa nitidula (Benth.) Merr. & Perry	Incense-wood
Pseudoraphis squarrosa (L.f.)Chase	
Randia cochinchinensis (Lour.) Merr.	
Rhizophora ?stylosa Griff.	Mangrove
Schizachyrium fragile (R. Br.) A. Camus	
S. obliqueberbe (Hack.) A. Camus	
S. pachyarthrum C. A. Gardner	
Sesbania sp.	Sesbania pea
Setaria	
Sorghum plumosum (R. Br.) Beauv.	Plume sorghum

Sporobolus virginicus (L.) Kunth	Sand or salt-water couch
Strychnos lucida R. Br.	Native strychnine
Syzygium sp.	
Terminalia chillagoensis Domin	
T. platyphylla F. Muell.	
T. sericocarpa F. Muell.	Damson
Thaumastochloa	
Themeda arguens (L.) Hack.	Bull Flinders
T. australis (R. Br.) Stapf	Kangaroo grass
T. avenacea (F. Muell.) Maid. & Betche	
Thryptomene digandra F. Muell.	
Triodia	Spinifex grass
Tristania grandiflora (Benth.) Cheel	
Urochloa	
Vetiveria sp.	
Vitex acuminata R. Br.	Vitex
Xanthorrhoea	Grass tree

Fig. 1.—Mountains on quartz sandstone. Deeply dissected plateaux in the north-east form part of Starcke land system. They form a practically unpopulated zone under natural eucalypt woodland which includes some useful timber species.

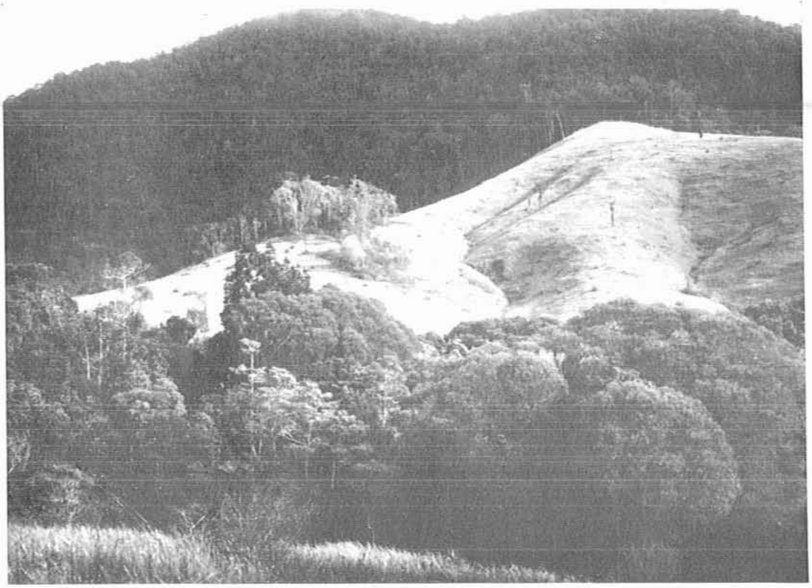

Fig. 2.—Mountains on greywackes and other sediments. Steep coastal ranges forming Rumula land system in the south-east receive heavy precipitation and have deep highly weathered soils which support rain forest. Limited areas on lower slopes have been cleared for pasture.

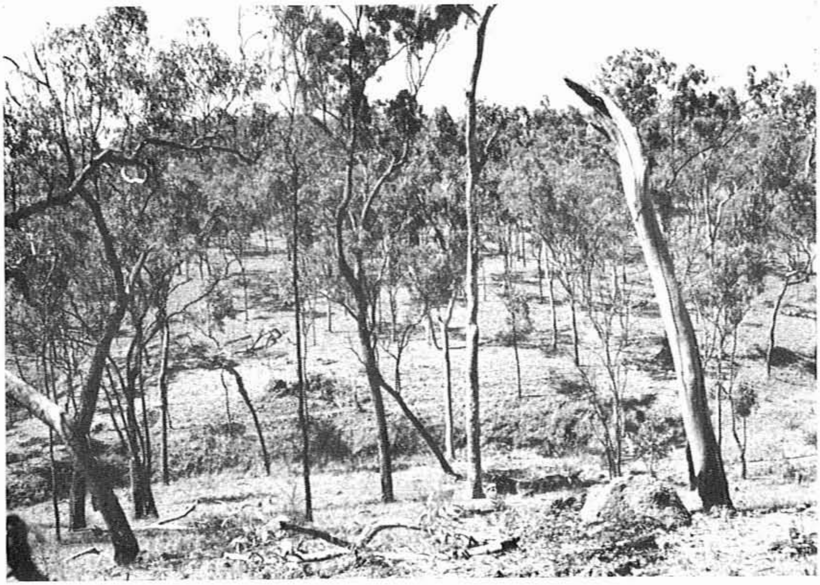

Fig. 1.—Hills on greywackes and other sediments. Stony hills with shallow soils and ironbark or box woodland form the extensive Maytown land system in the south-east.

Fig. 2.—Undulating country on metamorphics. Eucalypt woodland, rolling relief with occasional steeper strike ridges, and rather shallow stony or deep sandy soils are features of Arkara land system. The photograph shows an area in the extreme north-east that has a higher rainfall than most of the land system; consequently the grasses are unusually tall and luxuriant.

Fig. 1.—Plains on shale and claystone. Maple land system and part of Brixton land system consist of open deciduous scrub and grassland growing on cracking clay soils. This type of country provides good pastures and has potential for cropping but it occupies barely 1% of the area.

Fig. 2.—Plains on weathered terrestrial sediments. Plains with sandy or loamy massive earth soils of low fertility mainly under bloodwood–stringybark woodland cover one-quarter of the area mainly in the north-west. They comprise almost all of Koolburra land system and most of Balurga land system.

