General Report on Lands of the Leichhardt–Gilbert Area, Queensland, 1953-54

Comprising papers by R. A. Perry, J. R. Sleeman, C. R. Twidale, C. E. Prichard, R. O. Slatyer, M. Lazarides, and F. H. Collins

Compiled by R. A. Perry

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CONCLUSIONS AND RECOMMENDATIONS

The Leichhardt–Gilbert area is likely to remain mostly dependent on the grazing of natural pastures, with cattle most important in the northern three-quarters and sheep in the southern quarter. At present almost half the stock population is carried on the central heavy soil plains.

Beef cattle areas appear to have scope for increased production by increased stocking rate as a result of further station improvements and the provision of better roads, and an increased annual turn-off percentage by a change to production of young store cattle and sale of cast cows.

Management methods for the various animal–land ecosystems need to be defined in order to achieve maximum current productivity consistent with conservation of long-term productivity. Low protein content of dry standing pasture in the dry season appears to be a problem in almost all parts of the region and the possibilities of supplementing with protein concentrates or urea–molasses should be investigated.

From analysis of climatic data it appears that areas with more than 25 in. of rainfall in the Einasleigh uplands and more than 30 in. on the Carpentaria plains should be suitable for annual pastures and fodder crops. In this zone the lands along the lower Gilbert River appear to be most suitable.

Only those areas with more than 30 in. rainfall on the Einasleigh uplands appear to hold promise for arable cash crops or permanent pastures. The basalt soils, where stone-free, seem to offer the best prospects for agriculture.

The Einasleigh uplands are very poorly served with climatic stations recording more than rainfall data. As it is the major area with possibilities for agriculture the establishment of further stations is strongly recommended in order that more accurate appraisals can be made.

PART I. INTRODUCTION TO THE LEICHHARDT–GILBERT AREA

By R. A. PERRY*

I. METHODS

The survey reported is one of a series of scientific resources surveys undertaken in Australia and New Guinea by the Division of Land Research and Regional Survey, CSIRO.

The surveys are conducted by a team of scientists (in this case geologist, geomorphologist, pedologist, and botanists) who work together in the field and laboratory. The concepts and techniques have been described by Christian and Stewart (1953). A basic feature is that the areas are described in terms of land systems which are defined as "an area or group of areas throughout which there is a recurring pattern of topography, soils, and vegetation".

The technique of surveying large areas in limited time is based on the interpretation of aerial photographs and a basic assumption is that the patterns distinguishable on aerial photographs are a reflection of land characteristics and *vice versa*. A complete cover of aerial photographs is necessary—in this survey their scale was 1 : 50,000.

II. LOCATION AND SURVEY STATISTICS

The Leichhardt–Gilbert area lies wholly in north Queensland and comprises 117,000 sq miles bounded by long. 139° 30′E. and 145° 30′E. and by lat. 17°S. and 22°S.

The team covered 5500 miles of land traverses (Fig. 1) in two periods of field work—June to September 1953 and June to August 1954—totalling six months. Six months were spent on interpretation of aerial photographs in the laboratory.

III. TOWNS AND COMMUNICATIONS

The southern part of the area is served by a railway line which crosses from east to west (Fig. 2) and links Mt. Isa (a few miles west of the western limits of the area) with Townsville on the east coast. The largest towns in the area (Cloncurry, Julia Creek, Richmond, and Hughenden) are on this line, as are the smaller settlements of Pentland, Torrens Creek, Prairie, Maxwelton, Nonda, Nelia, Gilliat, Malbon, and Duchess. From this line at Hughenden a branch line goes south-west to Winton beyond the southern boundary of the area and forms an inland link to the other lines of central Queensland. At Cloncurry another branch line runs north-west through the small settlements of Quamby and Kajabbi to Dobbyn and at Duchess a branch runs south-west to Dajarra, which is the main trucking centre for cattle from the northern half of the Northern Territory.

The northern half of the area is only poorly served by railways. In the north-east a light line joins Forsayth with Cairns through Einasleigh and Mt. Surprise. The

* Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T.

Forsayth–Mt. Surprise part of this line is too light for stock vans and stock have to be driven to Mt. Surprise to be trucked. In the north-west a short isolated line links Croydon with Normanton. This line was built to serve Croydon when it was a thriving gold-mining area and is of little significance to the area now. Apart from the new mining town of Mary Kathleen, which is linked by bitumen road to Cloncurry, only four small settlements (Burketown, Georgetown, McKinlay, and Kynuna) are not on railway lines. Most of the area is within 200 miles of a trucking point on a railway line.

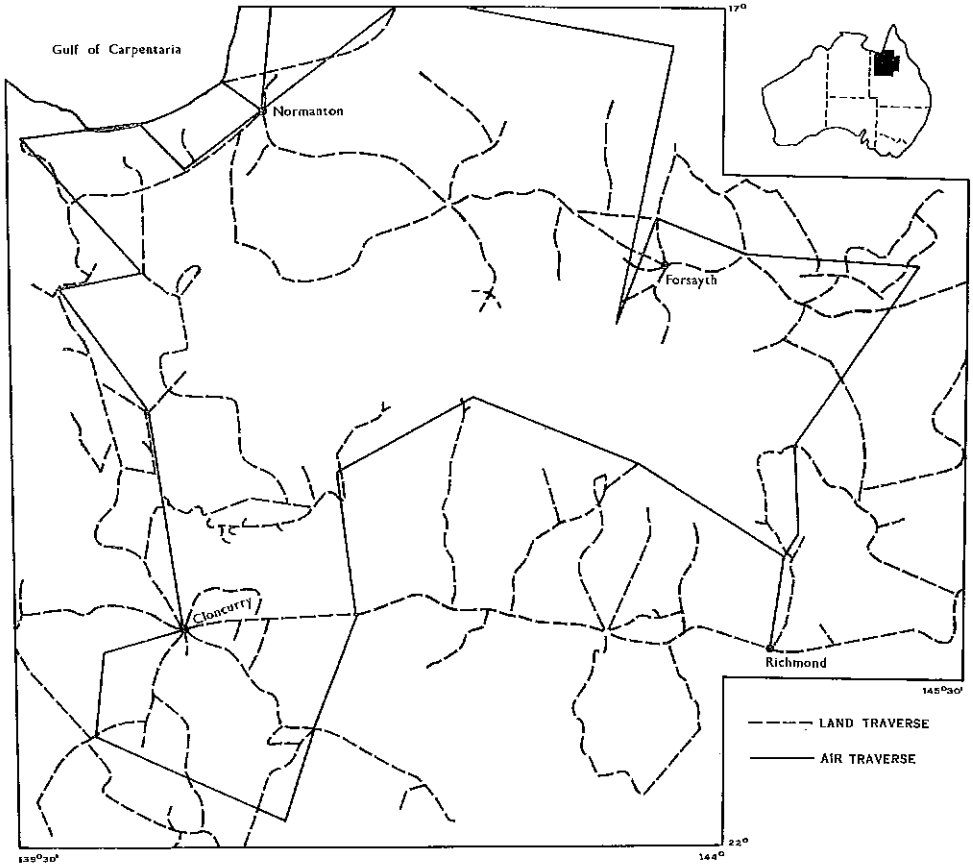

Fig. 1.—Traverse map.

Until recently the only good road was the Hann Highway, which runs north–south through the eastern part of the area and connects Hughenden with Mt. Garnet and the Atherton Tableland. However, in the last decade good formed-earth roads have been constructed to link Townsville with Normanton through Einasleigh, Forsayth, Georgetown, and Croydon and with Cloncurry through Hughenden, Richmond, and Julia Creek. In the western part similar roads link Normanton with Cloncurry and Julia Creek and a road from Cloncurry south-east through McKinlay and Kynuna connects the area with central and southern Queensland.

The area has good air communications. Cloncurry and Mt. Isa are linked by services through central Queensland to Brisbane and are ports of call on the Darwin–Brisbane services. A regular service operating several times a week links Mt. Isa, Cloncurry, Julia Creek, Richmond, and Hughenden with Charters Towers and Townsville. Stations and settlements in the western part of the area have regular weekly services from Cloncurry, and those in the northern part have regular weekly services from Cairns. Charter services are available from Cairns and Mt. Isa.

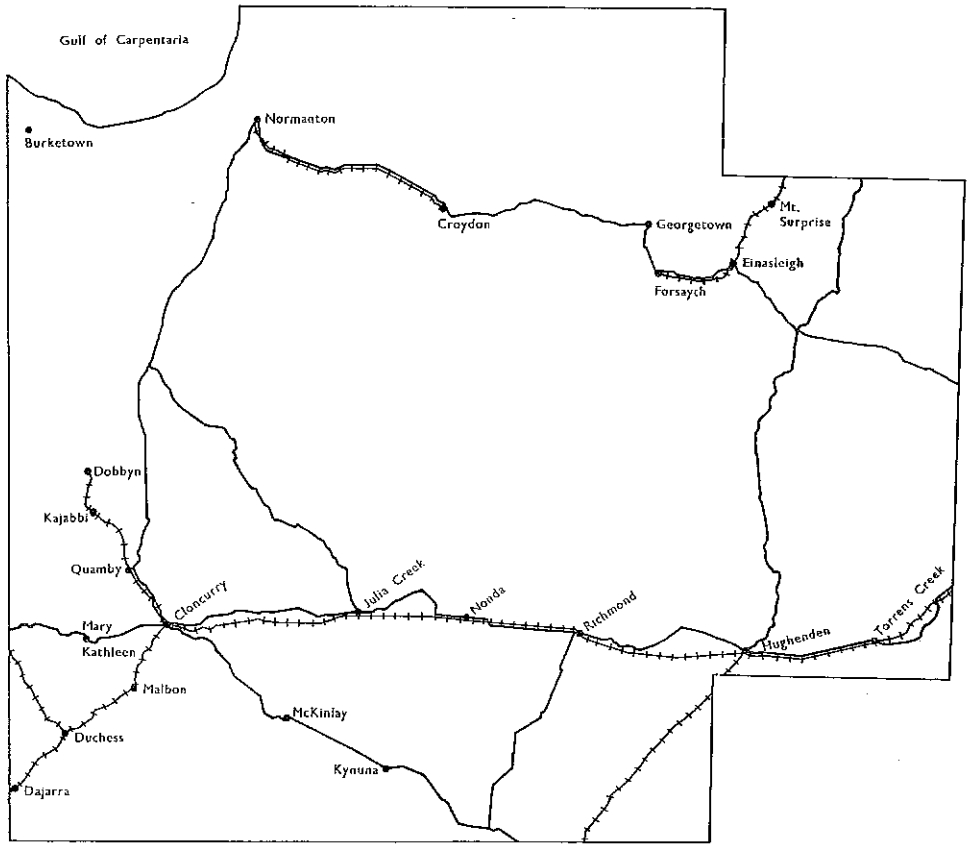

Fig. 2.—Roads, railways, and towns.

Much of the eastern and southern parts has telephone services and the remainder is served by the flying doctor radio networks based at Cloncurry and Charters Towers.

IV. History

The discovery, exploration, and development of the northern half of the area up to 1930 have been detailed by Bauer (1959) and the following are largely brief extracts.

The earliest Europeans to visit the coast near the area were Dutch. In 1623 the two vessels *Pera* and *Aernem* under Jan Carstenszoom sailed south along the east coast of the Gulf of Carpentaria to the Staeten (Staaten) River. They saw the country in April and May and were not impressed.

Detailed examination of the coast began in 1802 when Matthew Flinders in the *Investigator* explored the Gulf of Carpentaria. He gave good descriptions which contained nothing to arouse enthusiasm for settlement. Robert Brown was the naturalist. The next exploration was by Stokes in the *Beagle* in 1841. He ascended the Albert River for about 50 miles in a boat and was so impressed with the level grassy plains that he named them "the Plains of Promise". The naturalist of the expedition was Charles Darwin.

The earliest land exploration was Leichhardt's expedition of 1844–45, which skirted the Gulf all the way from the lower Mitchell River to the Queensland–Northern Territory border. The naturalist of the expedition, Gilbert, was speared by aboriginals near the present Dunbar station. Of interest is Leichhardt's account of the extensive and deliberate burning of the open grassy forests and plains by the aboriginals. In 1856–57 A. C. Gregory's successful but unspectacular journey from the Victoria River in the north-west of Australia to the settled areas of Queensland traversed the northern part of the area from west to east and ascended the Gilbert River. One of his party was Ferdinand von Mueller. Gregory was not impressed by the country and stated that it offered "no inducement to settlement".

The next visitors to the area were Burke and Wills, whose ill-fated expedition is well known. Of it Bauer states, "It is somewhat ironic—and prophetic—that the expedition which finally led to large-scale settlement was the most complete fiasco in the history of Australian exploration". Actually Burke and Wills's expedition contributed little, in itself, to our knowledge of northern Australia—it was the various search parties which did the real exploration. Those which traversed the Leichhardt–Gilbert area were McKinlay's, Landsborough's, and Walker's parties.

The first settlement in the area was in 1864 along the Flinders River near Hughenden and Richmond and near the Albert and lower Leichhardt Rivers. Settlement was rapid and by the end of 1865 Floraville, Canobie, Iffley, Donors Hills, Millungera, and Dalgonally stations had been founded as well as those, such as Hughenden and Richmond, in the upper Flinders. Sheep were more important than cattle. Burketown, the first town, was founded in the same year but was abandoned in 1866 because of a fever which caused the death of many of the population. Normanton was settled in 1867. Burketown was refounded in 1875. Isolation, drought, and floods mitigated against success and by 1870 the pastoral industry had virtually failed.

In 1870 gold was found in the Etheridge–Georgetown area. Although outside the area, the Palmer gold-field, discovered in 1873, caused a demand for meat and assisted in the gradual reoccupation of the gulf area. This time cattle were the main animals. These early stations were dependent on surface water and the only areas occupied were close to river frontages, although cattle may have ranged more widely.

Copper was discovered at Cloncurry in 1867 but isolation prevented much exploitation and the Queensland government was pressed to provide a railway. By 1885 Normanton had been selected as its terminus and surveying of the route started.

By 1887 rails and sleepers began to be landed at Normanton. However, gold was accidentally discovered at Croydon in 1885 and by 1887 a town of 6000 had grown up. The Cloncurry line was shelved and the materials were used for the construction of the Normanton–Croydon line, which was completed in 1891.

Queensland's first artesian bore was drilled at Barcaldine in 1884 and by the early 1890s several had been drilled in the southern part of the Leichhardt–Gilbert area. Those at Normanton and Burketown were drilled in 1896 and 1897 respectively. Artesian water enabled pastoralists to use country other than the frontages.

In 1894 the cattle tick (and tick fever or red-water) reached the area and until the present remains one of the most serious scourges of the cattle industry. From this same year Croydon began to decline and along with it Normanton. By 1915 both were only remnants of the previous towns. Cloncurry and Selwyn were connected to Townsville by rail in 1910 and the Cloncurry area (Cloncurry, Selwyn, Kuridala, Duchess) enjoyed its period of greatest prosperity and population in the next decade. Its population rose to nearly 7000 people. With the fall in copper prices and the exhaustion of high-grade ore the field virtually died in 1920.

Mt. Isa mines were discovered in 1923 but did not come into production until the mid 1930s and did not pay their first dividend until 1947. By 1962 Mt. Isa was a thriving city of 12,000. In 1954 Mary Kathleen uranium mine was discovered and was rapidly developed to a population of about 1000 people. This mine closed in 1963. The history and development of the Cloncurry and Mt. Isa mines are described in detail by Blainey (1960).

It was in the 1920s that renewed interest was taken in sheep and by 1954 the southern quarter of the area was almost entirely sheep country with holdings mainly of 20,000–50,000 acres. The rest of the area remains cattle country.

Historically it is of interest that the railways on which the pastoral industry depends were all developed as a result of mining activity. It was not until the interest in motor transport of stock developed in the late 1950s that a beginning was made in the provision of a transport system for the pastoral industry. Since then good formed-earth roads have been constructed to link Cloncurry and Julia Creek with Normanton, and Normanton through Croydon, Georgetown, Forsayth, and Einasleigh to the Hann Highway at Lynd junction.

V. The Report

A deliberate attempt has been made to make various parts of the report comprehensible to different kinds of readers.

Part III contains detailed basic descriptions of the 61 land systems and is the central core of the report. Much of the information is presented in technical language but non-technical readers should be able to gain a broad general impression of the land systems from parts of the text above the block diagrams. The land systems have been arranged according to their geomorphological affinities so that land systems with a similar landscape genesis appear close to each other.

Parts IV–IX are specialist chapters which amplify the land system descriptions and present some additional data and conclusions on their particular topics. Technical language is used.

Parts X and XI deal with land use and the grazing industry and have been written for more general consumption. Part II is a summary of the whole report in non-technical language. Each land system is mentioned within the descriptions of the pasture lands. The plates have been selected and the narrative captions written to give a balanced pictorial representation, paralleling Part II, of the whole report. The first four pictures illustrate the physiographic divisions, the next three climatic variation, the next two the current land use, and the last fifteen illustrate each of the pasture lands.

On the single map sheet the lands of the area are depicted in several different ways. The main map presents the land systems, arranged according to pastoral affinities, in pasture lands. Smaller maps present the land systems arranged according to geomorphological affinities (the arrangement used in Part III) and to their dominant soils and vegetation. A fourth small map shows geology.

VI. Acknowledgments

The advice and criticism of Mr. C. S. Christian, Chief of the Division when the field work was done, and Mr. G. A. Stewart, the present Chief, are gratefully acknowledged. Botanists of the Queensland Department of Agriculture and Stock assisted with identification of plants both in the field and at Brisbane. Dr. N. T. Burbidge, of the CSIRO Division of Plant Industry, also assisted with plant determinations. The Bureau of Mineral Resources, Geology and Geophysics seconded Mr. C. E. Prichard to the team for the duration of the survey. Other geologists of the Bureau cooperated at various stages of the survey. Mr. J. R. Sleeman was seconded from the CSIRO Division of Soils for the survey. Messrs. J. H. Kelly and F. H. Collins, of the Commonwealth Bureau of Agricultural Economics, cooperated with the team during various stages of the survey. The topographic base for the maps was prepared by the Division of National Mapping, Department of National Development. The maps were prepared and colour separations made by the Division of Land Research and Regional Survey.

Thanks are due to station residents, stock companies, and regional staff of the Queensland Department of Agriculture and Stock for assistance, advice, and hospitality during the field periods.

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PART II. SUMMARY DESCRIPTION OF THE LEICHHARDT–GILBERT AREA

By R. A. PERRY*

The Leichhardt–Gilbert area stretches from sea-level to the top of the Great Dividing Range and from arid to humid climates. It is a diverse area containing many types of country which have been mapped and described in 61 land systems in this report.

I. PHYSIOGRAPHY

The area consists of three very distinct physiographic divisions (Plate 1, Fig. 1). Only one land system (Torwood) transgresses their boundaries.

(*a*) *Isa Highlands*

The hilly and mountainous high country in the west (Plate 1, Fig. 2) averages about 1200 ft above sea-level and locally exceeds 1650 ft. It constitutes about one-twentieth of the area and corresponds with the outcrop of the igneous and metamorphic rocks of the Cloncurry complex.

(*b*) *Carpentaria and Inland Plains*

These are the broad belt of plains, about 200 miles wide (Plate 2, Fig. 1), stretching from the Gulf of Carpentaria to beyond the southern margin of the area. The altitude ranges from sea-level to about 1000 ft on the divide between gulf and inland drainage. The plains are coincident with the Great Artesian Basin.

(*c*) *Einasleigh Uplands*

The eastern third of the area consists of mountains, hills, and plateaux mostly above 2000 ft but varying in height from a few hundred feet near Croydon to about 3000 ft near Chudleigh Park. Although rugged in many parts the local relief seldom exceeds 500 ft and is normally much less (Plate 2, Fig. 2).

II. DRAINAGE

Most of the area is drained by three major river systems all flowing into the Gulf of Carpentaria. The largest of these is the Flinders, which, with its major tributaries (Cloncurry, Saxby, Norman, and Yappar Rivers), drains the central part of the area. The other two are the Leichhardt, which drains the western part, and the Gilbert–Einasleigh, which drains the northern part. In addition to the gulf drainage the area includes some of the head-waters of the Herbert and Burdekin Rivers, which flow eastwards into the Pacific Ocean, and the head-waters of the Diamantina River and Burke and Wills Creeks, which are part of the southward-flowing inland drainage.

* Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T.

Because of seasonal rainfall river flow is intermittent. During the summer flash floods are common and large volumes of water pass down the channels within a few weeks. During winter flow is very small, limited to subsurface, or ceases, depending on the river (Plate 3, Fig. 1).

III. Climate

(*a*) *General Climatic Characteristics*

The climate of the area varies from arid tropical in the south-west to humid tropical in the north-east. Rainfall is strongly seasonal, most of it falling in four summer months. In the western two-thirds (the Isa highlands and the Carpentaria and inland plains) rain comes mainly from a north-western influence. Within this part the south-western corner is the driest (Plate 3, Fig. 2) and conditions become gradually wetter in both easterly and northerly directions. For example, the average rainfall in the south-west is about 15 in. and the average evaporation more than 110 in., whereas Normanton has 37 in. of rain and evaporation is about 90 in. Winter rainfall increases from north to south and at Cloncurry, Richmond, and Hughenden averages about 2 in. This is enough to produce herbage growth in many years and may be responsible for the generally better nutritional stability of the pastures of the southern plains. The south-western corner has higher summer and lower winter temperatures than areas further north and the daily range is also greater. Infrequent frosts occur in mid winter in the south-west but are unknown further north.