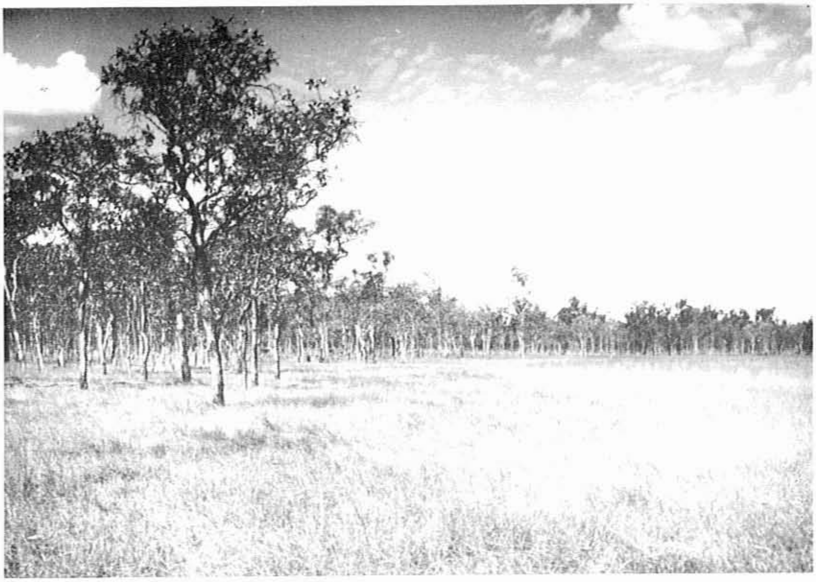

Fig. 1.—Plains on weathered terrestrial sediments. Mottle land system is mainly an alternation of grassy flats, open paperbark woodland, and eucalypt woodland (just visible in background) on massive earths and texture-contrast soils.

Fig. 2.—Plains on older alluvium. Leinster land system occurs on extensive alluvial plains laid down by the Mitchell and other rivers. Vast stretches of open paperbark woodland on poorly drained hard-pan soils are characteristic.

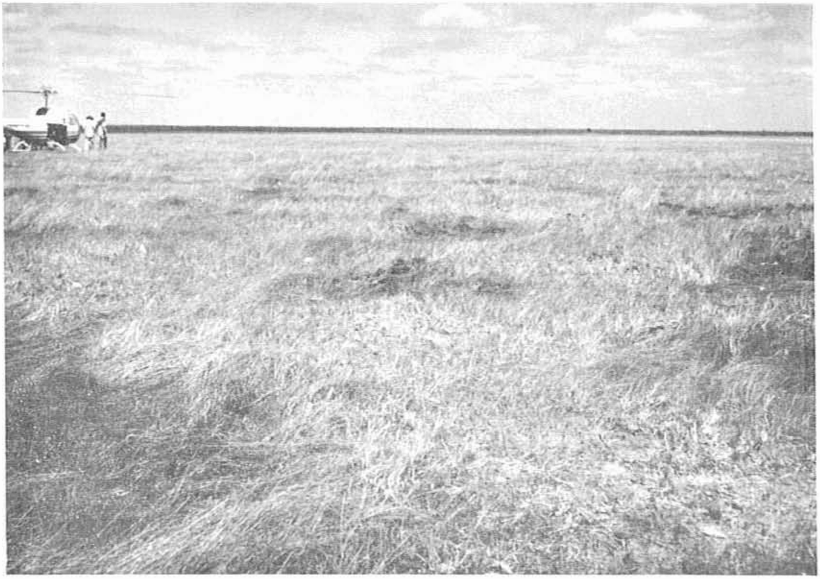

Fig. 1.—Plains on coastal sediments. Extensive clay plains fringe the west and north-east coasts. The lower parts are at least partly tidal (Battersea land system) while the slightly higher Inkerman land system shown here is above tide level but probably waterlogged during wet periods. Saline–alkaline soils, sometimes gilgaied, predominate.

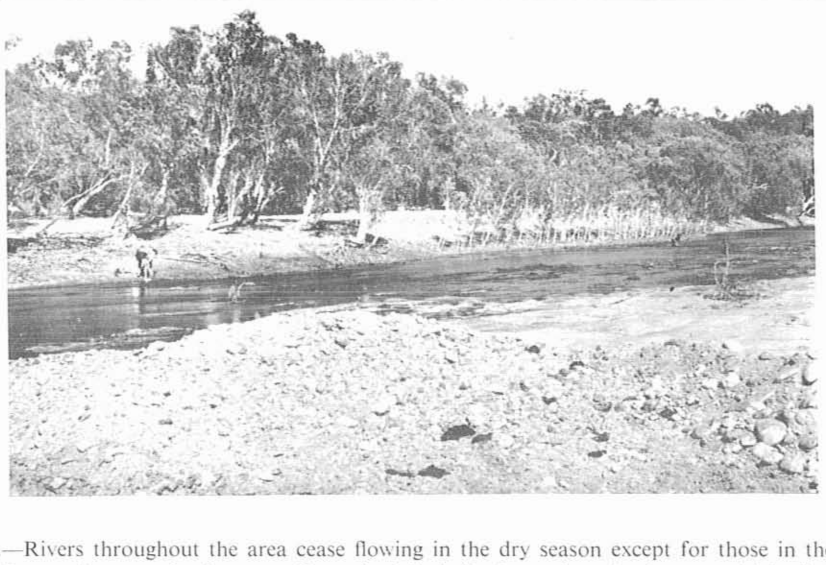

Fig. 2.—Rivers throughout the area cease flowing in the dry season except for those in the well-watered coastal ranges in the east. Even the Mitchell, shown here in August, which discharges 8,000,000 ac ft per annum ceases to flow by the end of the dry season.