In the eastern third of the area (Einasleigh uplands) rain comes mainly from an eastern influence, and although most of it falls between December and April frequent light falls extend through most of the year. This, combined with the relatively high altitude (mostly about 2000 ft) and closeness to the wet coast, gives the eastern part a cooler and more humid climate than the rest of the area (Plate 4, Fig. 1). This is particularly so in the north-east, for example the rainfall at Cashmere is about 30 in. and the evaporation only about 53 in. Infrequent light frosts occur in mid winter over most of the Einasleigh uplands.

(*b*) *Growing Period for Agricultural Plants*

A reasonable requirement for safe agriculture is that the growing season should be 16 weeks or longer in at least 4 years out of 5. This happens only in a small part of the area, the north-eastern corner. A growing period of 12 weeks or more in 4 out of 5 years is probably adequate for growing short-season fodder crops. This condition is satisfied north of about the 25-in. isohyet in the Einasleigh uplands and about the 30-in. isohyet in the western parts.

(*c*) *Growing Period for Natural Pastures*

Because light falls of rain at the beginning of the season may be sufficient to initiate pasture growth but are not adequate for crop establishment, the pastoral growing season is longer than the agricultural growing season. The pastoral growing season ranges from about 8 weeks in the south-west to about 35 weeks in the north-east. During this season the period of rapid growth varies from about 4 weeks in the south-west to about 12 weeks in the north-east.

IV. History of the Landscape

The land surface of the area is made up of landscapes which have very diverse histories. Some are young with a short, simple history, in others ancient landscapes are preserved and these have a long, complex history. The landscapes can be considered in two groups—destructional and constructional. The first owe their present shape to erosional causes and the second to constructional influences, either alluvial or volcanic. In Part III the land systems are classified according to the origin of their landscapes.

(*a*) *Destructional Surfaces*

The events of the following sequence have produced the present landscape.

The period from Ordovician (500 million years ago) to Jurassic times (150 million years ago) was one of erosion in the west and of deposition followed by erosion in the east. By Jurassic times the whole area was a plain of low relief which has been named the pre-mid Mesozoic surface.

During late Jurassic to Cretaceous times (100 million years ago) the whole area (except for the present coastal ranges in the extreme east) was under the sea and the pre-mid Mesozoic surface was covered with sediments.

From late Cretaceous, when the area was raised relative to the sea, to mid Tertiary times (15 million years ago) was a period of erosion and weathering. The cover of soft sediments was stripped from most of the Isa highlands and some of the Einasleigh uplands and a new plain of low relief was formed partly on the Mesozoic sediments and partly on the underlying rocks. During the early to mid Tertiary period this was deeply weathered and laterite profiles were formed. This deeply weathered plain of low relief is named the early to mid Tertiary surface.

In Miocene times (15 million years ago) another uplift occurred and erosion was renewed. Since then the early to mid Tertiary surface has been eroded away over vast areas and the present surface has been formed. Sediments have been stripped from some areas where they persisted through the previous cycle of erosion and weathering, exposing the long-buried pre-mid Mesozoic surface. The new surface is named the late Tertiary to Quaternary surface.

Thus three main periods of erosion have occurred. Between the first and second periods, the surface formed by the first period was covered by sediments which were partly removed in the second period. Between the second and third periods the surface formed by the second was deeply weathered. The third period removed much of the surface formed during the second and stripped further areas of sediments. The present surface of the area contains elements of all three surfaces of erosion.

(*b*) *Constructional Surfaces*

These fall into two groups—those which have been formed by the deposition of alluvia and those which have been formed by outpourings of lava.

(i) *Alluvial.*—The products of the last period of erosion have been deposited in the lower parts of the Carpentaria plains. The oldest deposits are sandy and gravelly and were deposited as broad fans on both sides of the Carpentaria plains.

More recently, under swampy conditions, extensive fine-textured deposits have been spread over the middle parts.

(ii) *Volcanic.*—Since post-Miocene times (10 million years ago) large areas of the Einasleigh uplands have been covered with basalt.

V. Regional Geology, Soils, and Vegetation

The three physiographic divisions are distinctly different and they are considered separately.

(*a*) *Isa Highlands*

These are coincident with the outcrop area of the folded and metamorphosed rocks and igneous rocks of the Cloncurry complex. Where soils occur they are shallow and skeletal. The common vegetation is sparse eucalypt woodland 15–20 ft high in which snappy gum (*Eucalyptus brevifolia*), box (*E. argillacea*), and bloodwood (*E. terminalis*) are the prominent trees and spinifex (*Triodia pungens* and *T. molesta*) is the common understorey.

(*b*) *Carpentaria and Inland Plains*

These lowlands are part of the Great Artesian Basin and are underlain at depth by sandstones of the Blythesdale group (Mesozoic) which are the artesian aquifer. Overlying them are 1000–2000 ft of shales and siltstones of the Rolling Downs group (Mesozoic) on which calcareous cracking clay soils carrying grasslands characterized by Mitchell grass (*Astrebla* spp.) have formed. In the lower parts large areas of fine-textured alluvia derived from the Rolling Downs group also have cracking clay soils carrying grasslands. An extensive tract in the eastern part of the plains (i.e. that part adjacent to the Einasleigh uplands) has been covered by up to 40 ft of sand, gravel, and clay. This tract is known in the area as "sandy forest country". The common soils are brown soils of light texture and the common vegetation is a low woodland (15 ft) characterized by paperbarks (*Melaleuca* spp.) with a sparse grassy understorey characterized by ribbon grass (*Chrysopogon* spp.) and three-awns (*Aristida* spp.).

In the north the lowlands include the Gilbert "delta" country and the saline coastal country.

Low lateritic plateaux mostly with shallow soils and spinifex are also a feature of the central lowlands and adjacent to the Isa highlands is an area of undulating country with red earth soils carrying sparse low trees.

(*c*) *Einasleigh Uplands*

The main rocks are the metamorphic and igneous rocks of the Etheridge complex (mainly Pre-Cambrian). Palaeozoic rocks—Broken River group of sediments and Croydon felsite—occupy lesser areas. All these form hilly and mountainous country. Extensive plateaux and dissected plateaux are formed in the western and southern parts on Blythesdale sandstone (Mesozoic) and in the eastern part on basalt (Tertiary).

The dissected and hilly country has only shallow skeletal soils or rock outcrop. Red and yellow earths and red and yellow podzolics are the commonest soils on the flatter parts of the topography on the older rocks and krasnozems and black earths on the basalt.

The common vegetation is eucalypt woodland in which ironbark (*E. crebra*), 20 to 100 ft high, is the most prominent tree in the higher eastern part and Georgetown box (*E. microneura*), 15 to 30 ft high, is the most prominent tree in the lower and drier western part. An understorey of medium-height grasses is almost universal with kangaroo grass (*Themeda australis*), black spear grass (*Heteropogon contortus*), and blue grasses (*Dichanthium* spp. and *Bothriochloa* spp.) characteristic of the eastern part and three-awns (*Aristida* spp.) more common further west.

VI. Land Use

(*a*) *Climate and Land Use*

On the basis that safe dry-land agriculture requires a growing season of 16 weeks in 4 years out of 5, only the north-eastern corner of the area is suitable. A larger area, corresponding to that part of the Einasleigh uplands where mean annual rainfall exceeds 25 in. and that part of the Carpentaria plains where rainfall exceeds 30 in., appears suitable climatically for annual pastures and short-season fodder crops. In the rest of the area it seems that dry-land use will be virtually limited to the grazing of natural pastures.

(*b*) *Possibilities of Water Storage*

Most properties can locate water storages large enough to irrigate a few acres but the only river system with a large discharge and with suitable dam sites is the Gilbert–Einasleigh.

(*c*) *Agricultural Potential*

Within that part of the area (north-eastern corner) climatically suitable for cash crops or perennial pastures, only the flatter and less stony parts are arable. The area suitable is of the order of 1000 to 1500 sq miles, most of which is basalt country with krasnozems or black earth soils.

The area suitable for annual pastures or short-season fodder crops comprises the flatter and less stony parts of the eastern plateau where rainfall exceeds 25 in., the levees of the Gilbert and Einasleigh Rivers, and parts of the Gilbert delta.

As the only possibilities for large-scale water storage are on the Gilbert–Einasleigh river system, the only possibilities for large-scale irrigation projects are areas commandable from these storages. Of these Abingdon land system is the most attractive on the basis of soils but is small. The river levees and sandier soils of the delta would be nearly as good. For more extensive areas the Wallabadah soils of Mayvale land system appear to be fair for irrigation, but infertile. The heavier delta soils are intractable and may present salting and surface crusting problems.

(*d*) *Present Land Use*

(i) *The Grazing Industry.*—Currently the main land use is the grazing of natural pastures (Plate 4, Fig. 2). In 1960 the area carried 834,000 cattle mostly in the northern and eastern three-quarters and 2,825,000 sheep in the southern quarter. The sheep industry is more intensive than the cattle industry but both are on an extensive scale.

(ii) *The Mining Industry.*—With the closure of the Mary Kathleen uranium mine in 1963, mineral production (Plate 5, Fig. 1) from the area became negligible.

(*e*) *Pasture Lands*

Because over most of the area the grazing of natural pastures is likely to remain the major land use, the land systems have been grouped on the basis of their pastoral affinities into 15 pasture lands, of which one—non-range country (Plate 5, Fig. 2)—comprises all the Isa highlands but occurs in all three physiographic divisions, 10 comprise the Carpentaria and inland plains, and 4 the Einasleigh uplands.

(i) *Non-range Country.*—The 21,700 sq miles of this country is unsuitable for grazing, or virtually so. Much of it consists of rugged stony hills and mountains. Of the nine land systems three (Mt. Elliott, Argylla, and Kuridala) are restricted to, and comprise most of, the Isa highlands. They consist of rugged, stony hills or mountains and mostly carry scattered low trees of snappy gum, box, and bloodwood over spinifex. Small areas of valleys and frontages carry better pastures but on the whole the country is of little use for grazing. Torwood land system occupies the remaining small part of the Isa highlands and occurs also in the other two physiographic divisions. It consists of broken sandstone country and mostly carries dense lancewood over bare ground or very sparse grasses. The other five land systems (Wairuna, Ortona, Leichhardt, Belmore, and Toomba) are limited to the Einasleigh uplands. They consist mostly of rugged hills or mountains with outcropping rock or shallow skeletal soils and eucalypt woodland. As they mostly carry eastern mid-height grass pastures, grazing is limited by steepness and stoniness rather than lack of forage. Narrow valleys and gentler slopes are grazed, especially adjacent to areas of lower relief, but the overall carrying capacity is low.

(ii) *Spinifex Plains and Low Plateaux.*—Most of the 2300 sq miles of this country consists of low, somewhat dissected plateaux in the Carpentaria plains. The remainder consists of undulating plains south of the Isa highlands and in the inland plains. The soils are mostly gravelly or sandy and the country is treeless or carries scattered low trees of snappy gum, silverleaf box, or bloodwood over spinifex (Plate 6, Fig. 1). Smaller areas carry better pastures.

The country has a low pastoral value but is useful in the latter part of the dry season when adjacent normally better-quality pastures are very poor.

Normanton, Punchbowl, and Cowan land systems are characterized by soft spinifex, Merlin land system by hard spinifex. Normanton land system has the highest rainfall, is mostly covered with stringybark woodland, and includes moderate areas of three-awn and ribbon grass. Punchbowl land system has large treeless areas and minor areas with blue grass and browntop. Cowan land system is similar but has moderate areas of silverleaf box over three-awn and ribbon grass.

(iii) *Northern Sandy Forest Country.*—Most of the 16,900 sq miles of this country occurs in the broad sandy outwash plains which make up the eastern part of the Carpentaria and inland plains. The soils are mostly deep sands and the common vegetation is low paperbark woodland (Plate 6, Fig. 2) gradually changing to stringybark–bloodwood woodland with increasing rainfall. The nine land systems (Strathpark, Dandry, Esmeralda, Strathmore, Stanhill, Mayvale, Claraville, Abingdon, and Prospect) differ in origin, soils, and tree vegetation. The grass cover of all is relatively sparse and mainly composed of three-awns and ribbon grass. Minor areas include treeless shallow flat-floored valleys carrying short grasses, small frontages, and lagoons and depressions.

This country has a low stocking rate and a deficiency disease (hooky-hooky) is common. Some of the higher-rainfall areas may be suitable for Townsville lucerne, if fertilized.

(iv) *Southern Sandy Forest Country.*—This country mostly lies immediately south of the northern sandy forest country and like it has mostly deep sandy soils and a sparse grass cover composed of three-awns and ribbon grass. However, the tree cover is a low woodland containing many top-feed species such as bean tree (*Bauhinia*), whitewood, and vine tree (Plate 7, Fig. 1), which may account for the somewhat higher stocking rate compared with the northern sandy forest country. It is commonly seasonally grazed alternately with heavy soil areas.

Of the 5800 sq miles most is Bylong land system—sandy outwash plains. Murgulla land system consists of sandy erosional plains.

(v) *Coastal Country.*—This pasture land consists of 2000 sq miles of coastal country classified as Carpentaria land system.

The soils are mostly saline and are commonly bare (Plate 7, Fig. 2), but particularly along the inland margins there are areas of good pastures characterized by salt couch or rice grass. However, shortage of fresh water mostly limits grazing to short periods during the wet season.

(vi) *Western Mid-height Grass Country.*—The 1800 sq miles of this country consists of flat to gently undulating plains with silverleaf box woodland over mid-height grasses, commonly three-awns and kangaroo grass (Plate 8, Fig. 1). The pastures are only of moderate quality and have a moderate carrying capacity.

Korong land system consists of outwash plains with red earth soils and Manrika land system is an erosional plain with yellow earth soils.

(vii) *Arid Short Grass Country.*—This country consists of sparsely timbered undulating plains (Plate 8, Fig. 2) with occasional low hills. It mostly has shallow soils carrying short grass pastures but wetter areas carry mid-height grasses and shallow stony soils carry spinifex. Buffel grass has established in some areas near Cloncurry. Many of the trees and shrubs are grazed. The pastures are palatable and apparently nutritious but yield is low.

The pasture land consists of four land systems (Collis, Wonomo, Quamby, and Percol) totalling 5000 sq miles, distinguished on underlying rock, landscape genesis, and soils.

(viii) *Delta Country.*—The only land system (Miranda, 1900 sq miles) of this pasture land comprises the heavier soil parts of the Gilbert River "delta". The plains are mostly sparsely timbered with short grasses (*Chloris* and *Eriachne*) (Plate 9, Fig. 1), but moderate areas support mid-height and tall grasses. Frontage country and channels occur to a minor extent.

The country is well watered naturally and has a fairly high stocking rate. The agricultural growing season is probably too short for safe cash cropping or perennial pastures but it should be long enough for short-season fodder crops and annual pastures.

(ix) *Frontage Country.*—The three land systems comprising the 1700 sq miles of this pasture land occur as strips adjacent to streams. They are very varied but mostly have deep, fairly coarse-textured soils and carry eucalypt woodland over mid-height grasses.

Because of the availability of stock water the country was the first stocked and has been heavily stocked since.

The agricultural growing season of the frontages of the Gilbert River and rivers to the north of it is probably long enough for short-season fodder crops or annual pastures but too short for safe dry-land agriculture. Townsville lucerne grows well on frontages within the Gilbert delta and buffel grass (Plate 9, Fig. 2) is well established along the Cloncurry and some other rivers.

The three land systems (Cloncurry, Gilbert, and Armraynald) are distinguished mainly on soils.

(x) *Blue Grass–Browntop Plains.*—The 15,400 sq miles of this pasture land comprise the northern, lower, and wetter portion of the heavy soil part of the Carpentaria and inland plains. It consists of nearly flat to undulating plains, mostly treeless and carrying mid-height grasses (Plate 10, Fig. 1) among which blue grasses, browntop, bull Mitchell grass, feathertop, ribbon grass, and sorghums are prominent.

The pastures have a high yield but in the dry season quality is low. The country has a fairly high stocking rate.

The five land systems (Donors, Donaldson, Balbirini, Glenore, and Georgina) differ mostly in parent material and origin, and to some extent in soils and vegetation.

(xi) *Mitchell Grass Plains.*—This pasture land is part of the vast Mitchell grass plains of western Queensland. The 22,700 sq miles in the Leichhardt–Gilbert area is mostly in the southern and central part. It is gently undulating treeless plains with heavy soils carrying Mitchell grass pastures (Plate 10, Fig. 2). In the southern parts winter rainfall is high enough to produce valuable herbage growth in many years.

The country has a fairly high stocking rate and most of it is used for sheep-grazing. The water supply is mostly from artesian bores.

The four land systems (Julia, Wonardo, Monstraven, and Gregory) differ mainly in parent material and landscape origin.

(xii) *Eastern Spinifex Country.*—About 600 sq miles of timbered plateau country in the south-eastern corner of the area comprises this pasture land. The soils are sandy and the vegetation is eucalypt woodland, 20–40 ft high, with ironbark, yellowjack, and woollybutt (Plate 11, Fig. 1).

The pasture is patchy with patches of spinifex and patches of mid-height grasses including three-awn, bunch spear grass, blue grass, and kangaroo grass.

The country has only a low stocking rate and in some areas is infested with heart-leaf poison (*Gastrolobium grandiflora*).

Of the two land systems Warrigal is somewhat more dissected than Eurunga.

(xiii) *Three-awn Country.*—This pasture land consists of a group of three land systems (Townley, Georgetown, and Hampstead—2000 sq miles) occurring in the western, lower part of the Einasleigh uplands, adjacent to the Carpentaria plains. The topography is undulating (Plate 11, Fig. 2) and the vegetation mainly a woodland of Georgetown box over a short to mid-height grass layer comprising mostly three-awns. As pasture yield is low and quality poor, the stocking rate is only moderate.

The three land systems differ in rocks and soil.

(xiv) *Eastern Mid-height Grass Country.*—The 10,300 sq miles of this pasture land comprise most of the non-basalt country of low relief in the Einasleigh uplands. The vegetation commonly is eucalypt woodland of ironbark, bloodwood, and other trees over fairly dense stands of mid-height grasses (Plate 12, Fig. 1). The most prominent grasses are blue grasses, bunch spear grass, kangaroo grass, ribbon grass, and three-awns. The pastures have a moderately high yield and in many places retain a green tinge well into the dry season. Stocking rate varies from place to place but is normally a little lower than that of the basalt country.

Most of the 10 land systems (Karoon, Boorooman, Yanman, Glenharding, Lyall, McKinnon, Heidelberg, Niall, Reedy Springs, and Kilbogie) are erosional plains differing mainly in underlying rocks and in the soils formed on them.

(xv) *Basalt Country.*—The 7000 sq miles of this country occurs in two belts, the larger stretching from Hughenden north-eastwards and the other in the north-eastern corner of the area. The country consists of irregular stony basalt plains, the stoniness tending to decrease northwards.

Red soils (krasnozems) are the most common. They carry a eucalypt woodland, 20–60 ft high, of ironbark, bloodwood, and ghost gum over a fairly dense mid-height grass layer of kangaroo grass, bunch spear grass, and blue grasses (Plate 12, Fig. 2). Black soils (black earths) commonly occur in lower parts of the topography and are either treeless or carry a sparse woodland. The grass layer is fairly dense, mid-height, and includes blue grasses, browntop, cane grass, and, in the lower-rainfall parts, bull Mitchell grass.

The pastures have a fairly high yield and appear to remain moderately nutritious until frosted, after which they are of poor quality. The pasture land has a relatively high carrying capacity and is the best cattle country in the area.

Climatically most of the pasture land appears suited for the growing of short-season fodder crops and the northern parts for dry-land cash cropping. The soils are relatively fertile but many areas, particularly of black soils and in the south, are very stony. Even so, the area climatically suited to cash cropping or perennial pastures which is also sufficiently stone-free is of the order of 1000 to 1500 sq miles.

Boonderoo land system consists mostly of red soils and Rosella mostly of black soils.

PART III. LAND SYSTEMS OF THE LEICHHARDT–GILBERT AREA

By R. A. PERRY,* J. R. SLEEMAN,† C. R. TWIDALE,‡ and C. E. PRICHARD§

I. GENERAL

The land of the Leichhardt–Gilbert area has been mapped as 61 land systems which are areas of country (landscapes) with similar patterns of topography, rocks, soils, and vegetation.

Land systems are ideally meant to be objective units which can be combined in various ways for various purposes. However, of all the ways in which they can be grouped or arranged the most natural is one based on the origin of their landscape. For example, some landscapes are young with short, simple histories, in others remnants of ancient landscapes are preserved and these have a long, complex history. A natural arrangement for the land systems of the Leichhardt–Gilbert area is summarized in Table 1.

The land systems are initially classified into destructional land surfaces (those landscapes which owe their present shape principally to erosional factors) and constructional land surfaces (those landscapes which owe their present shape to constructional influences, either alluvial, marine, or volcanic). The former are further classified according to the age and form of their land surfaces and the latter on the age and form of the deposits.