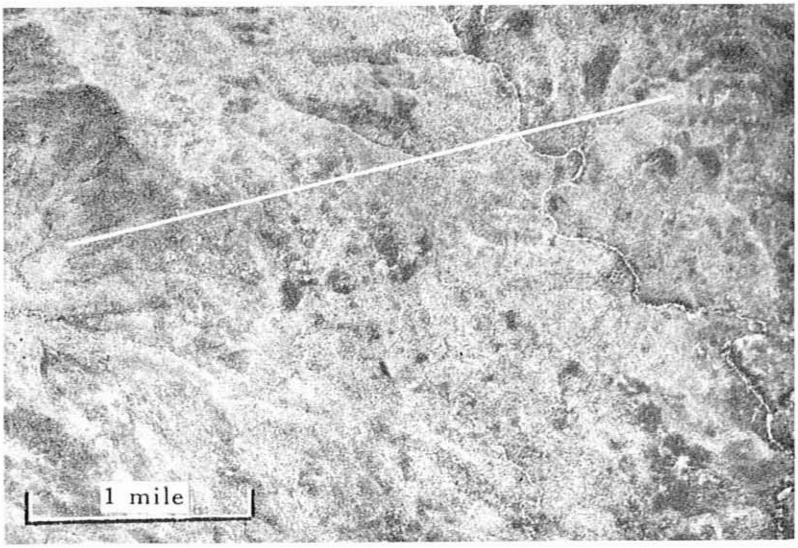

Fig. 1.—Unit 1 of Starcke land system consists of massive mountains on granitic or volcanic rocks with rounded bouldery summits, eucalypt woodland, and some scrub.

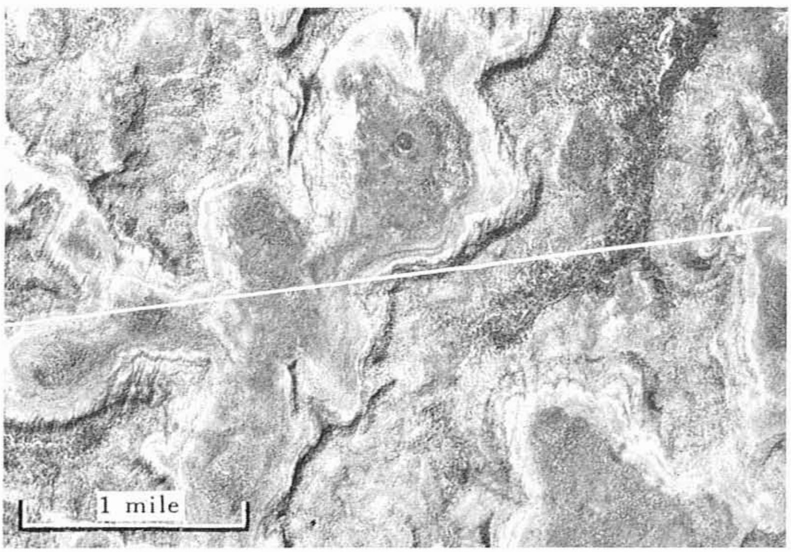

Fig. 2.—Unit 2 of Starcke land system comprises deeply dissected tablelands of resistant flat-lying quartz sandstone. The narrow valleys are often bounded by cliffs and benches of bare rock are a common feature of the plateau margins.

Fig. 1.—Closely dissected steep linear ranges on folded greywackes and other sediments form unit 3 of Starcke land system. Most of these ranges have ironbark woodland.

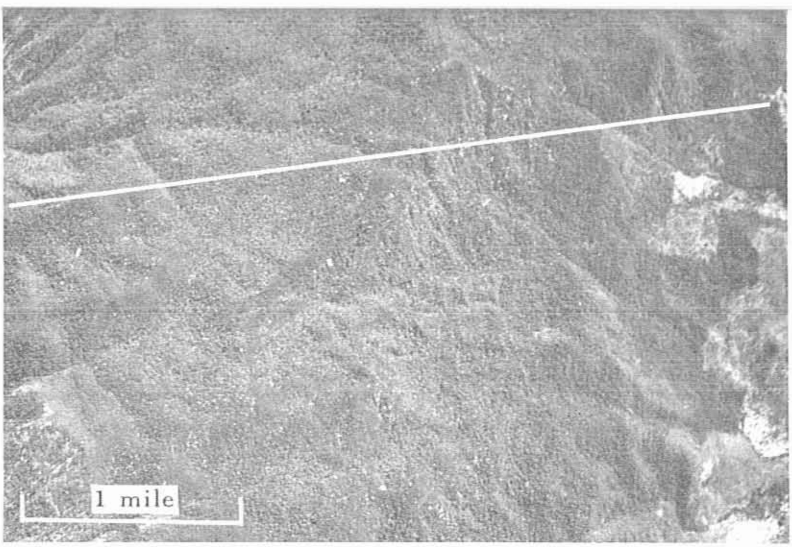

Fig. 2.—Dense rain forest on steep mountains forms the sole unit in Rumula land system.

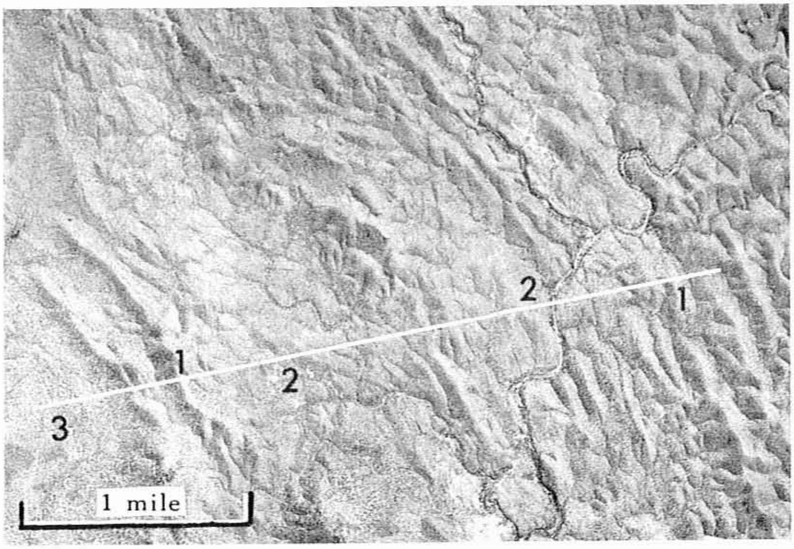

Fig. 1.—Maytown land system comprises closely dissected low hills on folded greywackes and other sediments. Rocky hills form unit 1; short stony colluvial foot slopes form unit 2; unit 3 consists of small areas of more extensive foot slopes.

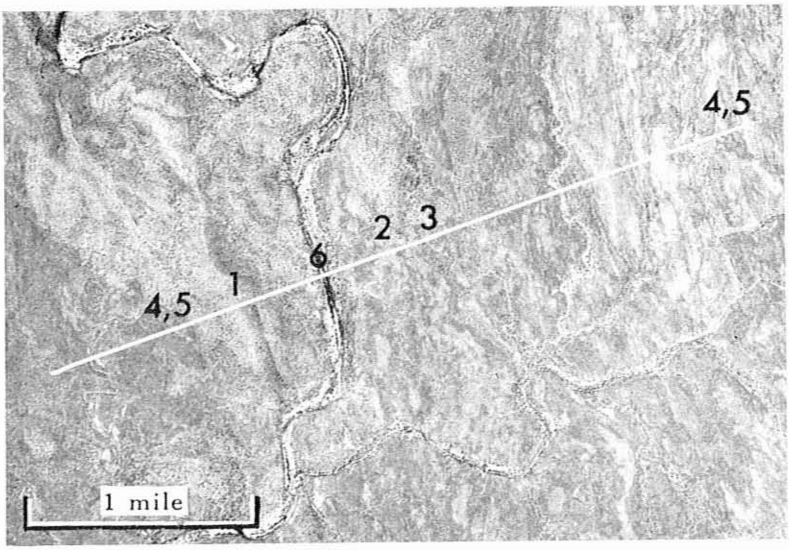

Fig. 2.—Undulating country on folded greywackes and other sediments make up Hodgkinson land system. Unit 1 consists of minor hill areas; crests and upper slopes with eucalypt woodland form units 2 and 3; units 4 and 5 with somewhat deeper soils occur on lower slopes; unit 6 comprises restricted alluvial flats.

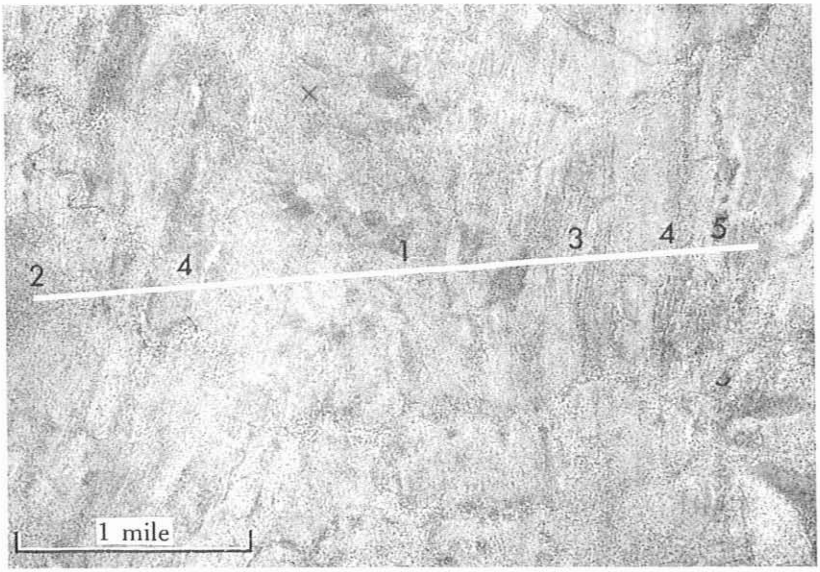

Fig. 1.—Arkara land system occupies undulating country on old metamorphic rocks. Restricted hill areas form unit 1; thick detrital sand or gravel underlies eucalypt woodland in unit 2; unit 3 with undulating relief and some strike control of the vegetation occurs where the detrital cover is very thin or absent. Unit 4 is mainly on lower slopes, and unit 5 is the drainage floors.

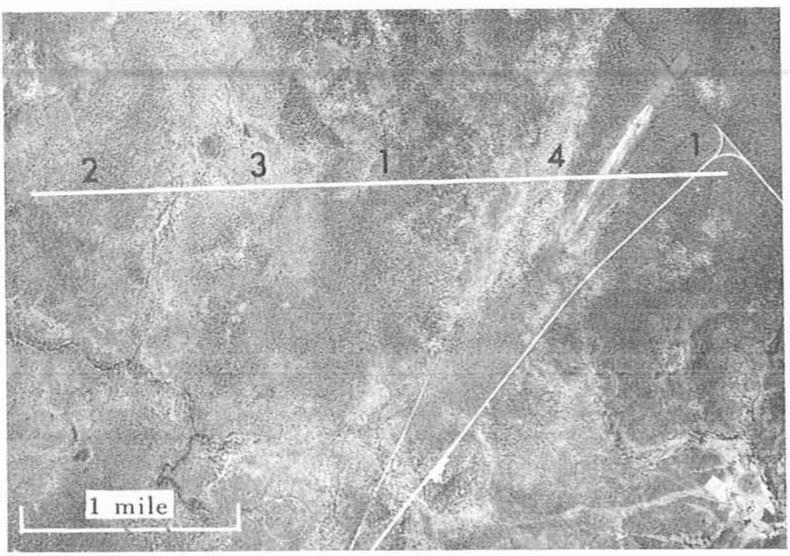

Fig. 2.—The basalt country of the small Lukin land system has been divided into plains with eucalypt woodland (unit 1), stony plains and plateau tops with shallow soils (unit 2), minor colluvial foot slopes (unit 3), and alluvial flats (unit 4).