In the Leichhardt–Gilbert area the destructional land surfaces are the result of three main periods of erosion, each of which produced an erosional surface (Part VI). Between the first (pre-mid Mesozoic) and second (early to mid Tertiary) periods of erosion the area was under the sea and the surface formed by the first was covered with sediments. These were partly removed by the second period of erosion. Between the second (early to mid Tertiary) and third (late Tertiary to Quaternary) periods the surface formed by the second was deeply weathered. During the third period of erosion much of the deeply weathered (i.e. early to mid Tertiary) surface was removed, forming the present (i.e. late Tertiary to Quaternary) surface, and further areas were stripped of sediments, thus exposing some of the earliest (i.e. pre-mid Mesozoic) surface. Thus the destructional land surface of the area contains elements of all three surfaces of erosion.

The constructional surfaces mainly comprise two groups—those formed by the deposition of alluvia and those formed by outpourings of lava. The six groups of alluvial land surfaces are the result of the deposition in the lower parts of the area of products of the late Tertiary to Quaternary period of erosion. The earliest were the outwash plains laid down on both sides of the Great Artesian Basin during

* Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T.

† Division of Soils, CSIRO, Canberra, A.C.T.

‡ Formerly Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T. Present address: Geography Department, University of Adelaide.

§ Bureau of Mineral Resources, Geology and Geophysics, Canberra, A.C.T.

TABLE 1

LAND SYSTEMS CLASSIFIED ACCORDING TO LAND FORM AND AGE OF SURFACE

		Land Form	Age Range of Surface	Land Systems
Destructional Land Surface		Plateaux and high plains	Early to mid Tertiary	Normanton, Karoon, Eurunga, Boorooman, Hampstead, Warrigal
		Immaturely dissected plateaux and high plains	Pre-mid Mesozoic	Mt. Elliott
			Pre-mid Mesozoic and early to mid Tertiary	Argylla, Wairuna
			Early to mid Tertiary	Ortona, Torwood
			Early to mid Tertiary with appreciable elements of late Tertiary to Quaternary plains	Punchbowl, Merlin, Cowan, Collis
		Maturely dissected hill country	Dissected pre-mid Mesozoic surface with some early to mid Tertiary elements and narrow late Tertiary to Quaternary plains	Leichhardt, Belmore, Kuridala
		Plains of erosion	Early to mid Tertiary	Strathpark, Manrika, Dandry, Esmeralda, Strathmore, Murgulla, Yanman, Glenharding
			Late Tertiary to Quaternary	Julia, Donors, Donaldson, Wonardo, Wonomo, Lyall, McKinnon
			Late Tertiary to Quaternary with elements of pre-mid Mesozoic	Quamby, Heidelberg, Stanhill, Niall, Georgetown, Reedy Springs, Kilbogie, Townley
Constructional Land Surface	Alluvial	Outwash plains	Pliocene	Mayvale, Claraville, Bylong, Abingdon, Korong, Percol
		Riverine paludal plains	Pleistocene	Balbirini, Monstraven, Glenore, Miranda
		Covered plains	Early Recent	Gregory, Cloncurry, Gilbert
		Bar plains	Late Recent	Georgina
		Lacine and scroll plains	Late Recent	Armraynald, Prospect
		Marine plains	Late Pliocene and Quaternary	Carpentaria
	Volcanic	Basalt plains and plateaux	Pliocene and Pleistocene	Rosella, Boonderoo
		Little-weathered lava flows	Early Recent	Toomba

Pliocene times. During wetter conditions in Pleistocene times riverine paludal plains formed in the centre of the northern part of the Great Artesian Basin. With improved drainage in early Recent times covered plains were laid on top of the earlier plains. More recently bar plains were deposited along the major rivers and marine plains formed near the coast. The most recent deposits are lacine and scroll plains.

Volcanic land surfaces comprise two groups of land systems—the basalt plains and plateaux formed by Pliocene and Pleistocene volcanic activity and the little-weathered lava flows formed by volcanic activity in early Recent times.

TABLE 2

CORRELATION OF APPROPRIATE LAND SYSTEMS WITH LAND ASSOCIATIONS OF HUBBLE AND BECKMANN (1957)

Land System (this Report)	Land Associations and Properties on which they are Mapped
Argylla	PS_M and PS_H (Kamileroi)
Balbirini	GP (Millungera), FP (Dalgonally), BPc (Canobie), D and BP (Kamileroi)
Bylong	MS (Millungera), S (Dalgonally)
Claraville	SA (Millungera)
Cloncurry	CS_D (Dalgonally), CSK (Kamileroi)
Cowan	LU and RD (Canobie)
Donaldson	GR (Dalgonally, Canobie, Granada), GD (Canobie, Granada, Kamileroi), RD (Granada, Canobie), D (Canobie)
Georgina	C (Millungera, Dalgonally, Granada, Canobie)
Gregory	SR and CS_G (Granada), BP (Kamileroi, Granada), GP (Kamileroi)
Julia	D (Dalgonally, Granada, Kamileroi)
Korong	SL, AS, ASi, and MA (Kamileroi), TP (Granada), LU (Dalgonally)
Kuridala	PS_M and PS_H (Kamileroi)
Monstraven	D and FP (Dalgonally), BP and BPs (Granada)
Punchbowl	LU (Canobie)
Quamby	PS_H (Kamileroi)

While the above classification of land systems is considered the most natural, other classifications have more practical significance, particularly in regard to land use. For example, on the 1 : 1,000,000 land system map the land systems are grouped into pasture lands and in each of the four smaller inset maps they are grouped on other criteria (land form and age of surface, geology, dominant soils, and dominant tree and grass vegetation). Descriptions of the various units used on the maps are given in the relevant chapters.

In the following pages each land system is described in tabular form and is illustrated with a diagram. The land systems are arranged as in Table 1, that is, in sequence according to the origin of their land surface. For brevity much of each description is in terms of names of units described in detail in succeeding relevant chapters. Areas of the land systems were estimated with a dot grid (25 dots/sq in) over a 1 : 1,000,000 map. Relative areas of the constituent units were estimated visually from the aerial photographs or from field experience.

The land of the Australian Estates Co. properties within the area has been surveyed by Hubble and Beckmann (1957) and described in terms of a number of "land associations". Allowing for differences in the scale of work, the broad relationships of their land associations to the land systems of this report are given in Table 2.

Some of the land systems are similar to land systems described in the Barkly (Christian *et al.* 1954) and Townsville–Bowen (Christian *et al.* 1953) regions. Where appropriate, comparisons have been noted at the bottom of the land system descriptions.

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CHRISTIAN, C. S., PATERSON, S. J., PERRY, R. A., SLATYER, R. O., STEWART, G. A., and TRAVES, D. M. (1953).—Survey of the Townsville–Bowen region, north Queensland, 1950. CSIRO Aust. Land Res. Ser. No. 2.

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(1) Normanton Land System* (300 sq miles)

Timbered low plateaux near Normanton and Warung.

Geomorphology.—Destructional land surface. Plateaux and high plains. Early to mid Tertiary surface.

Geology.—Rolling Downs group (Mesozoic). Mainly lateritized greywacke and sandstone.

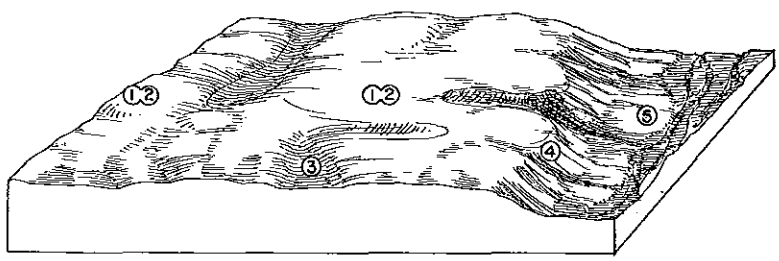
Drainage.—Moderate intensity.

Elevation.—300 ft and less. Local amplitude < 150 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 15 wk; mean pasture growing season 20 wk.

Driest locality: mean annual rainfall 22 in.; mean agricultural growing season 7 wk; mean pasture growing season 12 wk.

Pasture Land.—Spinifex plains and low plateaux.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Very gently undulating plateau surface	Gravelly Clarina: clay loam over clay over ferruginous zone	Stringybark woodland (*E. tetrodonta, E. dichromophloia*) with three-awn–ribbon grass (*Chrysopogon fallax, Aristida browniana, Sorghum* sp.) or, in small areas, western spinifex (*Triodia pungens*)
2†	Medium	Slightly higher parts of plateau surface	Gravelly Wonorah: clay loam over clay over ferruginous or mottled zones	As for unit 1 in higher-rainfall parts. Lower rainfall, Isa highland sparse low woodland (*E. brevifolia, E. setosa, E. pruinosa*) with western spinifex (*Triodia pungens*)
3	Very small	Shallow, flat depressions	Wallabadah: sand over clay	Paperbark low woodland (*Melaleuca viridiflora*) with solodic soil short grass (*Eriachne obtusa, E. armittii, Chrysopogon fallax*). Small areas with silverleaf box low woodland (*E. pruinosa*) and western box woodland (*E. argillacea*) both with three-awn–ribbon grass (*Chrysopogon fallax, Aristida hygrometrica*)
4	Small	Scarps at edges of plateaux	Skeletal sand and outcropping ferruginous, mottled, and pallid zones	Stringybark woodland (*E. dichromophloia, E. normantonensis*) with three-awn–ribbon grass (*Chrysopogon fallax, Aristida hygrometrica*) or western spinifex (*Triodia pungens*). Low rainfall, Isa highland sparse low woodland (*E. brevifolia*) with western spinifex (*Triodia pungens*)
5	Small	Alluviated deeper valleys bounded by low scarps	Nangum: clay loam over clay	Margins, western box woodland (*E. argillacea*) with western mid-height grass (*Aristida pruinosa, Dichanthium fecundum, Chrysopogon fallax*). Centres, downs sparse woodland (*E. microtheca*) with blue grass–browntop downs (*Eulalia fulva, Dichanthium fecundum*)

* Comparable with parts of Westmoreland land system of the Barkly region.

† In the higher-rainfall parts of the land system (near Normanton) this unit is small but in the lower-rainfall parts (near Canobie station) it is the largest unit.

(2) KAROON LAND SYSTEM (500 SQ MILES)

Timbered plains and plateaux in the south-east of the area.

Geomorphology.—Destructional land surface. Plateaux and high plains. Early to mid Tertiary surface.

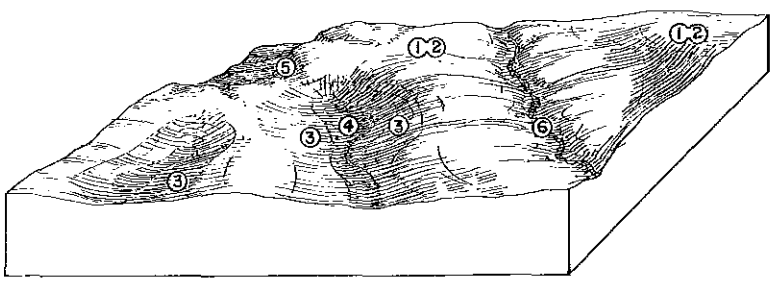
Geology.—Terrestrial deposits (Tertiary) overlying Blythesdale group (Mesozoic).

Drainage.—Sparse, parallel pattern.

Elevation.—1400 ft. Local amplitude < 100 ft.

Climate.—Mean annual rainfall 20 in. Mean agricultural growing season 10 wk. Mean pasture growing season 15 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Very gently undulating high plain	Elliott: sand over clay	Ironbark woodland (*E. crebra, E. papuana, E. polycarpa, E. dichromophloia, E. setosa*) with eastern mid-height grass (*Themeda australis, Aristida* spp., *Bothriochloa ewartiana, Heteropogon contortus*) and small patches of eastern spinifex (*Triodia mitchellii*)
2	Small		Sturgeon: sand over clay	
3	Small	Lower gentle slopes adjacent to unit 4	Zingari: clay loam over clay	Ironbark woodland (*E. crebra*) and Reid River box woodland (*E. brownii*) with eastern mid-height grass (*Themeda australis, Aristida* spp., *Heteropogon contortus*). Reid River box woodland (*E. brownii*) with three-awn (*Aristida* spp.)
4	Small	Discontinuous linear depressions	Barkly: calcareous cracking clay	Blue grass–browntop downs (*Eulalia fulva, Dichanthium fecundum, Bothriochloa ewartiana, Astrebla squarrosa*), in some places under downs sparse woodland (*E. microtheca*)
5	Very small	Steep scarp at edge of plateau	Outcropping ferruginous, mottled, and pallid zones and possibly with Forsayth (clay loam over clays) on adjacent plateau edge	Ironbark woodland (*E. crebra, E. setosa*) and lancewood woodland (*Acacia shirleyi*) over eastern spinifex (*Triodia mitchellii*)
6	Very small	Stream channel	—	Fringing woodland (*E. microtheca*) with fringing grass (*Chloris acicularis*)

(3) Eurunga Land System (300 sq miles)

Timbered plateaux and plains in the south-east of the area.

Geomorphology.—Destructional land surface. Plateaux and high plains. Early to mid Tertiary surface. Practically undissected uplifted and warped high plains.

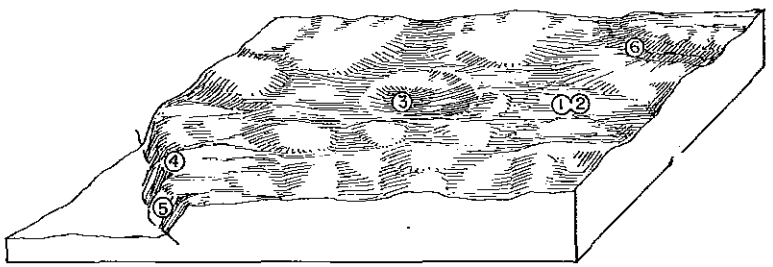
Geology.—Terrestrial deposits (Tertiary). Sandstones.

Drainage.—Sparse, subangular and angular tributary patterns.

Elevation.—1500 ft. Local amplitude < 100 ft.

Climate.—Mean annual rainfall 20 in. Mean agricultural growing season 10 wk. Mean pasture growing season 16 wk.

Pasture Land.—Eastern spinifex country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Gently undulating plateau surface	Mainly Elliott, minor Sturgeon: sand over clay, possibly over ferruginous, mottled, or pallid zone	Ironbark woodland (*E. crebra, E. polycarpa, E. papuana, E. setosa*) with eastern spinifex (*Triodia mitchellii*) and eastern mid-height grass (*Aristida* spp., *Heteropogon contortus*)
2	Medium		Cockatoo: sand	Ironbark woodland (*E. similis, E. polycarpa, E. setosa, E. crebra*) with eastern spinifex (*Triodia mitchellii*) and eastern mid-height grass (*Aristida* spp., *Heteropogon contortus*)
3	Very small	Rounded depressions in plateau surface	Endymion: cracking clay	Lagoon vegetation (*Pseudoraphis spinescens*)
4	Very small	Truncated margin of plateau	Currajong: sand over ferruginous zone	Ironbark woodland (*E. shirleyi, E. setosa*) with eastern spinifex (*Triodia mitchellii*)
5	Very small	Dissection scarp	Skeletal sand and outcrop of ferruginous and mottled rock	Lancewood woodland (*Acacia shirleyi*) with bare ground and ironbark woodland (*E. shirleyi, E. similis*) with eastern spinifex (*Triodia mitchellii*)
6	Very small	Stream channel	—	Fringing woodland (*E. camaldulensis*) with fringing grass

(4) Boorooman Land System (2600 sq miles)

Tall forest on plains and plateaux in the east of the area.

Geomorphology.—Destructional land surface. Plateaux and high plains. Early to mid Tertiary surface.

Geology.—Blythesdale group (Mesozoic). Medium- to coarse-grained silty quartz sandstone, thin beds and lenses of siltstone and pebble conglomerate. Terrestrial deposits (Tertiary). Sandstones and siltstones.

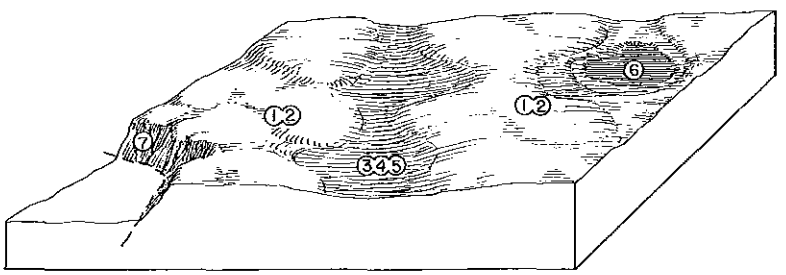
Drainage.—Sparse.

Elevation.—1500–2500 ft. Local amplitude < 100 ft.

Climate.—Wettest locality: mean annual rainfall 35 in.; mean agricultural growing season > 25 wk; mean pasture growing season > 35 wk.

Driest locality: mean annual rainfall 20 in.; mean agricultural growing season 10 wk; mean pasture growing season 16 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Higher parts of plateau surface	Sturgeon: sand over clay	Ironbark forest (*E. crebra, E. polycarpa, E miniata, E. dichromophloia,* low rainfall *E. similis,* high rainfall *E. citriodora, E. papuana, E. howittiana, E. tessellaris, E. cloeziana, Tristania suaveolens, Casuarina inophloia*) with eastern mid-height grass (*Themeda australis, Heteropogon contortus, H. triticeus,* low rainfall *Triodia pungens, Aristida* spp., high rainfall *Arundinella nepalensis, Coelorachis rottboellioides, Sorghum plumosum*)
2	Medium		Cockatoo: sand	
3	Small	Shallow depressions in plateau surface	Stawell: sand over clay over ferruginous zone	Upper margins, ironbark woodland (*E. crebra, E. dichromophloia, E. polycarpa, E. howittiana, E. trachyphloia, E. similis*). Lower slopes, Reid River box woodland (*E. brownii*). Bottoms, poplar gum–grey bloodwood woodland (*E. alba, E. polycarpa, E. tessellaris*). All with eastern mid-height grass (*Themeda australis, Heteropogon contortus, Arundinella nepalensis, Chrysopogon fallax, Bothriochloa ewartiana*)
4	Small		Cargoon: sand over clay	
5	Small		Clarina: clay loam over clay over lateritic horizons	
6	Very small	Lakes and surrounding areas	Nangum: clay loam over clay. Currajong: sand over ferruginous zone. Elliott: sand over clay	Lakes surrounded by lagoon vegetation (*Pseudoraphis spinescens, Imperata cylindrica, Eleocharis* spp., *Cyperus* spp., *Eragrostis* spp.). Higher margins as units 3–5
7	Small	Scarps at edge of plateaux	Skeletal sand, mottled sandstone and siltstone outcrop	Shallow soils, ironbark woodland (*E. crebra, E. trachyphloia, E. exserta, E. peltata, E. dichromophloia*) with eastern mid-height grass (sparse *Heteropogon contortus, H. triticeus, Aristida* spp., *Cymbopogon bombycinus*). Outcrop areas, lancewood woodland (*Acacia shirleyi*) or *Melaleuca foliolosa* both with mainly bare ground (very sparse *Cleistochloa subjuncea, Triodia mitchellii, Lomandra* sp.)

(5) Hampstead Land System (600 sq miles)

Gently sloping timbered plateau somewhat south-east of the centre of the area.

Geomorphology.—Destructional land surface. Plateaux and high plains. Early to mid Tertiary surface.

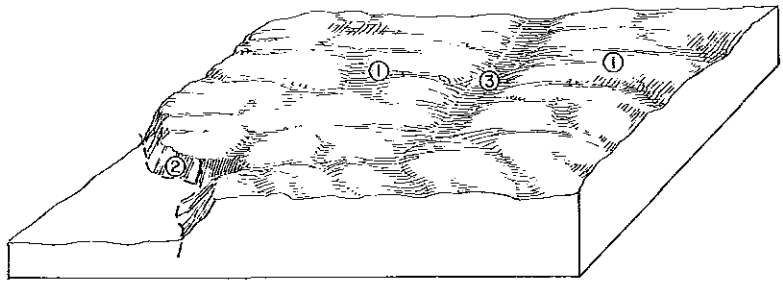
Geology.—Blythesdale group (Mesozoic). Medium- to coarse-grained silty quartz sandstone, thin beds and lenses of siltstone, and pebble conglomerate.

Drainage.—Sparse and subparallel.

Elevation.—1000–1700 ft. Local amplitude < 20 ft.

Climate.—Mean annual rainfall 20 in. Mean agricultural growing season 10 wk. Mean pasture growing season 15 wk.

Pasture Land.—Three-awn country.



Unit	Area	Land Forms	Soils	Vegetation
1	Very large	Very gently undulating plateau surface	Cockatoo: sand	Georgetown box woodland (*E. microneura*), ironbark woodland (*E. polycarpa*, *E. similis*, *E. setosa*, *E. miniata*), small areas stringybark woodland (*E. tetrodonta*, *E. miniata*), all with three-awn (*Aristida ingrata*, *A. hygrometrica*)
2	Small	Scarp at edge of plateau	Skeletal sand and rock outcrop	Lancewood woodland (*Acacia shirleyi*, *E. trachyphloia*) and Georgetown box woodland (*E. microneura*) with bare ground and patches of western spinifex (*Triodia* spp.)
3	Very small	Shallow depressions	Vanrook: sand over alkaline clay	Georgetown box woodland (*E. microneura*), with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*) and lagoon vegetation (*Pseudoraphis spinescens*)

(6) Warrigal Land System (300 sq miles)

Timbered plateaux and slopes in the south-east of the area.

Geomorphology.—Destructional land surface. Plateaux and high plains. Early to mid Tertiary surface.