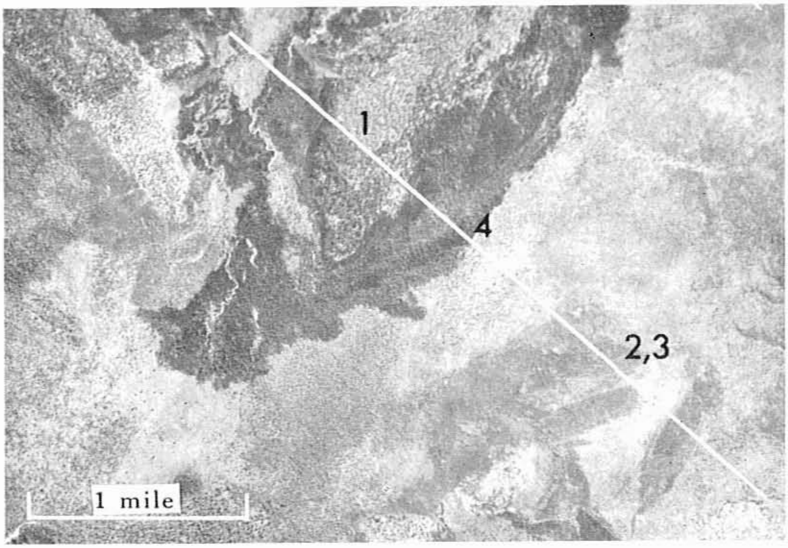

Fig. 1.—Maple land system comprises plains with cracking clay soils on shales and claystone. Unit 1 is made up of minor areas of box woodland; units 2 and 3 have deciduous scrub and grassland; unit 4 comprises alluvial flats. Dense black patches on the photograph show where the grasses have been burnt recently.

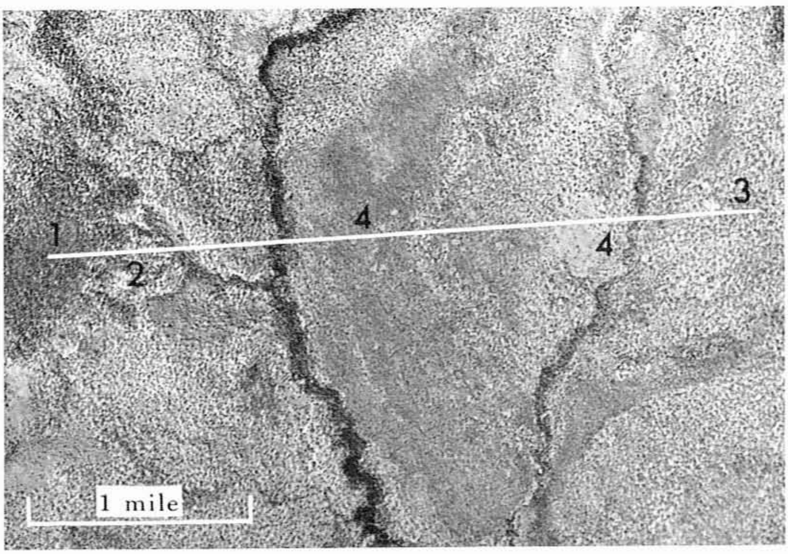

Fig. 2.—Apart from restricted low sand- or gravel-capped rises and their bounding slopes (units 1 and 2) Brixton land system consists of plains on shale and claystone with box (unit 3) or grassland and deciduous scrub (unit 4).

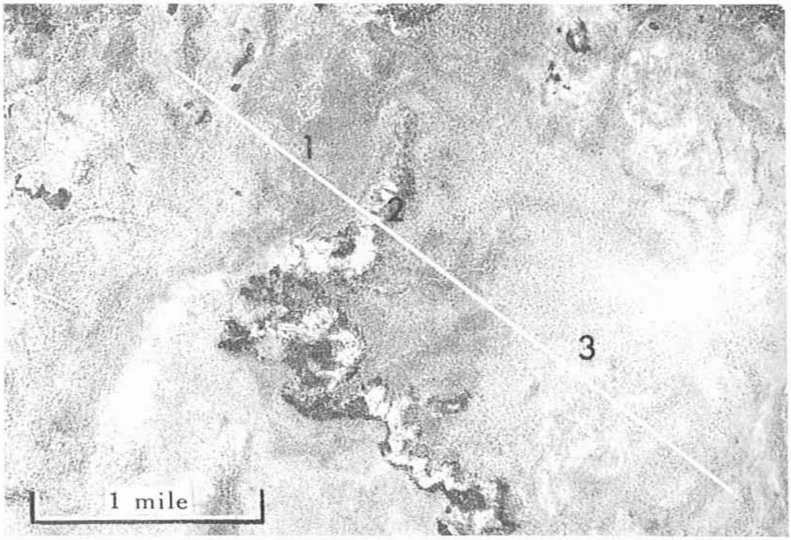

Fig. 1.—In Annaly land system low plateaux with bloodwood–stringybark woodland (unit 1) are separated by narrow breakaways and dissected zones with lancewood or dense paperbark scrub (unit 2) from gently undulating lowlands on shale or claystone with open paperbark or box woodland (unit 3).

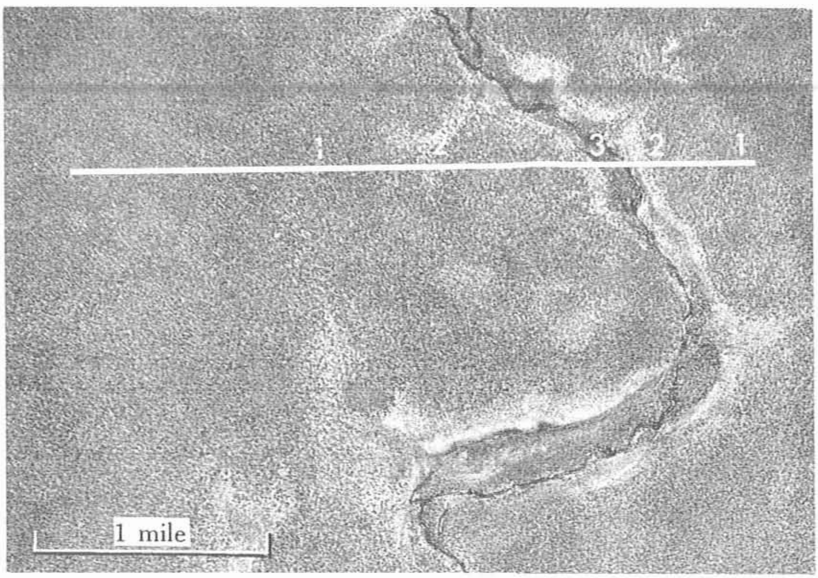

Fig. 2.—Most of Koolburra land system consists of plains with sandy earth soils and bloodwood–stringybark woodland. Unit 2 comprises middle slopes of the very widely spaced valley floors with paperbark woodland or grassland.

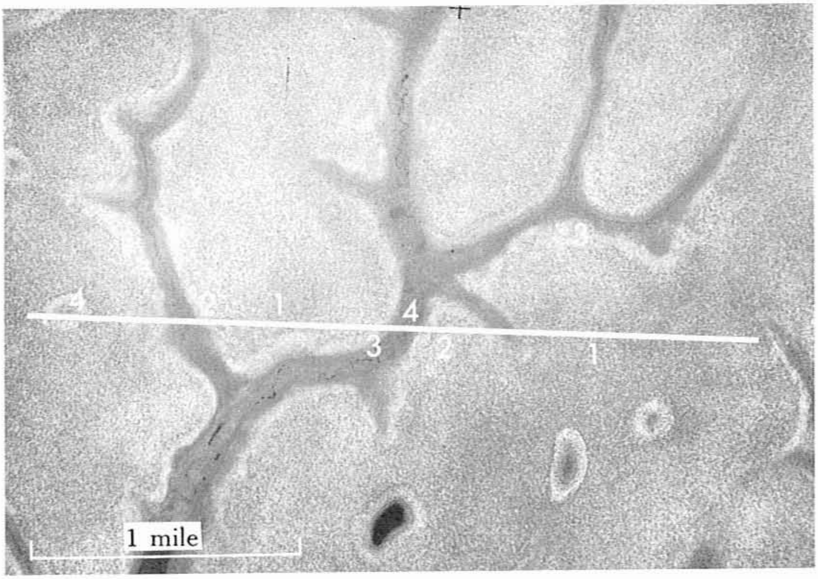

Fig. 1.—Balurga land system mostly consists of level or very gently undulating sandy or loamy plains with bloodwood–stringybark woodland (unit 1). Other units include gentle upper slopes of shallow valleys with similar vegetation but more shrubs (unit 2), narrow fringes of paperbark woodland on lower slopes (unit 3), and grassy drainage floors or swampy depressions (unit 4).

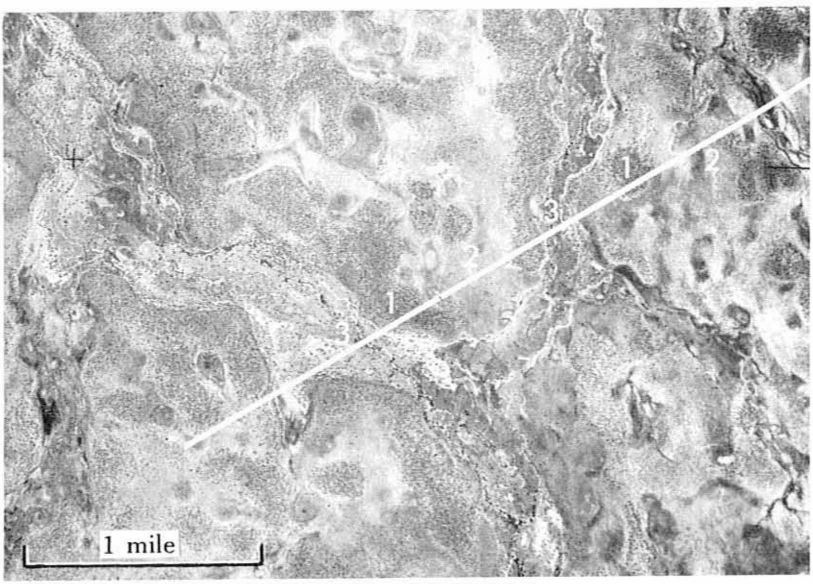

Fig. 2.—Mottle land system comprises patches of eucalypt woodland (unit 1) interspersed through plains with paperbark woodland (unit 2). Valley floors and shallow ill-drained depressions with grassland or open paperbark woodland form unit 3.

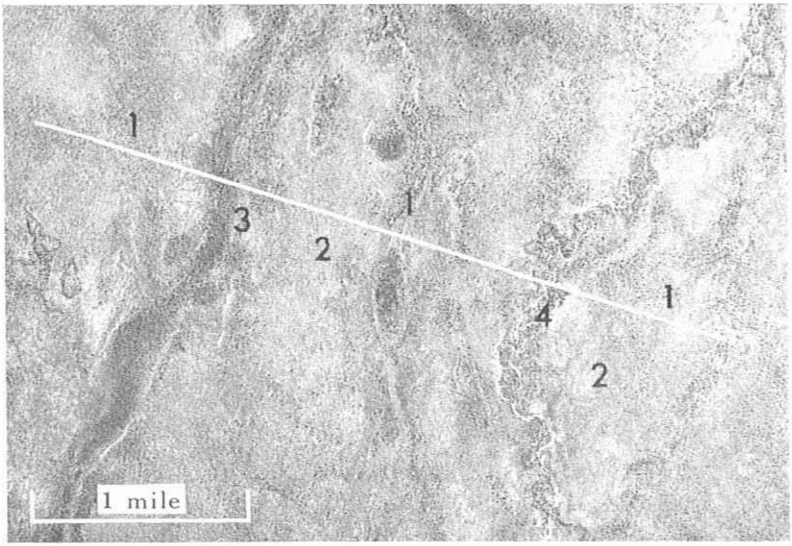

Fig. 1.—Leinster land system occurs on old alluvial plains of the lower Mitchell and Normanby Rivers. Patches of bloodwood–stringybark woodland, often on slight rises and relics of old levees, form unit 1. Most of the area comprises plains with paperbark woodland (unit 2) on massive leached earth soils. Shallow valleys with no active channels make up unit 3, while younger valleys with actively incising channels form unit 4.