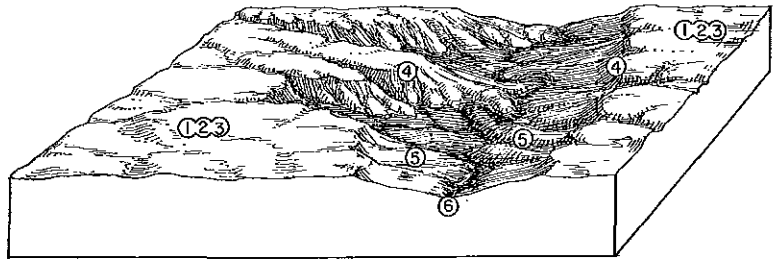
Geology.—Terrestrial deposits (sandstones of Tertiary age) overlying Blythesdale group (Mesozoic—medium- to coarse-grained silty quartz sandstone, thin beds and lenses of siltstone, and pebble conglomerate).

Drainage.—Sparse on plateaux. Intense on scarp.

Elevation.—1000–2000 ft. Local amplitude 100–150 ft.

Climate.—Mean annual rainfall 22 in. Mean agricultural growing season 12 wk. Mean pasture growing season 17 wk.

Pasture Land.—Eastern spinifex country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Slightly elevated parts of gently undulating high plain	Sturgeon: sand over clay	Ironbark woodland and forest (*E. similis, E. dichromophloia, E. crebra, E. setosa,* and less commonly *E. polycarpa, E. peltata, E. miniata*) with many shrubs and low trees and with eastern spinifex (*Triodia mitchellii*) and smaller areas of eastern mid-height grass (*Bothriochloa ewartiana, Aristida* spp., *Heteropogon contortus, Themeda australis*)
2	Medium		Cockatoo: sand	
3	Medium	Flatter parts of gently undulating high plain	Elliott: sand over clay	Ironbark woodland (*E. similis, E. setosa, E. crebra, E. peltata, E. shirleyi*) with shrubs and eastern spinifex (*Triodia mitchellii*)
4	Small	Truncated margin of plateau	Currajong: sand over ferruginous zone	Ironbark woodland (*E. similis, E. setosa, E. shirleyi*) with shrubs and eastern spinifex (*Triodia mitchellii*). Smaller areas of lancewood woodland (*Acacia shirleyi*) with bare ground. Very rocky areas with *Melaleuca foliolosa*
5	Medium	Steep dissection slopes	Skeletal sand and mottled sandstone outcrops	
6	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis*) with fringing grass

(7) Mt. Elliott Land System* (200 sq miles)

Several rocky plateaux in the south-west of the area.

Geomorphology.—Destructional land surface. Immaturely dissected plateaux and high plains. Pre-mid Mesozoic surface. Mesozoic sediments were deposited on, and later stripped from, the ancient surface. The surface is now dissected but extensive plateau areas remain.

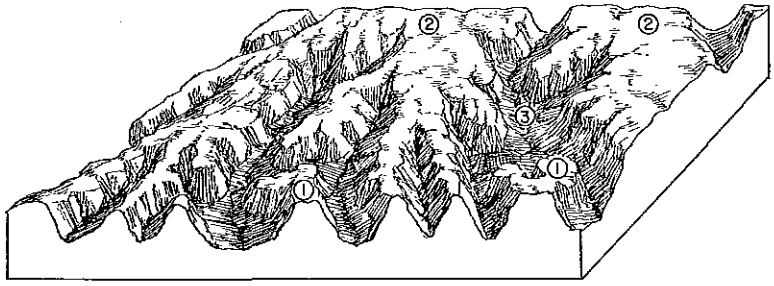
Geology.—Cloncurry complex (Pre-Cambrian). Folded and metamorphosed rocks.

Drainage.—Intense structurally controlled pattern.

Elevation.—1000 ft. Local amplitude approximately 200 ft.

Climate.—Mean annual rainfall approximately 15 in. Mean agricultural growing season < 5 wk. Mean pasture growing season < 10 wk.

Pasture Land.—Non-range—rugged, stony, or barren.



Unit	Area	Land Forms	Soils	Vegetation
1	Medium	Buttes	Skeletal and rock outcrop	Isa highlands sparse low woodland (*E. brevifolia*). Small areas trees absent. Both with western spinifex (*Triodia pungens, T. molesta*)
2	Medium	Mesas		
3	Medium	Valleys		

* Comparable to part of Mt. Isa land system of the Barkly region.

(8) ARGYLLA LAND SYSTEM* (2300 SQ MILES)

Rugged mountains in the west of the area.

Geomorphology.—Destructional land surface. Immaturely dissected plateaux and high plains. Pre-mid Mesozoic and early to mid Tertiary surfaces.

Geology.—Cloncurry complex (Pre-Cambrian). Mainly quartzites.

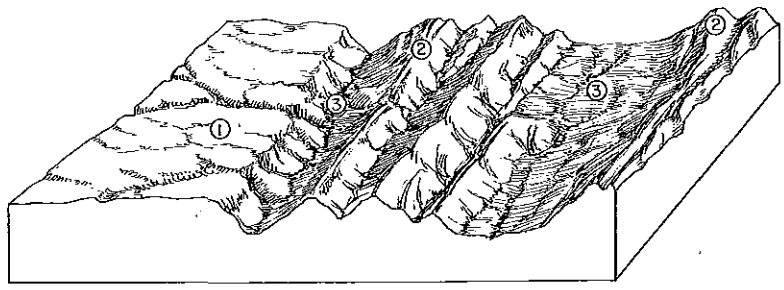
Drainage.—Moderately intense trellis pattern.

Elevation.—500–1600 ft. Local amplitude approximately 500 ft.

Climate.—Wettest locality: mean annual rainfall 20 in.; mean agricultural growing season 10 wk; mean pasture growing season 15 wk.

Driest locality: mean annual rainfall 15 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Pasture Land.—Non-range—rugged, stony, or barren.



Unit	Area	Land Forms	Soils	Vegetation
1	Medium	Plateaux	Skeletal and rock outcrop	Isa highland sparse low woodland (*E. brevifolia, E. argillacea, E. terminalis*). Small areas trees absent. Both with western spinifex (*Triodia pungens, T. molesta, T. barkensis*)
2	Medium	Flat-topped ridges with accordant crests		
3	Medium	Valleys		Mainly as units 1 and 2. Small areas Isa highlands sparse low woodland (*E. argillacea, E. terminalis*) with western mid-height grass (*Sehima nervosum, Aristida pruinosa, Themeda australis*). Fringing woodland (*E. camaldulensis*) with fringing grass (*Heteropogon contortus*).

* Comparable to part of Mt. Isa land system of the Barkly region. Includes some areas of the PS_M and PS_H land associations of Hubble and Beckmann (1957).

(9) Wairuna Land System (900 sq miles)

Rugged mountains in the east of the area.

Geomorphology.—Destructional land surface. Immaturely dissected plateaux and high plains. Pre-mid Mesozoic and early to mid Tertiary surfaces.

Geology.—Broken River group (Silurian–Devonian). Steeply folded and slightly metamorphosed slate and phyllite.

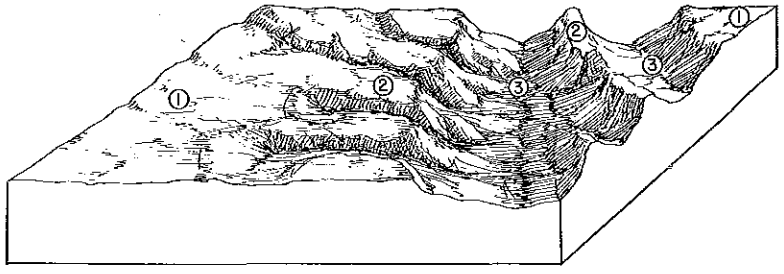
Drainage.—Intense structurally controlled pattern.

Elevation.—1500–2000 ft. Local amplitude approximately 500 ft.

Climate.—Wettest locality: mean annual rainfall 35 in.; mean agricultural growing season 25 wk; mean pasture growing season 35 wk.

Driest locality: mean annual rainfall 25 in.; mean agricultural growing season 15 wk; mean pasture growing season 20 wk.

Pasture Land.—Non-range—rugged, stony, or barren.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Plateaux	Skeletal and rock outcrop	Ironbark woodland (*E. crebra, E. dichromophloia*) with eastern mid-height grass (*Themeda australis, Aristida* spp., *Heteropogon* spp.) and small areas of eastern spinifex (*Triodia mitchellii*). Steep slopes and scarps, lancewood woodland or forest (*Acacia shirleyi*) with bare ground or sparse eastern spinifex
2	Medium	Mesas and buttes		
3	Medium	Valleys		Ironbark woodland with eastern mid-height grass. Reid River box woodland (*E. brownii*) with eastern mid-height grass, eastern spinifex, or bare ground

(10) Ortona Land System (600 sq miles)

Dissected plateaux near the centre of the area.

Geomorphology.—Destructional land surface. Immaturely dissected plateaux and high plains. Early to mid Tertiary surface. Streams penetrate through base of Mesozoic into underlying Etheridgean sediments and crystalline rocks; structural benches (exhumed pre-mid Mesozoic surface) occur at the junction.

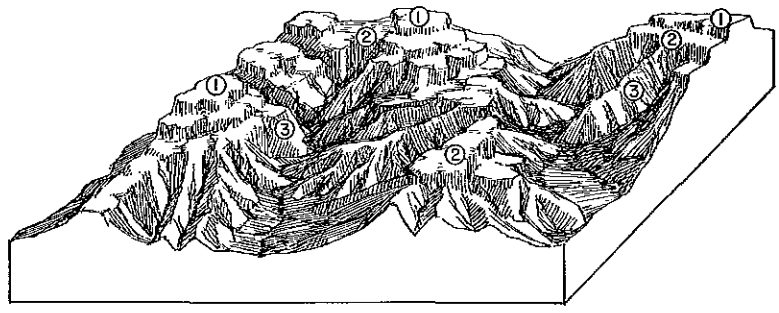
Geology.—Blythesdale group (Mesozoic). Subhorizontal sandstones. Etheridge complex (Pre-Cambrian) exposed in valleys.

Drainage.—Intense structurally controlled pattern in Etheridgean complex, sparse on Blythesdale group except on scarps.

Elevation.—1000–1500 ft. Local amplitude 500–700 ft.

Climate.—Mean annual rainfall 25 in. Mean agricultural growing season 12 wk. Mean pasture growing season 15 wk.

Pasture Land.—Non-range—rugged, stony, or barren.



Unit	Area	Land Forms	Soils	Vegetation
1	Medium	Mesa and butte surfaces	Skeletal and rock outcrop	Ironbark woodland (*E. shirleyi, E. trachyphloia, E. miniata*) with mainly bare ground
2	Medium	Stepped scarps		Lancewood woodland (*Acacia shirleyi*) with bare ground, on or near sandstone. Deciduous low woodland with bare ground on metamorphics
3	Medium	Structural benches and valley sides	Skeletal soils. Cockatoo: deep sands. Cargoon and Wyandotte: sands over clay. Forsayth: clay loam over clay	Ironbark woodland (*E. crebra, E. dichromophloia*) with eastern mid-height grass (*Heteropogon* spp., *Aristida* spp.) and small areas western spinifex (*Triodia molesta*). Moderate areas Georgetown box woodland (*E. microneura*) with eastern mid-height grass (*Aristida* spp.) and western spinifex (*Triodia molesta*)
4	Small	Stream channels and associated narrow alluvial areas	Manbulloo: deep fine sand	Fringing woodland (*E. camaldulensis, Melaleuca* sp., *Tristania* sp.) with fringing grass. Frontage woodland (*E. leptophleba, E. papuana*) with frontage mid-height grass (*Bothriochloa decipiens*)

(11) Torwood Land System (7700 sq miles)

Broken sandstone tablelands generally timbered with lancewood.

Geomorphology.—Destructional land surface. Immaturely dissected plateaux and high plains. Early to mid Tertiary surface.

Geology.—Blythesdale group and Rolling Downs group (Mesozoic). Lateritized, subhorizontal sandstones.

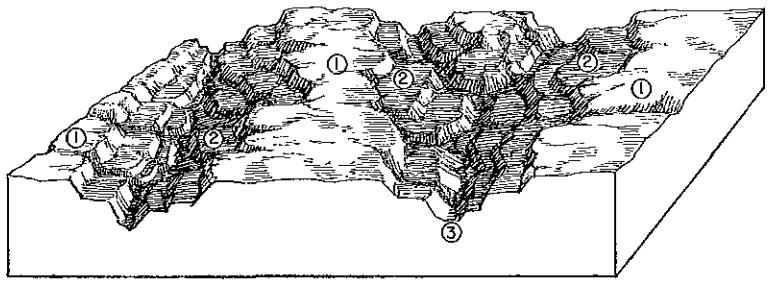
Drainage.—Sparse on plateaux but intense in valleys. Subrectangular pattern (related to jointing in the sandstone).

Elevation.—500–2500 ft. Local amplitude approximately 300 ft.

Climate.—Wettest locality: mean annual rainfall 32 in.; mean agricultural growing season 20 wk; mean pasture growing season 22 wk.

Driest locality: mean annual rainfall 15 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Pasture Land.—Non-range—rugged, stony, or barren.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Plateaux and mesa surfaces	Skeletal and rock outcrop	Lancewood woodland (*Acacia shirleyi*) with mainly bare ground (very sparse annuals or *Triodia pungens*). Shallow soils, high rainfall, ironbark woodland (*E. polycarpa, E. trachyphloia, E. miniata, E. dichromophloia, E. similis*) with bare ground (very sparse annuals), three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*), or eastern spinifex (*Triodia mitchellii*). Shallow soils, central part of area, Georgetown box woodland (*E. microneura*) with bare ground (very sparse annuals) or western spinifex (*Triodia pungens*). Shallow soils, low rainfall, Isa highlands sparse low woodland (*E. brevifolia, E. argillacea*) with western spinifex (*Triodia pungens, T. molesta*)
2	Medium	Stepped scarps		
3	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis, Terminalia platyphylla*)

(12) Punchbowl Land System* (900 sq miles)

Spinifex country near the Gulf of Carpentaria.

Geomorphology.—Destructional land surface. Immaturely dissected plateaux and high plains. Early to mid Tertiary surface with appreciable elements of late Tertiary to Quaternary plains. The early to mid Tertiary surface has suffered warping.

Geology.—Rolling Downs group (Mesozoic). Mainly lateritized greywacke, siltstone, and sandstone.

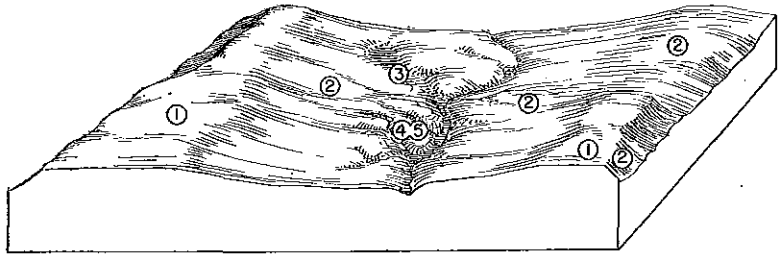
Drainage.—Moderate to intense.

Elevation.—< 100–300 ft. Local amplitude < 100 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 15 wk; mean pasture growing season 20 wk.

Driest locality: mean annual rainfall 20 in.; mean agricultural growing season 7 wk; mean pasture growing season 12 wk.

Pasture Land.—Spinifex plains and low plateaux.



Unit	Area	Land Forms	Soils	Vegetation
1	Small	Remnants of the old plateau surface	Sturgeon over ferruginous zone: sand over clay over ferruginous zone	Isa highlands sparse low woodland (*E. brevifolia*). Small areas high rainfall, stringybark woodland (*E. tetrodonta, E. dichromophloia*). Both with western spinifex (*Triodia pungens*)
2	Very large	Truncated plateau surface and scarps	Skeletal sand over pallid zone	Trees absent (occasional *E. brevifolia, E. grandifolia, Terminalia canescens, Melaleuca* spp.). Small areas Isa highlands sparse low woodland (*E. brevifolia*) and silverleaf box low woodland (*E. pruinosa*). All with western spinifex (*Triodia pungens*)
3	Small	Truncated plateau surface	Endymion: cracking clays	Blue grass–browntop downs (*Eulalia fulva, Astrebla squarrosa, Aristida latifolia, Chrysopogon fallax*). Small patches with gidgee low woodland (*Acacia cambagei*) and downs sparse woodland (*E. microtheca*)
4	Small	Gently sloping dissected areas	Barkly and Wonardo: calcareous cracking clay	
5	Small		Nangum: clay loam over clay	Silverleaf box low woodland (*E. pruinosa*), paperbark low woodland (*Melaleuca* spp.), and trees absent (occasional *E. grandifolia, Petalostigma banksii*). All with western spinifex (*Triodia pungens*), western mid-height grass (*Aristida* spp., *Sehima nervosum*), and three-awn–ribbon grass (*Aristida hygrometrica, Chrysopogon fallax*). Very small area, trees absent with solodic soil short grass (*Aristida superpendens, A. hirta, Eriachne* sp.)
6	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis, E. microtheca, Terminalia platyphylla*)

* Includes some areas of the LU land association of Hubble and Beckmann (1957).

(13) MERLIN LAND SYSTEM* (400 SQ MILES)

Stony spinifex country in the south-west of the area.

Geomorphology.—Destructional land surface. Immaturely dissected plateaux and high plains. Early to mid Tertiary surface with appreciable elements of late Tertiary to Quaternary plains.

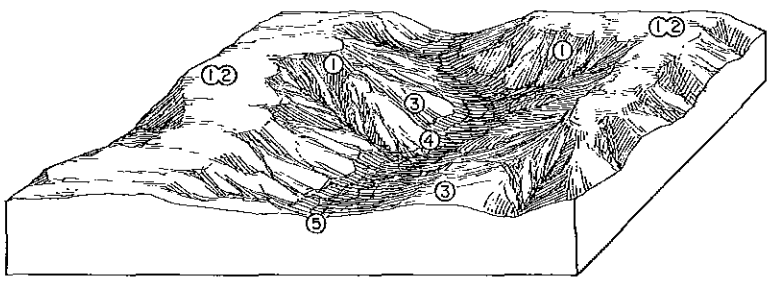
Geology.—Cambrian. Mainly lateritized quartz siltstone and sandstone with minor shale and limestone.

Drainage.—Sparse.

Elevation.—700–1000 ft. Local amplitude approximately 200 ft.

Climate.—Mean annual rainfall < 15 in. Mean agricultural growing season < 5 wk. Mean pasture growing season < 10 wk.

Pasture Land.—Spinifex plains and low plateaux.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Breakaways and higher parts of plateaux	Outcropping pallid zone and skeletal soils on ferruginous, mottled, and pallid zones	Trees absent and Isa highland sparse low woodland (*E. brevifolia, E. terminalis, E. papuana*), both with western spinifex (*Triodia longiceps, T. burkensis, T. molesta*) and smaller areas of arid short grass (*Enneapogon* spp., *Aristida* spp.). Small areas of mulga low woodland (*Acacia aneura*) with western spinifex (*Triodia longiceps*) and gidgee low woodland with bare ground
2	Medium	Plateau surface	Gravelly Sturgeon: sand over clay over mottled zone	
3	Small	Gentle dissection slopes	Forsayth: clay loam over clay	Arid sparse low woodland (*Atalaya hemiglauca, Ventilago viminalis, Grevillea striata, Owenia acidula, E. terminalis, E. papuana*) with western mid-height grass (*Themeda australis, Aristida* spp., *Sehima nervosum, Bothriochloa ewartiana*). Small patches of gidgee low woodland (*Acacia cambagei*)
4	Very small	Alluviated, entrenched valleys	Zingari: clay loam over clay	
5	Very small	Narrow incised stream channels	—	Fringing woodland (*E. camaldulensis, E. papuana, Atalaya hemiglauca, Ventilago viminalis, Acacia cambagei*) with fringing grass (*Themeda australis, Dichanthium sericeum, Chloris acicularis*)

* Somewhat comparable to Yelvertoft land system of the Barkly region.

(14) COWAN LAND SYSTEM* (700 SQ MILES)

Spinifex country, with some downs, in the northern part of the Carpentaria and inland plains.

Geomorphology.—Destructional land surface. Immaturely dissected plateaux and high plains. Early to mid Tertiary surface with appreciable elements of late Tertiary to Quaternary plains. Early to mid Tertiary surface uplifted and tilted.

Geology.—Rolling Downs group (Mesozoic). Mainly lateritized greywacke, siltstone, and sandstone.

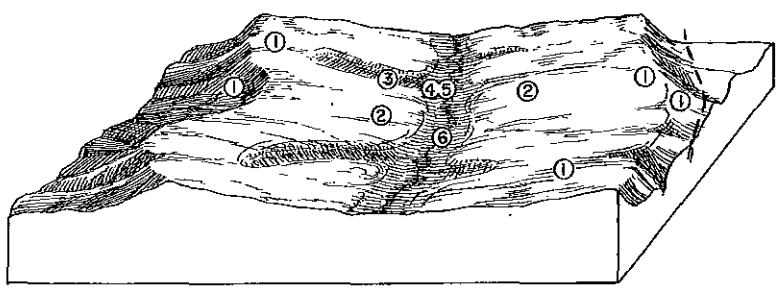
Drainage.—Sparse on flat tops, intense on scarps.