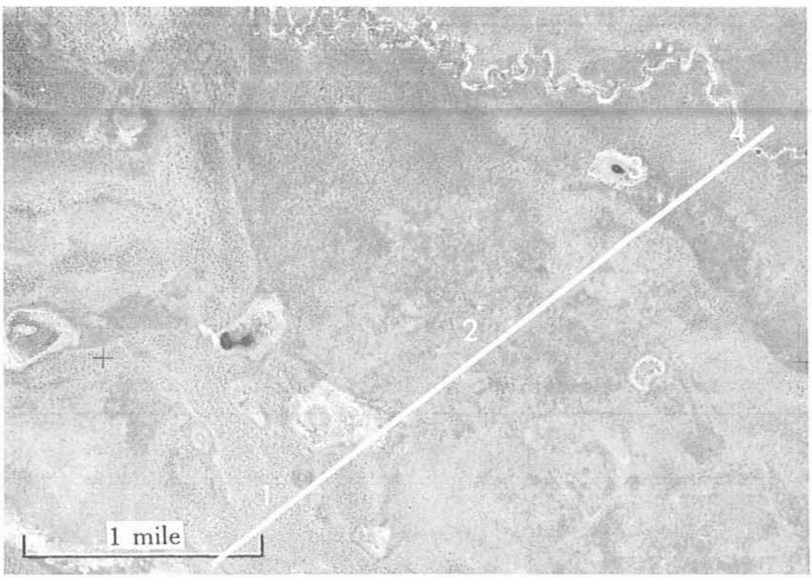

Fig. 2.—Dunbar land system consists of old alluvial plains of the Mitchell River on which features such as levees and old channels are still visible. The old levees carry eucalypt woodland (unit 1) and stand slightly higher than plains with paperbark woodland (unit 2) and scattered swampy depressions (unit 3). Shallow incised valleys of modern streams form unit 4.

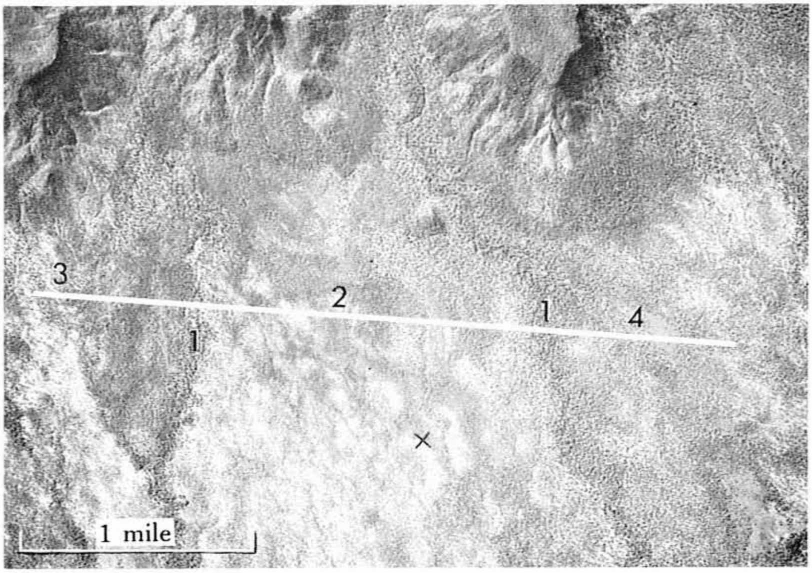

Fig. 1.—Extensive alluvial and colluvial fans at the foot of ranges in the east of the area form the Ninda land system. The alluvial fans (unit 1) have levees and channels which are absent on the colluvial aprons (unit 2). Older colluvial aprons (unit 3) are dissected and weathered, while in the extreme north-east texture-contrast soils are more important than elsewhere (unit 4).

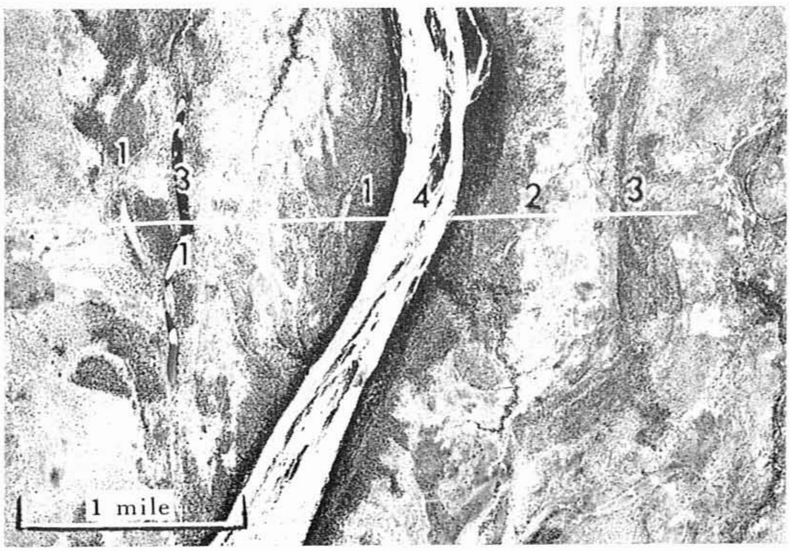

Fig. 2.—Radnor land system comprises stable alluvial plains. Unit 1 is formed by levees, unit 2 is on back plains with grassland or savannah woodland. Older channels sometimes with permanent water-holes form unit 3, while unit 4 consists of the present river channels and fringing gallery forest.

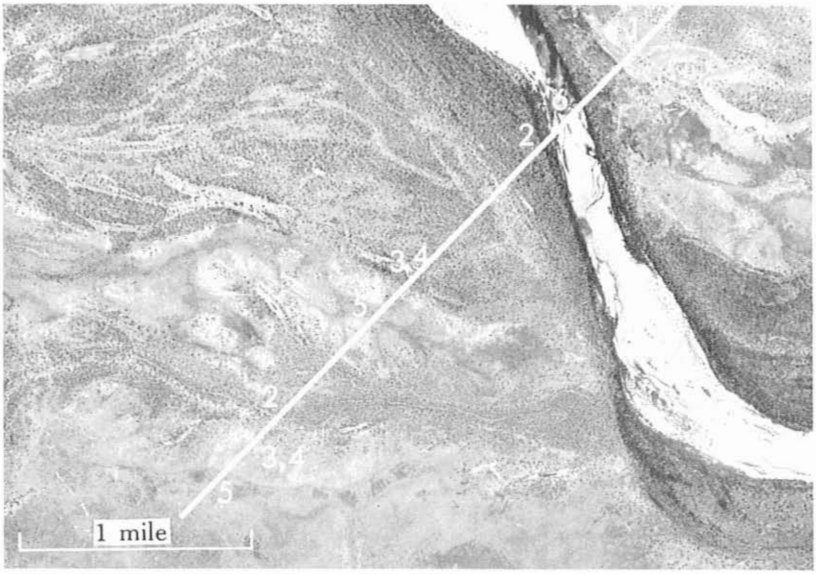

Fig. 1.—Cumbulla land system is found on recent alluvium. Minor inclusions of older alluvial terrain form unit 1. Unit 2 consists of levees and units 3 and 4 are back plains with grassland or savannah woodland. Unit 5 comprises swampy areas and old channels, while unit 6 includes the present-day channels and fringing gallery forest. Most of Cumbulla land system is subject to flooding and immature soils are prevalent.

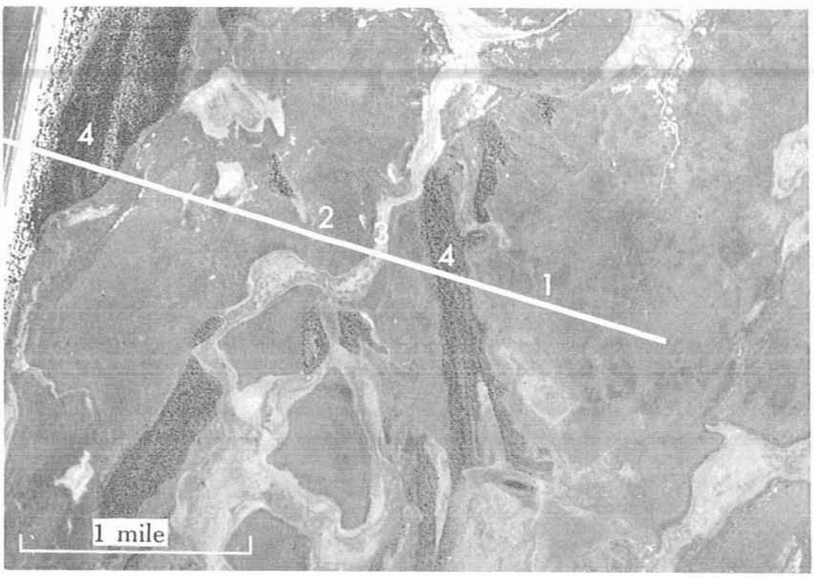

Fig. 2.—Inkerman land system occupies coastal plains just above tidal influence. Unit 1 comprises slightly higher clay plains with grassland; unit 2 is similar but slightly lower and wetter; unit 3 consists of minor occurrences of tidal mud flats, while unit 4 comprises sandy beach ridges.

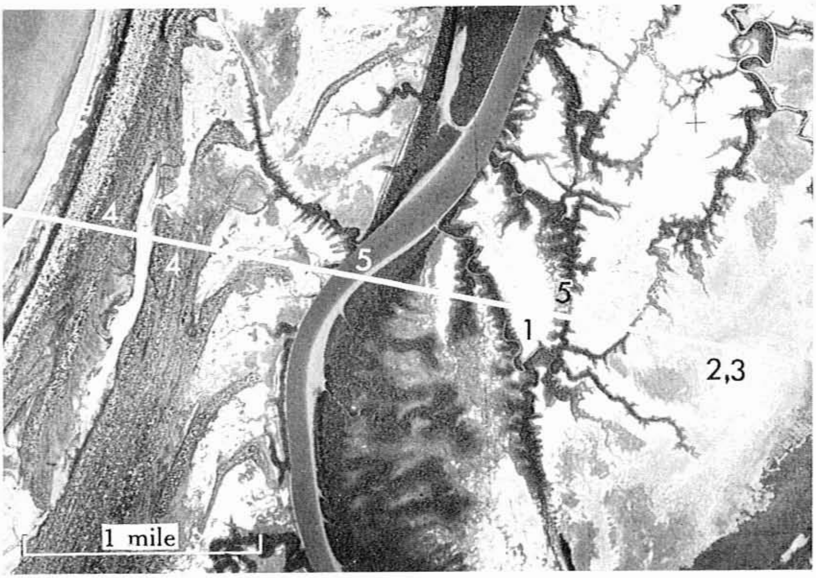

Fig. 1.—Battersea is a coastal land system which includes tidal mud flats (unit 1), slightly higher clay plains with halophytic vegetation (units 2 and 3), low sandy beach ridges (unit 4), and tidal creeks or river channels fringed by mangrove (unit 5).

Fig. 2.—In Flattery land system stable old dunes under woodland or scrub form unit 1. Unit 2 consists of actively blowing dunes and unit 3 comprises lakes and swamps in swales between the older dunes.