Elevation.—100–300 ft. Local amplitude < 120 ft.

Climate.—Wettest locality: mean annual rainfall 25 in.; mean agricultural growing season 10 wk; mean pasture growing season 15 wk.

Driest locality: mean annual rainfall 20 in.; mean agricultural growing season 7 wk; mean pasture growing season 12 wk.

Pasture Land.—Spinifex plains and low plateaux.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Tilted and truncated plateau—upper slopes and scarps	Skeletal sand and clay loam, and outcropping pallid and mottled zones	Isa highland sparse low woodland (*E. brevifolia, E. pruinosa*, less commonly *E. argillacea, E. dichromophloia, Terminalia canescens*) or trees absent, both with western spinifex (*Triodia pungens*)
2	Medium	Tilted and truncated plateau—lower slopes	Nangum: clay loam over clay	Silverleaf box low woodland (*E. pruinosa*) with western mid-height grass (*Aristida* spp., *Sehima nervosum, Chrysopogon fallax*), less commonly paperbark low woodland (*Melaleuca acacioides, Melaleuca* sp.) with three-awn–ribbon grass (*Aristida inaequiglumis, Chrysopogon fallax*). Smaller areas with shallower soil similar but with western spinifex (*Triodia pungens*)
3	Small	Tilted and truncated plateau—linear depressions	Barkly: calcareous cracking clays. Balootha: calcareous clay	Mitchell grass downs (*Astrebla lappacea, A. squarrosa*) and blue grass–browntop downs (*Eulalia fulva, Astrebla squarrosa, Aristida latifolia*), in small areas with downs sparse woodland (*E. microtheca*). Smaller areas gidgee low woodland with mostly bare ground
4	Small	Broad open valleys	Endymion: cracking clay	Blue grass–browntop downs (*Eulalia fulva, Aristida latifolia*) in some areas with downs sparse woodland (*E. microtheca*)
5	Small		Nangum: clay loam over clay	Trees absent (occasional *E. grandifolia, Terminalia canescens*) with solodic soil short grass (*Aristida hirta, Eriachne armittii*)
6	Very small	Small stream channels in units 4 and 5	—	Fringing woodland (*E. microtheca, Excoecaria parvifolia*) commonly with bare ground

* Somewhat comparable to Kilgour land system of the Barkly region. Includes some areas of the LU land association of Hubble and Beckmann (1957).

(15) COLLIS LAND SYSTEM* (200 SQ MILES)

Very sparsely timbered limestone plains and spinifex ridges in the south-west of the area.

Geomorphology.—Destructional land surface. Immaturely dissected plateaux and high plains. Early to mid Tertiary surface with appreciable elements of late Tertiary to Quaternary plains. Plains, ridges, and small lateritic plateaux.

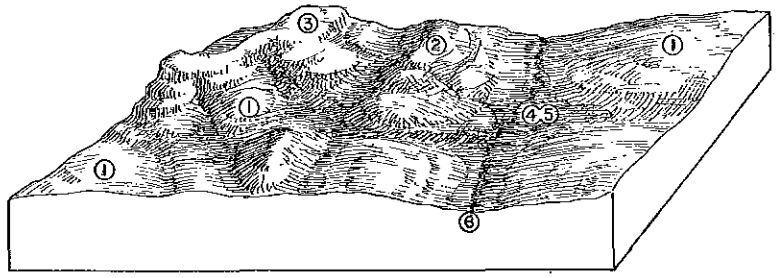
Geology.—Cambrian. Blue and grey thin-bedded limestone, argillaceous and quartz siltstone, and some arenaceous beds.

Drainage.—Sparse.

Elevation.—700–1100 ft. Local amplitude approximately 150 ft.

Climate.—Mean annual rainfall 15 in. Mean agricultural growing season < 5 wk. Mean pasture growing season < 10 wk.

Pasture Land.—Arid short grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Undulating plain	Skeletal calcareous silt	Trees absent with arid short grass (*Aristida arenaria, Enneapogon* spp.), small areas western spinifex (*Triodia longiceps, T. molesta*). Small areas Isa highland sparse low woodland (*E. argillacea*) with arid short grass or western spinifex
2	Medium	Hills and steeper slopes within the undulating plain	Rock outcrop	Trees absent and Isa highland sparse low woodland (*E. brevifolia, E. argillacea, E. terminalis*) with western spinifex (*Triodia longiceps, T. molesta*) and arid short grass (*Enneapogon* spp.)
3	Small	Plateau tops	Silicified pallid zone	Isa highland sparse low woodland (*E. brevifolia*) with western spinifex (*Triodia pungens*)
4	Small	Gentle lower slopes of undulating plains	Duchess: calcareous clay	Trees absent with arid short grass (*Aristida arenaria, A. superpendens, Enneapogon* spp.). Small patches of gidgee low woodland (*Acacia cambagei*)
5	Small		Barkly and Wonardo: calcareous cracking clay	Mitchell grass downs (*Astrebla pectinata*). Small patches of gidgee low woodland (*Acacia cambagei*)
6	Very small	Stream channels	—	Fringing woodland (*E. microtheca, E. camaldulensis*) with fringing grass (*Chloris acicularis, Bothriochloa decipiens*)

* Somewhat similar to Thorntonia land system of the Barkly region.

(16) Leichhardt Land System* (4600 sq miles)

Hilly country in the east of the area.

Geomorphology.—Destructional land surface. Maturely dissected hill country. Dissected pre-mid Mesozoic surface with some early to mid Tertiary elements and narrow late Tertiary to Quaternary plains. Ridge and vale topography on metamorphic rocks; massive joint-controlled hills, rhomboidal in plan, on felsites; tor-strewn hills on granite.

Geology.—Etheridge complex, plutonic rocks, Broken River group, and Croydon felsite. Pre-Cambrian–Palaeozoic. Igneous, metamorphic, and sedimentary rocks.

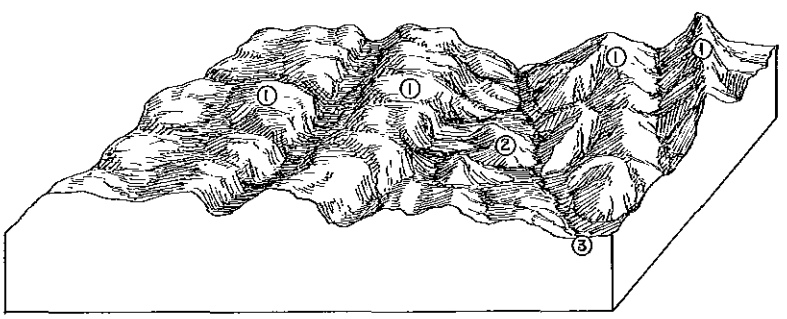
Drainage.—Very dense on some granite areas, sparse on felsites, structurally controlled, trellis, rectangular.

Elevation.—750–3000 ft. Local amplitude approximately 400 ft.

Climate.—Wettest locality: mean annual rainfall 40 in.; mean agricultural growing season 25 wk; mean pasture growing season 35 wk.

Driest locality: mean annual rainfall 22 in.; mean agricultural growing season 12 wk; mean pasture growing season 17 wk.

Pasture Land.—Non-range country—rugged, stony, or barren.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Steep slopes and crests of hilly country	Skeletal and rock outcrop	Ironbark woodland (*E. crebra, E. dichromophloia, E. papuana*, shallower soils *E. melanophloia, E. shirleyi, E. peltata*), small areas Georgetown box woodland (*E. microneura*). Both with eastern mid-height grass (*Themeda australis, Heteropogon contortus, H. triticeus, Aristida* spp.). Small areas rugged outcrops, deciduous low woodland (*Terminalia platyptera, Cochlospermum* sp., *Ficus* sp., *Brachychiton* spp., *Bauhinia* sp., *Gardenia* sp.), with bare ground or very sparse grasses
2	Small	Gentler slopes	Wide variety of soils similar to those in other land systems on comparable lithology but lower relief (Yaman, Glenharding, Heidelberg, Stanhill, Niall, Georgetown, Reedy Springs, Kilbogie, Lyall)	Ironbark woodland (*E. crebra, E. dichromophloia, E. papuana*) with eastern mid-height grass (*Aristida* spp., *Themeda australis, Heteropogon contortus, H. triticeus, Bothriochloa decipiens*). Small areas Georgetown box woodland (*E. microneura*) with eastern mid-height grass (*Themeda australis, Heteropogon contortus, Aristida* spp.) or three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*). Small areas shallow soils on sedimentary rocks under high rainfall, Reid River box woodland (*E. brownii*) with eastern mid-height grass (sparse *Themeda australis, Chrysopogon fallax, Aristida* spp.)
3	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis, Casuarina cunninghamiana, Terminalia platyphylla, Tristania* sp., *Pandanus* sp.) with fringing grass (*Arundinella nepalensis, Ischaemum* sp.). Frontage woodland with frontage grass

* Comparable with Leichhardt land system of the Townsville–Bowen region.

(17) Belmore Land System (1400 sq miles)

Hilly country on the western slopes of the Einasleigh uplands.

Geomorphology.—Destructional land surface. Maturely dissected hill country. Dissected pre-mid Mesozoic surface with some early to mid Tertiary elements and narrow Tertiary to Quaternary plains. Ridge and vale topography on metamorphic rocks; massive joint-controlled hills, rhomboidal in plan, on felsites.

Geology.—Etheridge complex (Pre-Cambrian) and Croydon felsite (Permian). Igneous and metamorphic rocks.

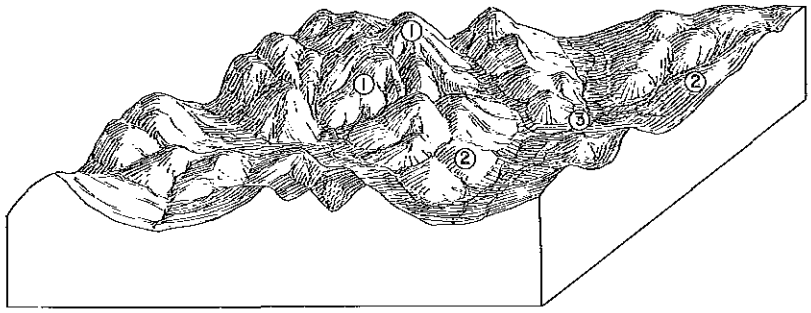
Drainage.—Structurally controlled, trellis, rectangular; sparse on felsites.

Elevation.—300–1100 ft. Local amplitude approximately 200 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 13 wk; mean pasture growing season 18 wk.

Driest locality: mean annual rainfall 25 in.; mean agricultural growing season 10 wk; mean pasture growing season 15 wk.

Pasture Land.—Non-range country—rugged, stony, or barren.



Unit	Area	Land Form§	Soils	Vegetation
1	Large	Steep slopes and crests of hilly country	Skeletal and rock outcrop	Georgetown box woodland (*E. microneura*), smaller areas ironbark woodland (*E. shirleyi*) both with three-awn (*Aristida* spp.) or eastern mid-height grass. Small areas rugged outcrops, deciduous low woodland (*Terminalia platyptera, Cochlospermum* sp.) with bare ground or very sparse grasses. Very small rocky areas, ironbark woodland (*E. shirleyi*) with western spinifex (*Triodia burkensis*)
2	Small	Gentler slopes	Wide variety of soils similar to those in other land systems of comparable lithology but lower relief (Townley, Georgetown)	Georgetown box woodland (*E. microneura*) with three-awn (*Aristida* spp.), three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*), or solodic soil short grass (*Aristida superpendens, Eriachne* sp.)
3	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis*) with fringing grass. Frontage woodland with frontage grass

(18) KURIDALA LAND SYSTEM* (3700 SQ MILES)

Hilly country in the west of the area.

Geomorphology.—Destructional land surface. Maturely dissected hill country. Dissected pre-mid Mesozoic surface with some early to mid Tertiary elements and narrow Tertiary to Quaternary plains. Ridge and vale topography on sediments, tor-strewn hills on granite.

Geology.—Cloncurry complex (Pre-Cambrian). Sediments, metamorphics, and igneous rocks.

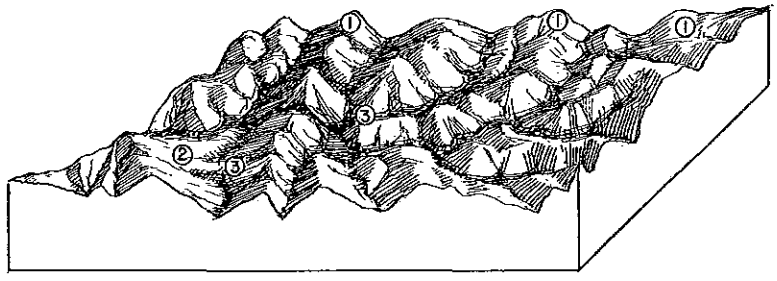
Drainage.—Very dense on some granite areas; structurally controlled, trellis, rectangular.

Elevation.—500–1600 ft. Local amplitude approximately 400–600 ft.

Climate.—Wettest locality: mean annual rainfall 20 in.; mean agricultural growing season 10 wk; mean pasture growing season 15 wk.

Driest locality: mean annual rainfall 15 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Pasture Land.—Non-range country—rugged, stony, or barren.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Steep slopes and crests of hilly country	Skeletal and rock outcrop	Isa highlands sparse low woodland (*E. brevifolia, E. terminalis, E. argillacea, E. pruinosa*) with western spinifex (*Triodia pungens, T. molesta, T. longiceps, T. burkensis*). Moderate areas trees absent (occasional *E. brevifolia, E. terminalis*) with western spinifex (*Triodia pungens*) and to a lesser extent arid short grass (*Enneapogon* spp., *Cleome viscosa*)
2	Very small	Gentler slopes	Soils similar to Quamby land system	Isa highland sparse low woodland (*E. brevifolia, E. terminalis, E. argillacea*) and arid sparse low woodland (*Acacia estrophiolata, A. victoriae, Atalaya hemiglauca, Hakea lorea*) with arid short grass (*Enneapogon* spp., *Aristida hygrometrica*) and in favoured localities western mid-height grass (*Aristida pruinosa, Heteropogon contortus, Bothriochloa ewartiana, Sehima nervosum*)
3	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis, Melaleuca* sp.) with fringing grass. Frontage woodland (*E. papuana, E. terminalis*) with frontage grass (*Aristida pruinosa, Heteropogon contortus, Themeda australis*)

* Comparable with part of Mt. Isa land system of the Barkly region. Includes some areas of the PS_M and PS_H land associations of Hubble and Beckmann (1957).

(19) Strathpark Land System (800 sq miles)

Gently sloping timbered plains near the centre of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Early to mid Tertiary surface.

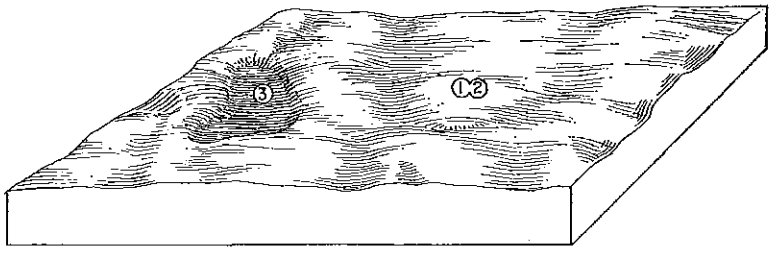
Geology.—Blythesdale group (Mesozoic). Medium- to coarse-grained silty quartz sandstone, thin beds and lenses of siltstone, and pebble conglomerate.

Drainage.—Sparse, subparallel.

Elevation.—500–1000 ft. Local amplitude approximately 10 ft.

Climate.—Mean annual rainfall 22 in. Mean agricultural growing season 10 wk. Mean pasture growing season 15 wk.

Pasture Land.—Northern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Very large	Very gently undulating plain	Cockatoo: sand	Georgetown box woodland (*E. microneura*) with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*)
2	Small		Skeletal sand and rock outcrop	Lancewood woodland (*Acacia shirleyi*) and Georgetown box woodland (*E. microneura*) with bare ground
3	Very small	Shallow depressions	Vanrook: sand over alkaline clay	Georgetown box woodland (*E. microneura*) with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*). Lagoon vegetation (*Pseudoraphis spinescens*)

(20) Manrika Land System (600 sq miles)

Lightly timbered plains in the northern part of the Carpentaria and inland plains.

Geomorphology.—Destructional land surface. Plains of erosion. Early to mid Tertiary surface. Undulating or rolling plains.

Geology.—Rolling Downs group (Mesozoic). Mainly greywacke, siltstone, and sandstone.

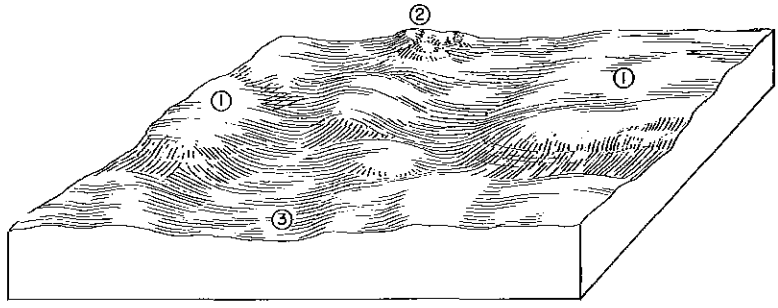
Drainage.—Moderately intense.

Elevation.—< 200 ft. Local amplitude approx. 20 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 15 wk; mean pasture growing season 20 wk.

Driest locality: mean annual rainfall 22 in.; mean agricultural growing season 8 wk; mean pasture growing season 13 wk.

Pasture Land.—Western mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Rolling plain of erosion	Nangum: clay loam over clay over pallid zone at depth	Silverleaf box low woodland (*E. pruinosa*) with western mid-height grass (*Aristida* spp., *Sehima nervosum*, *Dichanthium fecundum*). Less commonly paperbark low woodland (*Melaleuca viridiflora*, *Melaleuca* sp.) with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*). Small areas trees absent (occasional *E. grandifolia*) with solodic soil short grass (*Eriachne armittii*, *Chloris* spp.)
2	Very small		Outcropping ferruginous zone and Wonorah: clay loam over clay over ferruginous or mottled zones	Isa highland sparse low woodland (*E. brevifolia*, *E. pruinosa*, *E. dichromophloia*, *E. setosa*, *Terminalia canescens*) with western spinifex (*Triodia pungens*). Small areas trees absent with western spinifex
3	Very small	Slightly lower parts of plains	Barkly: calcareous cracking clay. Balootha: calcareous clay	Blue grass–browntop downs (*Eulalia fulva*, *Dichanthium fecundum*, *Aristida latifolia*, *Astrebla squarrosa*), in small areas with downs sparse woodland (*E. microtheca*, *Excoecaria parvifolia*) or arid sparse low woodland (*Ventilago viminalis*, *Atalaya hemiglauca*, *Grevillea striata*)

(21) DANDRY LAND SYSTEM (2600 SQ MILES)

Extensive, timbered, gently sloping plains in the north of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Early to mid Tertiary surface.

Geology.—Blythesdale group (Mesozoic). Medium- to coarse-grained silty quartz sandstone.

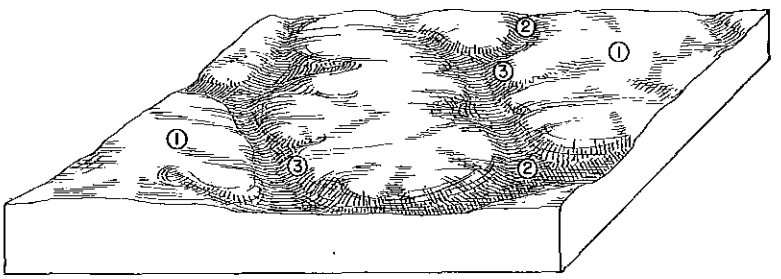
Drainage.—Intense, subparallel.

Elevation.—250–750 ft. Local amplitude < 30 ft.

Climate.—Wettest locality: mean annual rainfall 33 in.; mean agricultural growing season 20 wk; mean pasture growing season 23 wk.

Driest locality: mean annual rainfall 25 in.; mean agricultural growing season 12 wk; mean pasture growing season 17 wk.

Pasture Land.—Northern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Very gently undulating and sloping plain of erosion	Cockatoo: sands. Sturgeon: sand over clay	Stringybark woodland (*E. tetrodonta, E. dichromophloia, E. polycarpa*, occasionally *E. miniata, E. microneura*) with three-awn–ribbon grass (*Aristida ingrata, A. hygrometrica, Chrysopogon fallax*)
2	Small	Flat-floored, shallow valleys, mainly unchannelled	Elliott: sand over clay. Smaller areas of Nangum: clay loam over clay	Paperbark low woodland (*Melaleuca viridiflora, M. acacioides*) with three-awn–ribbon grass (*Aristida ingrata, A. hygrometrica, Chrysopogon fallax*). Small central parts, trees absent with solodic soil short grass (*Aristida superpendens, Eriachne armittii*)
3	Small	Short, fairly steep slopes between units 1 and 2	Skeletal sand and outcrops of mottled sandstone	Mainly Georgetown box woodland (*E. microneura* with three-awn–ribbon grass (*Aristida ingrata, Chrysopogon fallax*) and small areas western spinifex (*Triodia pungens*). Small areas ironbark woodland (*E. melanophloia*) with three-awn–ribbon grass or lancewood woodland (*Acacia shirleyi*) with bare ground
4*	Small	Plains near Langdon River, in part alluvial	Elliott: sand over clay. Nangum: clay loam over clay	Mainly Georgetown box woodland (*E. microneura*) with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*). Small areas frontage woodland (*E. leptophleba, E. papuana, E. confertiflora*) with frontage mid-height grass (*Bothriochloa decipiens, Chrysopogon pallidus, Panicum delicatum*)

* Only occurs in one part of the land system.

(22) Esmeralda Land System (800 sq miles)

Sparsely timbered undulating plains north of the centre of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Early to mid Tertiary surface.

Geology.—Blythesdale group (Mesozoic). Medium- to coarse-grained silty quartz sandstone, thin beds and lenses of siltstone, and pebble conglomerate.

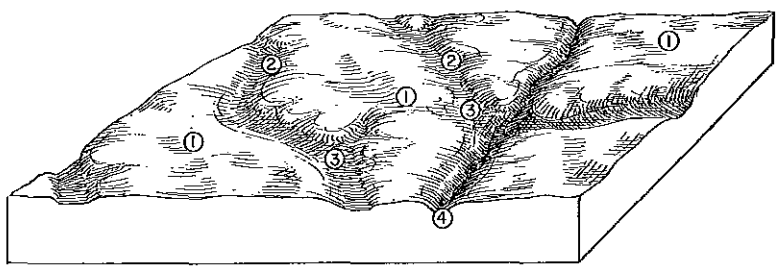
Drainage.—Moderately intense, confined to main lines, subparallel.

Elevation.—300–1000 ft. Local amplitude approx. 10 ft.

Climate.—Wettest locality: mean annual rainfall 32 in.; mean agricultural growing season 17 wk; mean pasture growing season 20 wk.

Driest locality: mean annual rainfall 25 in.; mean agricultural growing season 10 wk; mean pasture growing season 15 wk.

Pasture Land.—Northern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Low sandy rises	Cockatoo: sand	Georgetown box woodland (*E. microneura*), less commonly stringybark woodland (*E. miniata, E dichromophloia*), both with three-awn–ribbon grass (*Aristida pruinosa, A. ingrata, A. hygrometrica, Chrysopogon fallax*)
2	Very small	Gentle valley sides	Elliott: sand over clay	Georgetown box woodland (*E. microneura*) and paperbark low woodland (*Melaleuca viridiflora, M. acacioides*), both with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*)
3	Small	Narrow flat-floored alluviated valleys	Vanrook: sand over alkaline clay	Margins, paperbark low woodland (*Melaleuca viridiflora, M. acacioides*) with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*). Centres, trees absent with solodic soil short grass (*Aristida hirta, Eriachne armittii, Sorghum* sp.)
4	Very small	Faintly incised valleys	—	Frontage woodland (*E. leptophleba, E. confertiflora, E. polycarpa*) with frontage grass (*Bothriochloa decipiens, Dichanthium fecundum, Aristida ingrata, Heteropogon contortus*)

(23) Strathmore Land System (500 sq miles)

Timbered plains near the centre of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Early to mid Tertiary surface. Uplifted and upwarped plateaux.

Geology.—Blythesdale group (Mesozoic). Medium- to coarse-grained silty quartz sandstone, thin beds and lenses of siltstone, and pebble conglomerate.

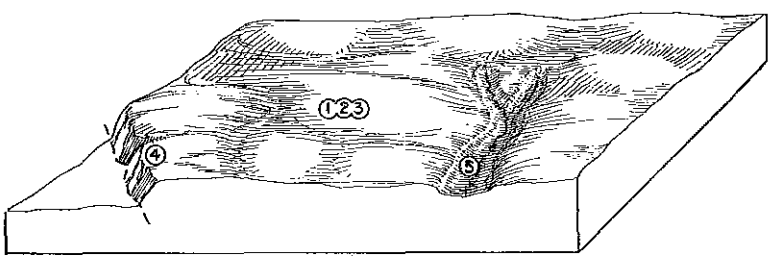
Drainage.—Sparse and subparallel.

Elevation.—250–800 ft. Local amplitude approximately 10 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 13 wk; mean pasture growing season 18 wk.

Driest locality: mean annual rainfall 20 in.; mean agricultural growing season 8 wk; mean pasture growing season 13 wk.

Pasture Land.—Northern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Very gently undulating plateau surface	Norman: sand with cemented subsoil	Paperbark low woodland (*Melaleuca viridiflora, M. acacioides, M. symphyocarpa*) with three-awn–ribbon grass (*Aristida ingrata, A. hygrometrica, Eriachne obtusa, Chrysopogon fallax*). Small areas near Strathmore, stringybark woodland (*E. tetrodonta, E. miniata, E. dichromophloia, E. polycarpa*) with three-awn–ribbon grass (*Aristida ingrata, A. hygrometrica*). Small areas near Pelham, Bylong low woodland (*Bauhinia cunninghamii, Melaleuca* spp., *Erythrophleum chlorostachys*) with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*). Area near Mt. Norman, mainly Georgetown box woodland (*E. microneura*) with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*)
2	Medium		Elliott: sand over clay	
3	Medium		Cockatoo: sand	
4	Small	Truncated plateau margin	Currajong: sand over ferruginous zone	Near Strathmore, stringybark woodland (*E. setosa*) with three-awn–ribbon grass (*Aristida hygrometrica, Chrysopogon fallax*). Near Pelham, trees absent (occasional *Melaleuca acacioides, Grevillea striata*) with western spinifex (*Triodia pungens*). Near Mt. Norman, Georgetown box woodland (*E. microneura*) with western spinifex (*Triodia pungens*)
5	Very small	Narrow flat-floored valleys	Vanrook: sand over alkaline clay	Margins, paperbark low woodland (*Melaleuca viridiflora, M. acacioides*), centre, trees absent, in both cases with solodic soil short grass (*Aristida superpendens, Eriachne armittii, Eragrostis basedowii*)

(24) Murgulla Land System (300 sq miles)

Lightly timbered plains in the northern part of the Carpentaria and inland plains.

Geomorphology.—Destructional land surface. Plains of erosion. Early to mid Tertiary surface.

Geology.—Terrestrial deposits (Tertiary) overlying Rolling Downs group (Mesozoic).

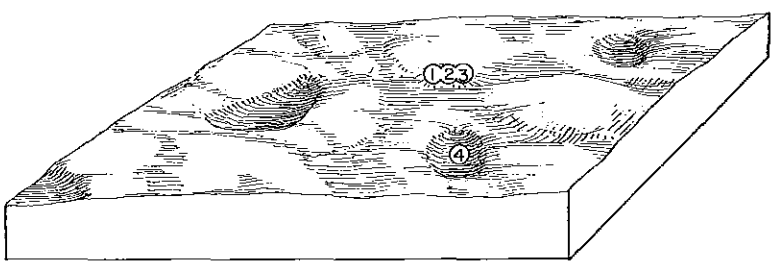
Drainage.—Sparse.

Elevation.—100–250 ft. Relief < 10 ft.

Climate.—Wettest locality: mean annual rainfall 25 in.; mean agricultural growing season 12 wk; mean pasture growing season 16 wk.

Driest locality: mean annual rainfall 23 in.; mean agricultural growing season 9 wk; mean pasture growing season 13 wk.

Pasture Land.—Southern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Plain of erosion	Cockatoo: sand	Bylong low woodland (*Bauhinia cunninghamii* etc.) with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*)
2	Medium		Elliott: sand over clay	Silverleaf box low woodland (*E. pruinosa*) with western spinifex (*Triodia pungens*)
3	Very small		Stawell: sand over clay over ferruginous zone	Trees absent (occasional *E. pruinosa*) with western spinifex (*Triodia pungens*)
4	Small	Rounded shallow depressions	Probably Wallabadah: sand over clay	Trees absent with solodic soil short grass (*Eriachne obtusa*, *Aristida* spp.). Few with gidgee low forest (*Acacia cambagei*) with bare ground

(25) YANMAN LAND SYSTEM (900 SQ MILES)

Timbered plains in the north-east of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Early to mid Tertiary surface.

Geology.—Etheridge complex and plutonic rocks. Pre-Cambrian and Palaeozoic. Metamorphic rocks and granite. Minor areas of terrestrial deposits (Tertiary).

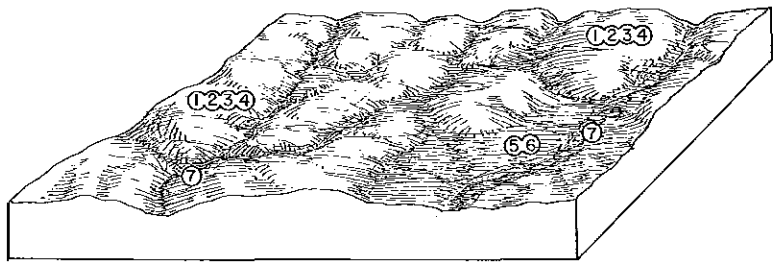
Drainage.—Moderately intense, subrectangular pattern.

Elevation.—750–2000 ft. Local amplitude < 150 ft.

Climate.—Wettest locality: mean annual rainfall 35 in.; mean agricultural growing season 25 wk; mean pasture growing season > 35 wk.

Driest locality: mean annual rainfall 23 in.; mean agricultural growing season 12 wk; mean pasture growing season 17 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Medium	Gently undulating granite plains	Zingari and Nangum: clay loam over clay. Minor Cargoon: sand over clay	Very largely ironbark woodland (*E. crebra, E. dichromophloia, E. papuana, E. polycarpa, E. confertiflora*, sparse layer of low trees) with eastern mid-height grass (*Themeda australis, Bothriochloa ewartiana, Aristida* spp., *Heteropogon contortus, H. triticeus*). Small areas with shallow soils, ironbark woodland (*E. melanophloia, E. shirleyi*) with eastern mid-height grass. Small areas lower slopes, Reid River box woodland (*E. brownii*) with eastern mid-height grass (sparse *Themeda australis, Heteropogon contortus, Aristida* spp.) or three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*). Small areas sandy soil depressions, poplar gum–grey bloodwood woodland (*E. alba, E. polycarpa, E. tessellaris, E. brownii*) with eastern mid-height grass (*Bothriochloa decipiens, Heteropogon contortus, Arundinella nepalensis*). Small areas clay soil depressions, blue grass–browntop downs (*Ophiuros exaltatus, Dichanthium fecundum, Bothriochloa ewartiana, Aristida leptopoda*) generally with downs woodland (*E. leptophleba*). Small areas near Einasleigh (lower rainfall), Georgetown box woodland (*E. microneura*) with eastern mid-height grass (*Bothriochloa ewartiana, Aristida* spp.). Small swamps, lagoon vegetation (*Eleocharis* spp., *Pseudoraphis spinescens*)
2	Large	Lateritized parts of gently undulating granite plain	Cargoon, Wallabadah, and Sturgeon: sand over clay. Currajong: sand over ferruginous zone	
3	Medium	Undulating granite plains	Cargoon: sand over clay	
4	Small	Undulating plains on metamorphosed rocks	Wyandotte: sand over clay. Barkly: calcareous cracking clay	
5	Medium to small	Flatter parts of the undulating plains on metamorphosed rocks	Cargoon: sand over clay	
6	Very small	Flatter parts of the undulating plains on granite	Miranda: clay loam over alkaline clay	
7	Very small	Stream channel	—	Fringing woodland (*E. camaldulensis, Casuarina cunninghamiana, Melaleuca* spp., *Pandanus whitei*) with fringing grass (*Arundinella nepalensis, Cynodon dactylon*). Associated frontage woodland (*E. leptophleba*) with frontage mid-height grass (*Bothriochloa decipiens* etc.)

(26) Glenharding Land System (200 sq miles)

Timbered plains in the north-east of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Early to mid Tertiary surface.

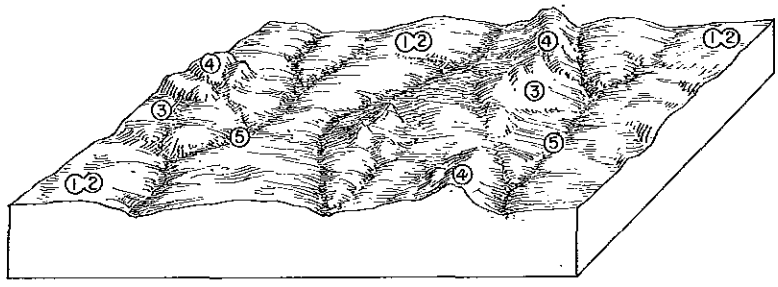
Geology.—Plutonic rocks. Granite of probable Palaeozoic age.

Drainage.—Sparse.

Elevation.—2200 ft. Local amplitude approx. 25 ft.

Climate.—Mean annual rainfall 30 in. Mean agricultural growing season 25 wk. Mean pasture growing season 30–35 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Undulating plain	Sturgeon: sand over clay	Ironbark woodland (*E. crebra, E. polycarpa, E. papuana*) with eastern mid-height grass (*Themeda australis, Heteropogon contortus*)
2	Medium		Cargoon: sand over clay. Minor Cockatoo: sand	Poplar gum–grey bloodwood woodland (*E. alba, E. polycarpa, E. tessellaris*) with eastern mid-height grass (*Heteropogon contortus, H. triticeus*)
3	Medium	Steeper slopes of low hills	Cockatoo: sand	
4	Medium	Upper slopes of low hills and of undulating plain	Skeletal and granite outcrop	Deciduous low woodland (*Ficus obliqua, Brassaia actinophylla, Tristania suaveolens*) with eastern mid-height grass (sparse *Heteropogon contortus, H. triticeus, Aristida* spp.)
5	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis, Tristania suaveolens*) with fringing grass (*Arundinella nepalensis, Cynodon dactylon*)

(27) JULIA LAND SYSTEM* (18,700 SQ MILES)

Rolling Mitchell grass plains occupying most of the southern part of the Carpentaria and inland plains.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface.

Geology.—Rolling Downs group (Mesozoic). Slightly calcareous siltstone and fine-grained argillaceous greywacke.

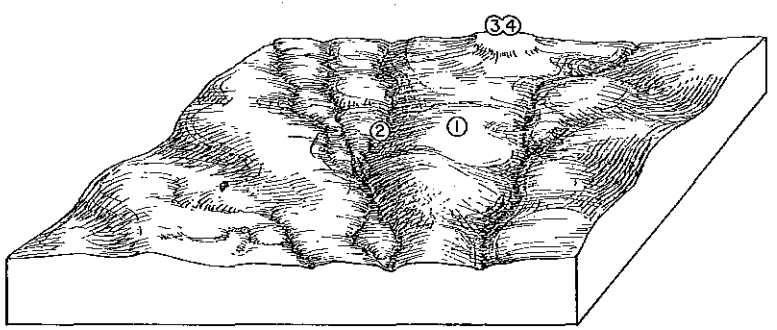
Drainage.—Sparse, subparallel, some structural control evidenced by asymmetry of valleys in transverse section (uniclinal shift).

Elevation.—250–1000 ft approximately. Local amplitude < 100 ft.

Climate.—Wettest locality: mean annual rainfall 20 in.; mean agricultural growing season 9 wk; mean pasture growing season 14 wk.

Driest locality: mean annual rainfall < 15 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Pasture Lands.—Mitchell grass plains.



Unit	Area	Land Forms	Soils	Vegetation
1	Very large	Rolling plains	Barkly with minor Wondardo: calcareous cracking clay	Mitchell grass downs (*Astrebla squarrosa, A. lappacea, Aristida latifolia, Eriochloa pseudoacrotriche, Iseilema* spp., small areas in south *Astrebla pectinata*). Small areas, arid sparse low woodland (*Atalaya hemiglauca, Acacia cana*) with arid short grass (sparse *Sporobolus australasicus, Enneapogon* spp.)
2	Very small	Braided stream channels	Barkly: calcareous cracking clay	
3	Very small	Crests of low rises	Tobermorey: calcareous clay loam	Trees absent or arid sparse low woodland (*Atalaya hemiglauca, Ventilago viminalis, E. terminalis, Acacia cana*) with arid short grass (*Enneapogon* spp., *Sporobolus australasicus, Aristida arenaria*)
4	Very small		Limestone outcrop	

* Includes most areas of the D land association of Hubble and Beckmann (1957).

(28) Donors Land System (900 sq miles)

Grassy plains with areas of silverleaf box country, in the northern part of the Carpentaria and inland plains.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface.

Geology.—Rolling Downs group (Mesozoic). Mainly slightly calcareous siltstone and fine-grained argillaceous greywacke.

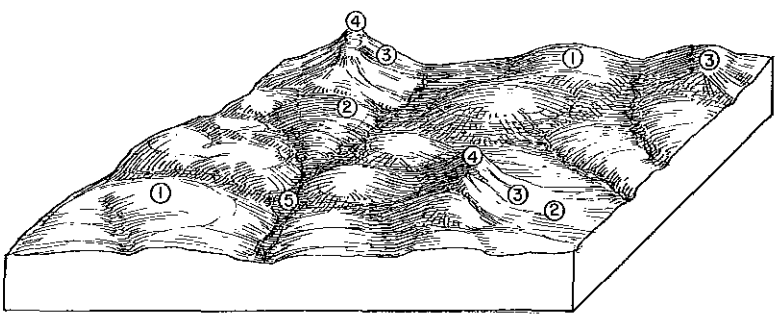
Drainage.—Sparse, subparallel, some structural control evidenced by asymmetry of valley cross sections.

Elevation.—< 200 ft. Local amplitude < 100 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 15 wk; mean pasture growing season 20 wk.

Driest locality: mean annual rainfall 20 in.; mean agricultural growing season 8 wk; mean pasture growing season 13 wk.

Pasture Land.—Blue grass–browntop plains.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Gently undulating plain	Barkly: calcareous cracking clay, locally with gilgai	Blue grass–browntop downs (*Eulalia fulva, Aristida latifolia, Astrebla squarrosa, Dichanthium fecundum*). Small areas low rainfall, Mitchell grass downs (*Astrebla squarrosa, A. lappacea*). Small patches gidgee low woodland (*Acacia cambagei*). Near creeks, downs sparse woodland (*E. microtheca*) with blue grass–browntop downs (*Eulalia fulva, Dichanthium superciliatum*)
2	Small	Gentle slopes generally below unit 3	Wonardo: calcareous cracking clay, commonly with much ferruginous gravel and gilgai	Trees absent or arid sparse low woodland (*Atalaya hemiglauca*), small patches gidgee low woodland (*Acacia cambagei*) or silverleaf box low woodland (*E. pruinosa*). All with arid short grass (*Enneapogon* spp.). Small areas arid sparse low woodland with blue grass–browntop downs (*Dichanthium fecundum, Aristida latifolia*)
3	Medium	Slopes below unit 4 or crests of lower rises	Nangum: clay loam over clay with variable amounts of ferruginous gravel	Silverleaf box low woodland (*E. pruinosa*) with western mid-height grass (*Aristida inaequiglumis, Dichanthium fecundum, Sehima nervosum, Chrysopogon fallax*) and blue grass–browntop downs (*Aristida latifolia*). Small area paperbark low woodland (*Melaleuca* spp.) with three-awn–ribbon grass (*Chrysopogon fallax, Aristida* spp.)
4	Very small	Crests of rises	Skeletal	Silverleaf box low woodland (*E. pruinosa*) and Isa highlands sparse low woodland (*E. brevifolia*) with western spinifex (*Triodia pungens*)
5	Very small	Braided river channels	—	Fringing woodland (*E. camaldulensis, E. microtheca*) with fringing grass (*Chionachne cyathopoda*)

(29) Donaldson Land System* (1700 sq miles)

Grassy plains with some gidgee and silverleaf box country, in the northern part of the Carpentaria and inland plains.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface.

Geology.—Rolling Downs group (Mesozoic). Mainly slightly calcareous siltstone and fine-grained argillaceous greywacke. Also terrestrial deposits (Tertiary). Sand, gravel, and clay.

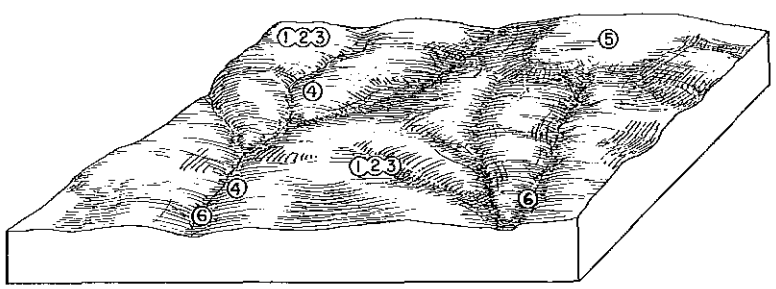
Drainage.—Sparse, subparallel, some structural control evidenced by asymmetry of valleys in transverse section (uniclinal shift).

Elevation.—250–750 ft. Local amplitude < 100 ft.

Climate.—Wettest locality: mean annual rainfall 21 in.; mean agricultural growing season 8 wk; mean pasture growing season 13 wk.

Driest locality: mean annual rainfall 15 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Pasture Land.—Blue grass–browntop plains.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Undulating plain	Barkly with minor Wonardo: calcareous cracking clays	Blue grass–browntop downs (*Eulalia fulva*, *Aristida latifolia*), small areas Mitchell grass downs (*Astrebla squarrosa*, *A. lappacea*, *Aristida latifolia*)
2	Medium		Barkly with associated Wonardo, gravelly with slight to moderate gilgai	Gidgee low woodland (*Acacia cambagei*) with Mitchell grass downs (*Aristida latifolia*), and arid short grass (*Enneapogon* spp.) and bare ground. Blue grass–browntop downs (*Eulalia fulva*) in gilgai depressions
3	Small		Zingari: clay loam over clay frequently gravelly	Silverleaf box low woodland (*E. pruinosa*) with western mid-height grass (*Aristida inaequiglumis*, *Sehima nervosum*) and western spinifex (*Triodia pungens*). Small areas arid sparse low woodland (*Atalaya hemiglauca*, *Ventilago viminalis*) with western mid-height grass (*Aristida inaequiglumis*) and Isa highland sparse low woodland (*E. brevifolia*) with western spinifex (*Triodia pungens*)
4	Very small	Gentle slopes	Balootha: calcareous clay soil frequently gravelly	Trees absent with arid short grass (*Enneapogon* spp.) or bare ground. Small areas gidgee low woodland (*Acacia cambagei*)
5	Small	Slightly higher plain	Cockatoo: gravelly sand	Silverleaf box low woodland (*E. pruinosa*) with western spinifex (*Triodia pungens*)
6	Very small	Channels	—	Fringing woodland (*E. camaldulensis*, *E. microtheca*) with fringing grass (*Cenchrus ciliaris*)

* Includes the GR, GD, and some areas of D and RD land associations of Hubble and Beckmann (1957).

(30) Wonardo Land System* (600 sq miles)

Mitchell grass plains in the south-west of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface.

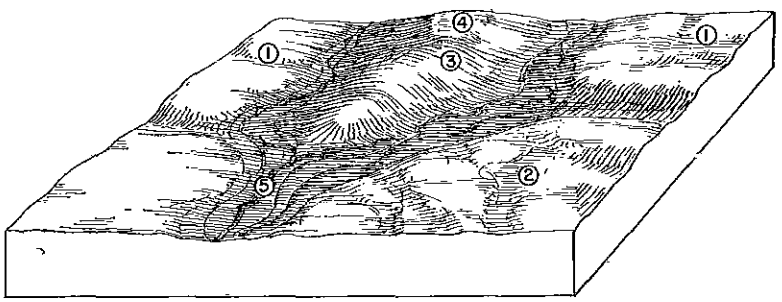
Geology.—Cambrian. Thin-bedded limestone and argillaceous siltstone.

Drainage.—Sparse.

Elevation.—600 to 1000 ft. Local amplitude < 60 ft.

Climate.—Mean annual rainfall 15 in. Mean agricultural growing season < 5 wk. Mean pasture growing season < 10 wk.

Pasture Land.—Mitchell grass plains.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Gently rolling plain	Wonardo with associated Barkly: calcareous cracking clay	Mitchell grass downs (*Astrebla pectinata, Aristida latifolia*). Small gravelly areas, arid short grass (*Enneapogon* spp.)
2	Medium	Alluvial plain	Barkly: calcareous cracking clay	
3	Small	Slightly elevated areas within the rolling plain	Duchess: calcareous clay	Trees absent or arid sparse low woodland (*E. terminalis, Ventilago viminalis, Hakea lorea*) with arid short grass (*Aristida arenaria, Enneapogon* spp., *Sporobolus australasicus, S. actinocladus*)
4	Very small	Low plateau remnants capping rise tops	Rock outcrop	Isa highland sparse low woodland (*E. brevifolia, E. terminalis, E. argillacea*) with western spinifex (*Triodia pungens, T. molesta*)
5	Very small	Small stream channel	—	Fringing woodland (*E. camaldulensis, E. microtheca*) with fringing grass (*Chloris acicularis, Themeda avenacea, Eulalia fulva*)

* Comparable with Wonardo land system of the Barkly region.

(31) WONOMO LAND SYSTEM* (100 SQ MILES)

Sparsely timbered plains in the south-west of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface.

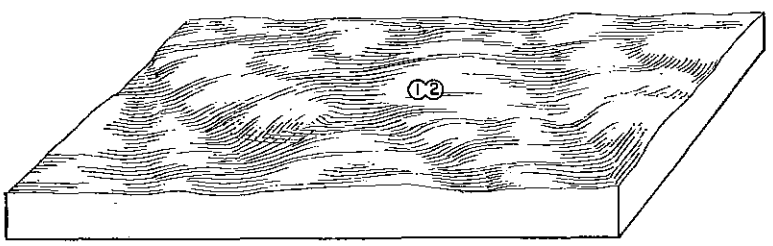
Geology.—Cambrian. Argillaceous and quartz siltstones, with some arenaceous beds and thin-bedded limestone.

Drainage.—Sparse.

Elevation.—700–1000 ft. Local amplitude approx. 10 ft.

Climate.—Mean annual rainfall < 15 in. Mean agricultural growing season < 5 wk. Mean pasture growing season < 12 wk.

Pasture Land.—Arid short grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Flat plain	Forsayth: clay loam over clay	Mulga low woodland (*Acacia aneura*, occasional *A. estrophiolata*, *Atalaya hemiglauca*, *Grevillea striata*) with arid short grass (*Aristida arenaria*, *Enneapogon* spp.) and western mid-height grass (*Aristida anthoxanthoides*, *Themeda australis*, *Bothriochloa ewartiana*, *Eulalia fulva*)
2	Very small		Wonardo: calcareous cracking clay	Mitchell grass downs (*Astrebla* spp., *Aristida latifolia*)

* Somewhat comparable with Bundella land system of the Barkly region.

(32) LYALL LAND SYSTEM (100 SQ MILES)

Timbered plains in the east of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface.

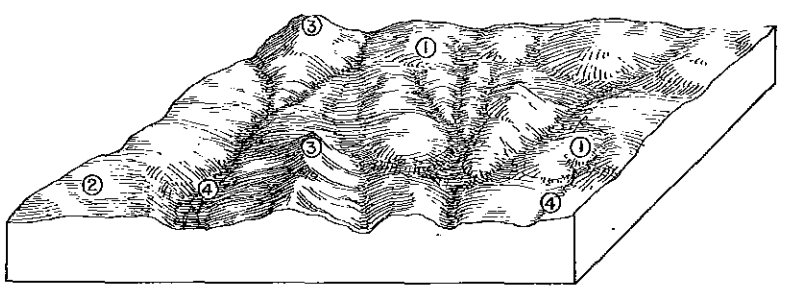
Geology.—Broken River group (Silurian–Devonian). Mainly the metamorphic and calcareous beds with intrusions of diorite.

Drainage.—Sparse.

Elevation.—2000 ft. Local amplitude approx. 20 ft.

Climate.—Mean annual rainfall 25 in. Mean agricultural growing season 20 wk. Mean pasture growing season 25 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Undulating plain	Forsayth: clay loam over clay	Ironbark woodland (*E. crebra, E. dichromophloia, E. papuana*) with eastern mid-height grass (*Heteropogon contortus, Themeda australis, Bothriochloa ewartiana*)
2	Small	Flatter parts of the undulating plain	Rosella: calcareous cracking clay	Blue grass–browntop downs (*Ophiuros exaltatus, Heteropogon contortus*), in some places with downs woodland (*E. crebra*)
3	Small	Upper slopes	Skeletal and rock outcrop	Ironbark woodland (*E. crebra*) and Reid River box woodland (*E. brownii*), both with eastern mid-height grass (*Themeda australis, Heteropogon contortus*)
4	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis*) with fringing grass

(33) McKinnon Land System (300 sq miles)

Timbered plains in the east of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface.

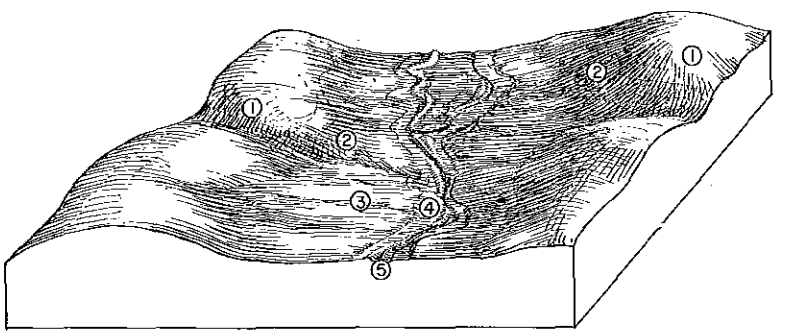
Geology.—Etheridge complex (Pre-Cambrian). Mainly granodiorite, some diorite.

Drainage.—Moderately intense, structurally controlled, rectangular and subrectangular.

Elevation.—2000 ft. Local relief approx. 20 ft.

Climate.—Mean annual rainfall 25 in. Mean agricultural growing season 17 wk. Mean pasture growing season > 22 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Slopes and crests of low hills	Forsayth: clay loam over clay. Wyandotte and Cargoon: sand over clay	Ironbark woodland (*E. crebra, E. papuana, E. dichromophloia*) with eastern mid-height grass (*Themeda australis, Heteropogon contortus, Aristida armata*)
2	Medium	Lower slopes adjacent to plains of unit 3	Glendhu: clay loam over clay	Reid River box woodland (*E. brownii*) with eastern mid-height grass (*Bothriochloa decipiens, B. ewartiana, Dichanthium fecundum, Aristida armata*)
3	Large	Plains, generally narrow	Rosella: calcareous cracking clay	Blue grass–browntop downs (*Ophiuros exaltatus, Dichanthium fecundum, Astrebla squarrosa, Iseilema* spp.) with scattered *Acacia farnesiana*
4	Small	Plains associated with stream-lines	Balootha: calcareous clays	Reid River box woodland (*E. brownii*) with blue grass–browntop downs (*Dichanthium fecundum, Themeda australis, Chrysopogon fallax*)
5	Very small	Stream channels and associated small river terraces and levees	Cockatoo: sand	Frontage woodland (*E. leptophleba, E. polycarpa, E. alba, E. tessellaris*) with frontage grass (*Bothriochloa decipiens, Panicum delicatum*). Fringing woodland (*E. camaldulensis, Melaleuca* spp.) with fringing grass (*Bothriochloa decipiens*)

(34) Quamby Land System* (4500 sq miles)

Sparsely timbered undulating plains in the west of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface with elements of the pre-mid Mesozoic surface. Pediments occur on some granite areas.

Geology.—Cloncurry complex (Pre-Cambrian). Folded and metamorphosed sediments, basic and acidic lavas, basic dykes and sills, and granite.

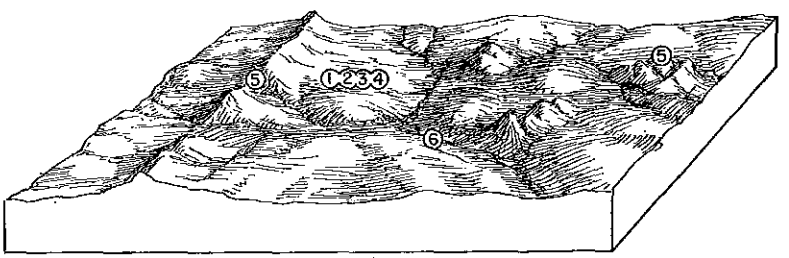
Drainage.—Generally a vague rectangular pattern, generally of moderate intensity but with intense patterns in places.

Elevation.—250–1300 ft. Local amplitude 50–200 ft.

Climate.—Wettest locality: mean annual rainfall 20 in.; mean agricultural growing season 8 wk; mean pasture growing season 13 wk.

Driest locality: mean annual rainfall < 15 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Pasture Land.—Arid short grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Undulating plains with smooth, concave, and little-dissected slopes	Forsayth: clay loam over clay; commonly associated with more basic rocks	Trees absent, arid sparse low woodland (*Atalaya hemiglauca, Acacia estrophiolata, Ventilago viminalis, Grevillea striata, Hakea lorea, Ehretia saligna, E. terminalis*) and Isa highland sparse low woodland (*E. brevifolia, E. terminalis, E. argillacea*) all with arid short grass (*Aristida arenaria, Enneapogon* spp.). Small areas depressions, arid sparse low woodland and Isa highland sparse low woodland with western mid-height grass (*Aristida pruinosa, A. anthoxanthoides, Sehima nervosum, Chrysopogon fallax, Bothriochloa ewartiana*). Patches gidgee low woodland (*Acacia cambagei*) with arid short grass
2	Medium		Sturgeon: sand over clay; commonly associated with more acidic rock types	
3	Medium		Skeletal sand and clay loam, rock outcrop and silicified rock	Trees absent and Isa highland sparse low woodland (*E. brevifolia, E. terminalis, E. argillacea*) with western spinifex (*Triodia pungens, T. molesta, T. longiceps*)
4	Small		Varied soils of minor extent —distribution controlled by rock type. Wonardo, Barkly, Baloottha: calcareous clays. Moonah and Vanrook: sand over alkaline clay. Tobermorey: calcareous clay loam	Variable vegetation. As well as that of units 1 and 2 also small areas Mitchell grass downs (*Astrebla* spp.) and gidgee low woodland (*Acacia cambagei*) with Mitchell grass downs (*Aristida latifolia*)
5	Small	Ridges and low hills	Skeletal and rock outcrop	As for unit 3
6	Small	Channels and associated levees	Manbulloo: fine sand	Fringing woodland (*E. camaldulensis, E. microtheca, E. argillacea*) with fringing grass (*Dichanthium fecundum, Themeda australis, Bothriochloa decipiens, Heteropogon contortus*). Frontage woodland (*E. papuana, E. terminalis, E. argillacea, Bauhinia cunninghamii*) with frontage grass (*Heteropogon contortus, Themeda australis, Chrysopogon fallax, Sehima nervosum, Chloris divaricata, Aristida* spp.)

*Somewhat comparable with Waverley land system of the Barkly region. Includes some areas of PS$_H$ land association of Hubble and Beckmann (1957).

(35) Heidelberg Land System* (400 sq miles)

Timbered, undulating, granite plains in the east of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface with elements of pre-mid Mesozoic surface.

Geology.—Plutonic rocks. Granites of Proterozoic and Palaeozoic age.

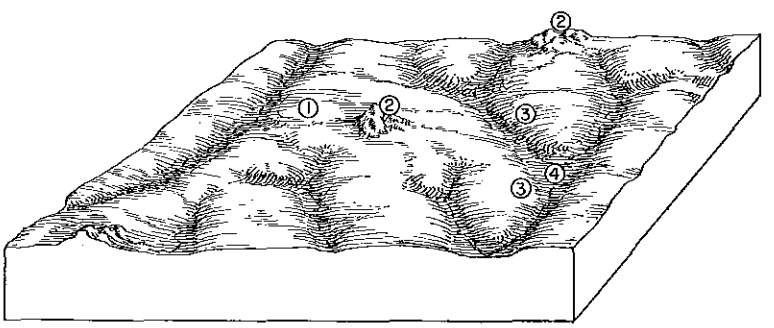
Drainage.—Moderately intense, subrectangular pattern.

Elevation.—1000–2000 ft. Local amplitude 20–200 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 20 wk; mean pasture growing season 25 wk.

Driest locality: mean annual rainfall 25 in.; mean agricultural growing season 15 wk; mean pasture growing season 20 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Middle slopes	Cockatoo: gritty sand	Ironbark woodland (*E. crebra, E. polycarpa, E. papuana*) with eastern mid-height grass (*Heteropogon contortus, Aristida* spp.). Moderate areas poplar gum–grey bloodwood woodland (*E. alba, E. polycarpa*) with eastern mid-height grass. Small areas in lower rainfall, Georgetown box woodland (*E. microneura*) and paperbark low woodland (*Melaleuca* spp.) both with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*)
2	Small	Mainly upper slopes	Skeletal grit and rock outcrop	Ironbark woodland (*E. shirleyi, E. peltata, E. crebra*) with eastern mid-height grass (sparse *Aristida* spp., *Heteropogon contortus, Arundinella setosa*)
3	Small	Lower slopes	Vanrook: sand over alkaline clay	
4	Small	Flat-floored valleys	Endymion: cracking clay	Poplar gum–grey bloodwood woodland (*E. alba, E. polycarpa, E. leptophleba, E. tessellaris*) with eastern mid-height grass (*Bothriochloa ewartiana, Aristida* spp.). Small areas in low rainfall, Georgetown box woodland (*E. microneura*) with eastern mid-height grass (*Bothriochloa ewartiana, Aristida* spp.)

* Comparable with Heidelberg land system of the Townsville–Bowen region.

(36) Stanhill Land System (300 sq miles)

Gently undulating, timbered, granite plains north of the centre of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface with elements of pre-mid Mesozoic surface.

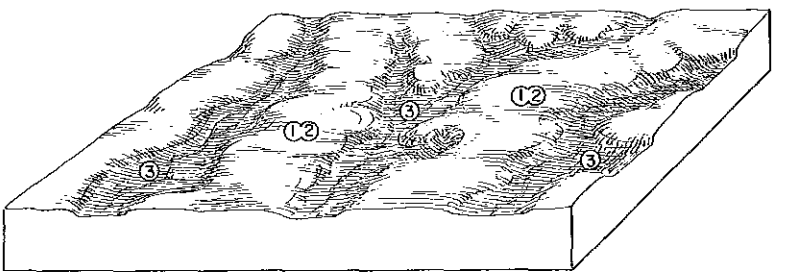
Geology.—Plutonic rocks. Granites of Pre-Cambrian and (?)Palaeozoic age.

Drainage.—Subrectangular.

Elevation.—400–700 ft. Local amplitude approx. 20 ft.

Climate.—Mean annual rainfall 27 in. Mean agricultural growing season 12 wk. Mean pasture growing season 17 wk.

Pasture Land.—Northern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Low rise	Cullen: gritty sand	Georgetown box woodland (*E. microneura, Petalostigma banksii*) with three-awn–ribbon grass (*Aristida ingrata, A. pruinosa, A. hygrometrica, Sorghum plumosum*). Outcrops, deciduous low woodland (*Terminalia platyptera, T. citrilagoensis, Erythrophleum chlorostachys, Petalostigma banksii*) with sparse grass
2	Medium		Skeletal grit and rock outcrop	
3	Medium	Broad shallow valleys	Vanrook: sand over alkaline clay	Margins, paperbark low woodland (*Melaleuca* spp.). Centre, trees absent (occasional *Melaleuca acacioides, E. grandifolia*). Both with solodic soil short grass (*Aristida superpendens, A. hirta, A. hygrometrica, Polycarpaea* spp.)

(37) NIALL LAND SYSTEM (1300 SQ MILES)

Timbered, irregular plains in the east of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface with elements of pre-mid Mesozoic surface.

Geology.—Broken River group (Silurian–Devonian). Steeply folded and slightly metamorphosed marine sediments, mainly slate and phyllite with greywacke, siltstone, shale, limestone, and conglomerate.

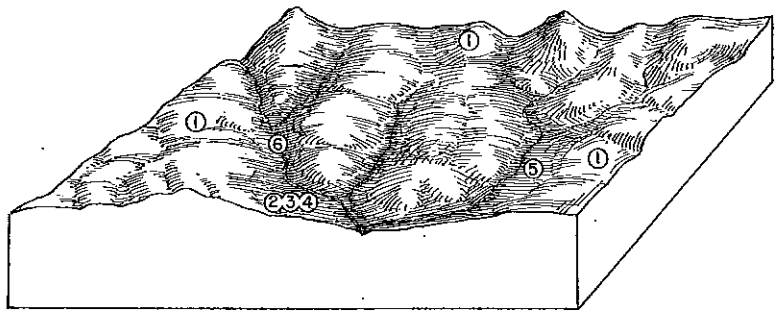
Drainage.—Moderately intense.

Elevation.—1500–2000 ft. Local amplitude approx. 250 ft.

Climate.—Wettest locality: mean annual rainfall 27 in.; mean agricultural growing season 25 wk; mean pasture growing season 30 wk.

Driest locality: mean annual rainfall 25 in.; mean agricultural growing season 15 wk; mean pasture growing season 20 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Upper slopes	Skeletal sand and silt and rock outcrop	Reid River box woodland (*E. brownii*). Small areas ironbark woodland (*E. melanophloia*). Very small areas high rainfall, poplar gum–grey bloodwood woodland (*E. alba, E. leptophleba*). All with eastern mid-height grass (*Bothriochloa decipiens, B. ewartiana, Dichanthium fecundum, Themeda australis, Aristida* spp., *Heteropogon contortus*)
2	Very small	Gentler slopes (on greywacke and phyllite)	Wyandotte: sand over clay. Forsayth: clay loam over clay	Ironbark woodland (*E. crebra, E. polycarpa, E. papuana*, also in higher-rainfall areas *E. citriodora, E. cambageana, E. howittiana*) with eastern mid-height grass (*Bothriochloa decipiens, B. ewartiana, Heteropogon contortus, Themeda australis, Dichanthium fecundum*)
3	Small	Gentle colluvial slopes	Elliott: sand over clay	
4	Small	Lower, gentler parts of the colluvial slope	Vanrook: sand over alkaline clay	Reid River box woodland (*E. brownii*) with eastern mid-height grass (*Bothriochloa decipiens, B. ewartiana, Heteropogon contortus, Chrysopogon fallax, Aristida* spp.)
5*	Small	Alluvial plains*	Nangum: clay loam over clay. Minor Manbulloo: fine sand	Lagoons, lagoon vegetation. Margins, couch grass short grass (*Cynodon dactylon*) or blue grass–browntop downs (*Ophiuros exaltatus, Dichanthium fecundum*). Frontage woodland (*E. alba, E. tessellaris*) with frontage mid-height grass (*Bothriochloa decipiens*)
6	Small	Stream channels	—	Fringing woodland (*E. camaldulensis, Casuarina cunninghamiana*) with frontage tall grass (*Chionachne cyathopoda, Arundinella nepalensis, Vetiveria* spp.). Frontage woodland (*E. alba, E. tessellaris, E. polycarpa, E. camaldulensis*) with frontage mid-height grass (*Bothriochloa decipiens*)

* Very limited throughout the land system as a whole, but more extensive adjacent to lakes (Pelican, Lucy, Lamond, and Wairuna) on the upper Burdekin River.

(38) Georgetown Land System (1100 sq miles)

Lightly timbered, rolling granite plains north-east of the centre of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface with elements of pre-mid Mesozoic surface.

Geology.—Plutonic rocks (Pre-Cambrian granites) and Croydon felsite (Permian). Small areas of Etheridge complex (Pre-Cambrian metamorphic rocks).

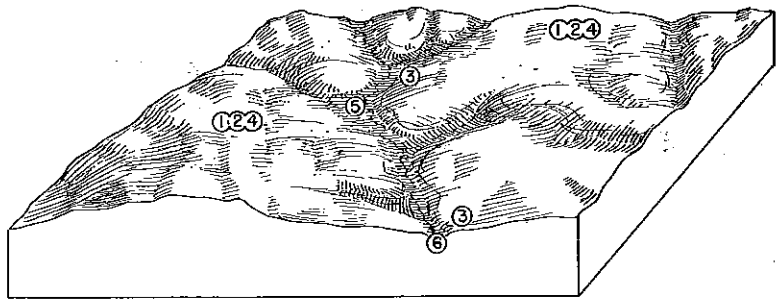
Drainage.—Moderately intense, subrectangular pattern.

Elevation.—300–1500 ft. Local amplitude approx. 40 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 16 wk; mean pasture growing season 20 wk.

Driest locality: mean annual rainfall 25 in.; mean agricultural growing season 10 wk; mean pasture growing season 15 wk.

Pasture Land.—Three-awn country.



Unit	Area	Land Forms	Soils	Vegetation
1	Medium	Steeper slopes in irregular plain	Rock outcrop	Deciduous low woodland (*Terminalia platyptera, Cochlospermum* sp., *Brachychiton* sp., *Erythrophleum chlorostachys*) with three-awn–ribbon grass (sparse *Aristida ingrata, A. hygrometrica*). Small areas ironbark woodland (*E. shirleyi, E. melanophloia*)
2	Large		Skeletal grit, sand, and silt	Georgetown box woodland (*E. microneura*) with three-awn (*Aristida armata, A. praealta, A. hygrometrica, A. pruinosa*) and three-awn–ribbon grass (*Aristida ingrata, A. hygrometrica, Chrysopogon fallax*)
3	Small	Lower slopes	Cargoon: sand over clay	
4	Small	Gentler slopes	Cockatoo: sand	
5	Small	Alluviated flats	Miranda: clay loam over alkaline clay	Outer margins, Georgetown box woodland (*E. microneura*); inner margins, paperbark low woodland (*Melaleuca acacioides*); centre, trees absent; all with solodic soil short grass (*Aristida hirta, A. superpendens, Chloris scariosa, Eriachne arnittii*)
6	Small	Stream channels	—	Fringing woodland (*E. camaldulensis*) with fringing grass (*Arundinella nepalensis*). Frontage woodland (*E. polycarpa, E. leptophleba, E. confertiflora*) with frontage grass (*Bothriochloa decipiens, Aristida* spp., *Heteropogon contortus*)

(39) Reedy Springs Land System (800 sq miles)

Timbered, irregular plains in the east of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface with elements of the pre-mid Mesozoic surface.

Geology.—Plutonic rocks. Granites of Pre-Cambrian and Palaeozoic age.

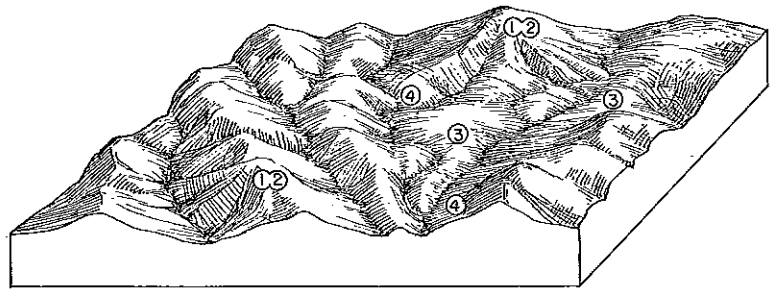
Drainage.—Sparse.

Elevation.—1500–2500 ft. Local amplitude approx. 100 ft.

Climate.—Wettest locality: mean annual rainfall 25 in.; mean agricultural growing season 14 wk; mean pasture growing season 20 wk.

Driest locality: mean annual rainfall 23 in.; mean agricultural growing season 12 wk; mean pasture growing season 17 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Medium	Steeper slopes in undulating to low hilly landscape	Rock outcrop	Ironbark woodland (*E. shirleyi, E. peltata, E. crebra*) with eastern mid-height grass (sparse *Aristida* spp., *Heteropogon* spp.)
2	Large		Skeletal grit	Ironbark woodland (*E. crebra, E. polycarpa, E. papuana, E. citriodora*). Small areas slight depressions, poplar gum–grey bloodwood woodland (*E. alba, E. polycarpa*). Both with eastern mid-height grass (*Bothriochloa decipiens, Heteropogon contortus, H. triticeus, Aristida* spp., *Themeda australis, Chrysopogon fallax, Rhynchelytrum repens*)
3	Medium	Gentler lower slopes	Cockatoo: gritty sand	
4	Small	Foot of steeper slopes	Cargoon: sand over clay	Reid River box woodland (*E. brownii*) with eastern mid-height grass (sparse *Bothriochloa decipiens, Heteropogon contortus, Themeda australis, Chrysopogon fallax*)
5	Small	Stream channels	—	Fringing woodland (*E. tereticornis, Casuarina cunninghamiana*) with fringing tall grass (*Arundinella nepalensis*). Frontage woodland (*E. crebra, E. polycarpa*) with frontage mid-height grass (*Bothriochloa decipiens*)

(40) Kilbogie Land System* (3200 sq miles)

Timbered, irregular plains in the east of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface with elements of the pre-mid Mesozoic surface.

Geology.—Etheridge complex (Pre-Cambrian). Metamorphic rocks and granite.

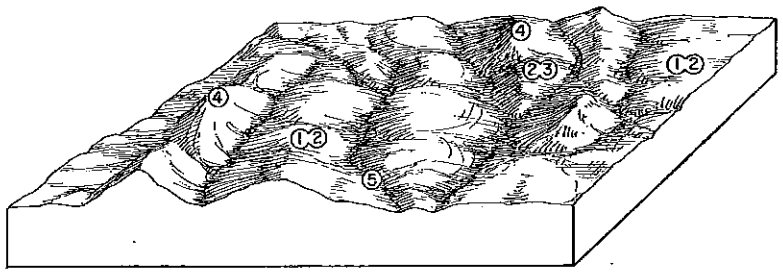
Drainage.—Moderate intensity, subrectangular pattern.

Elevation.—500–2500 ft. Local amplitude approx. 100 ft.

Climate.—Wettest locality: mean annual rainfall 32 in.; mean agricultural growing season 17 wk; mean pasture growing season 22 wk.

Driest locality: mean annual rainfall 22 in.; mean agricultural growing season 12 wk; mean pasture growing season 17 wk.

Pasture Land.—Eastern mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Gentle to moderate slopes on metamorphic rocks	Wyandotte: sand over clay. Very small areas of Forsayth: clay loam over clay. On flatter parts Rosella: calcareous cracking clay	Ironbark woodland (*E. crebra, E. whitei, E. dichromophloia, E. papuana*) with eastern mid-height grass (*Themeda australis, Heteropogon contortus, Bothriochloa ewartiana, Aristida* spp.). In areas west of Einasleigh (lower rainfall, lower elevation) Georgetown box woodland (*E. microneura*) with eastern mid-height grass. Small areas lower slopes, Reid River box (*E. brownii*) with eastern mid-height grass
2	Medium	Gentle to moderate slopes on both metamorphic rocks and granite	Cargoon: sand over clay. Very small areas of Sturgeon: sand over clay	
3	Small	Gentle to moderate slopes on granite	Elliott: sand over clay. Smaller areas of Cockatoo and Cullen: sand	
4	Small	Upper slopes	Skeletal sand and clay, and rock outcrop	Vegetation on skeletal soils similar to units 1–3. On outcrops ironbark woodland (*E. shirleyi, E. peltata, E. similis*) with eastern mid-height grass
5	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis, Casuarina cunninghamiana*) with fringing grass (*Arundinella nepalensis, Cynodon dactylon*). Frontage woodland (*E. polycarpa, E. tessellaris, E. papuana, E. leptophleba*) with frontage grass (*Bothriochloa decipiens, B. ewartiana, Panicum delicatum, Aristida* spp.)

* Comparable with Kilbogie land system of the Townsville–Bowen region.

(41) Townley Land System (300 sq miles)

Timbered, irregular plains north of the centre of the area.

Geomorphology.—Destructional land surface. Plains of erosion. Late Tertiary to Quaternary surface, with elements of the pre-mid Mesozoic surface.

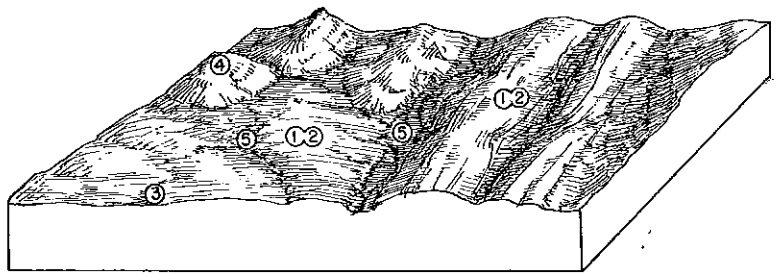
Geology.—Etheridge complex. Mainly mica-schist and amphibolite.

Drainage.—Moderately intense, subrectangular pattern.

Elevation.—750–1000 ft. Local amplitude approx. 20 ft.

Climate.—Mean annual rainfall 27 in. Mean agricultural growing season 12 wk. Mean pasture growing season 17 wk.

Pasture Land.—Three-awn country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Gentle to moderate slopes	Forsayth: clay loam over clay	Georgetown box woodland (*E. microneura*). Small areas ironbark woodland (*E. crebra, E. dichromophloia*). Both with three-awn (*Aristida* spp., patches *Bothriochloa ewartiana, Heteropogon contortus*)
2	Small		Wyandotte: sand over clay	
3	Small	Flatter parts of topography	Rosella: calcareous cracking clay	Blue grass–browntop downs (*Bothriochloa ewartiana, Dichanthium fecundum*)
4	Small	Upper slopes	Skeletal sand and clay and rock outcrop	Georgetown box woodland (*E. microneura*) with three-awn–ribbon grass (*Aristida pruinosa, A. hygrometrica, Chrysopogon fallax*). Small areas ironbark woodland (*E. melanophloia*) with three-awn–ribbon grass (*Aristida hygrometrica, Chrysopogon fallax, Sorghum* sp.) and western spinifex (*Triodia pungens*)
5	Very small	Stream channels	—	Fringing woodland (*E. camaldulensis, Melaleuca* sp.) with fringing tall grass (*Arundinella nepalensis*). Frontage woodland (*E. terminalis, E. confertiflora, E. leptophleba*) with frontage mid-height grass (*Bothriochloa decipiens, Dichanthium fecundum, Aristida* spp.)

(42) Mayvale Land System (6200 sq miles)

Timbered sandy plains in the north of the area.

Geomorphology.—Constructional land surface. Depositional. Outwash plains. Pliocene surface. Depositional plains formed on fluviatile sands laid down as a large low-angle outwash fan in Pliocene times as a result of Miocene upwarping of the Gilberton and Red Plateaux and the Gregory Range, from which areas most of the materials of the plain have been derived.

Geology.—Terrestrial deposits (Tertiary). Mainly unconsolidated sand.

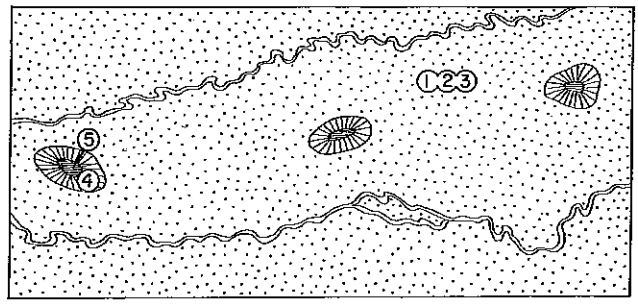
Drainage.—Sparse, subparallel.

Elevation.—50–300 ft. Local amplitude < 20 ft.

Climate.—Wettest locality: mean annual rainfall 33 in.; mean agricultural growing season 16 wk; mean pasture growing season 21 wk.

Driest locality: mean annual rainfall 27 in.; mean agricultural growing season 12 wk; mean pasture growing season 17 wk.

Pasture Land.—Northern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Very gently undulating plain	Wallabadah: sand over clay	Paperbark low woodland (*Melaleuca acacioides, M. viridiflora, M. symphyocarpa, M. nervosa*) with three-awn–ribbon grass (*Aristida hygrometrica, Chrysopogon fallax, Eriachne armittii, Sorghum* sp.). Small areas deeper sands, Bylong low woodland (*Bauhinia cunninghamii, Terminalia platyptera, T. chillagoensis, Cochlospermum* sp., *Erythrophleum chlorostachys, E. pruinosa*) with three-awn–ribbon grass
2	Medium		Elliott: sand over clay	
3	Small		Stawell: sand over clay over ferruginous zone	
4	Very small	Very gentle slopes fringing lagoons	Mayvale: sand over clay over ferruginous zone	Fringing woodland (*E. camaldulensis*) with fringing grass (*Eragrostis bella, Triraphis mollis*)
5	Very small	Well-defined, rounded, shallow lagoons seasonally flooded	Wallabadah: sand over clay	Lagoon vegetation (*Pseudoraphis spinescens*)
6	Very small	Shallow stream channels	—	Fringing woodland (*E. microtheca*) with fringing grass (*Eulalia fulva*)

(43) CLARAVILLE LAND SYSTEM* (5400 SQ MILES)

Timbered sandy plains north of the centre of the area.

Geomorphology.—Constructional land surface. Depositional. Outwash plains. Pliocene surface. Depositional plains formed on fluviatile sands laid down as a large low-angle outwash fan in Pliocene times as a result of Miocene upwarping of the Gilberton and Red Plateaux and the Gregory Range, from which areas most of the materials of the plain have been derived.

Geology.—Terrestrial deposits (Tertiary). Mainly unconsolidated sand.

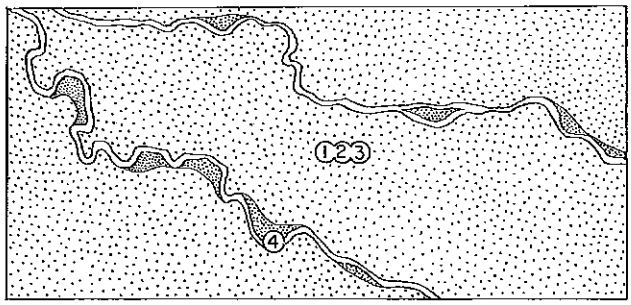
Drainage.—Sparse, subparallel.

Elevation.—100–550 ft. Local amplitude approx. 10 ft.

Climate.—Wettest locality: mean annual rainfall 27 in.; mean agricultural growing season 12 wk; mean pasture growing season 17 wk.

Driest locality: mean annual rainfall 20 in.; mean agricultural growing season 7 wk; mean pasture growing season 12 wk.

Pasture Land.—Northern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Gently undulating plain	Cockatoo: sand	Paperbark low woodland (*Melaleuca viridiflora, M. acacioides, M. nervosa, M. symphyocarpa*, sparse *E. polycarpa, Erythrophleum chlorostachys*). Small areas, particularly on deeper sandy soils, Bylong low woodland (*Bauhinia cunninghamii, Terminalia platyptera, Erythrophleum chlorostachys, Grevillea striata, Melaleuca minor*). Both with three-awn–ribbon grass (*Aristida hygrometrica, A. ingrata, Chrysopogon fallax, Sorghum* sp.)
2	Medium		Wallabadah and Elliott: sand over clay	
3	Small		Cullen: sand. Norman: sand with cemented subsoil	
4	Small	Small shallow stream channels and associated alluvial tracts	Manbulloo: fine sand. Nangum: clay loam over clay	Frontage woodland (coarse soils *E. polycarpa, Melaleuca* spp., finer soils *E. microtheca*) with frontage grass (coarse soils *Aristida* spp., *Chrysopogon fallax*, finer soils *C. fallax*). Fringing woodland (*E. microtheca, E. camaldulensis, Pandanus* sp.) with fringing grass (*Chrysopogon fallax, Eriachne* spp.)

* Includes the SA land association of Hubble and Beckmann (1957).

(44) Bylong Land System* (5500 sq miles)

Timbered sandy plains near the centre of the area.

Geomorphology.—Constructional land surface. Depositional. Outwash plains. Pliocene surface. Depositional plains formed on fluviatile sands laid down as a large low-angle outwash fan in Pliocene times as a result of Miocene upwarping of the Gilberton and Red Plateaux and the Gregory Range, from which most of the materials of the plain have been derived.

Geology.—Terrestrial deposits (Tertiary). Mainly unconsolidated sand.

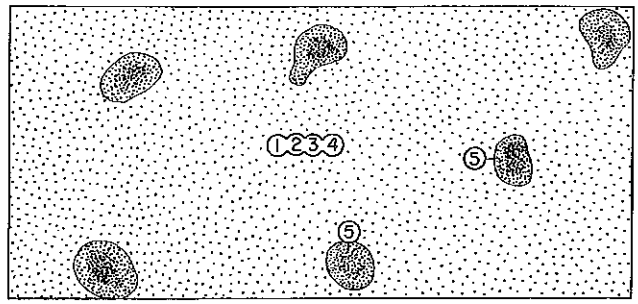
Drainage.—Sparse, parallel.

Elevation.—100–1000 ft. Local amplitude approx. 10 ft.

Climate.—Wettest locality: mean annual rainfall 25 in.; mean agricultural growing season 10 wk; mean pasture growing season 15 wk.

Driest locality: mean annual rainfall 18 in.; mean agricultural growing season 7 wk; mean pasture growing season 12 wk.

Pasture Land.—Southern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Very large	Gently undulating plain	Cockatoo: sand	Bylong low woodland (*Bauhinia cunninghamii, Albizia basaltica, Grevillea striata, Erythrophleum chlorostachys, Atalaya hemiglauca, Owenia acidula, Melaleuca* spp., *Terminalia ferdinandiana*) with three-awn–ribbon grass (*Aristida ingrata, A. hygrometrica, A. browniana, Chrysopogon fallax*). In the eastern parts of the land system, moderate areas of Georgetown box woodland (*E. microneura*) with three-awn–ribbon grass. Small patches gidgee low woodland (*Acacia cambagei*)
2	Medium		Cullen: sand	
3	Small		Elliott and Wallabadah: sand over clay. Norman: sand with cemented subsoil	
4	Very small		Currajong: sand over ferruginous zone	
5	Small	Well-defined, shallow depressions, mainly ovoid in outline, some elongated	Balootha: calcareous clay. Miranda: clay loam over alkaline clay. Vanrook: sand over alkaline clay. Endymion: cracking clay	Outer margins, paperbark low woodland (*Melaleuca* spp.) with three-awn–ribbon grass (*Aristida* spp., *Chrysopogon fallax*). Inner margins of large depressions and centres of small depressions, downs sparse woodland (*E. microtheca*) with lagoon vegetation (*Aeschynomene indica, Eleocharis* spp., *Marsilea* sp., *Pseudoraphis spinescens*). Centres of large depressions, Mitchell grass downs (*Astrebla* spp.) or solodic soil short grass (*Aristida hirta, A. superpendens, Chloris scariosa*)

* Includes the S and MS land associations of Hubble and Beckmann (1957).

(45) Abingdon Land System (200 sq miles)

Timbered sandy plains near the Gilbert and Einasleigh Rivers.

Geomorphology.—Constructional land surface. Depositional. Outwash plains. Pliocene surface. Depositional plains formed on fluviatile sands laid down as a large low-angle outwash fan in Pliocene times as a result of Miocene upwarping of the Gilberton and Red Plateaux and the Gregory Range, from which most of the materials of the plain have been derived.

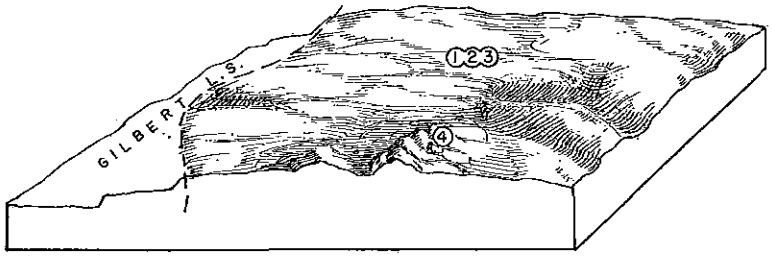
Geology.—Terrestrial deposits (Tertiary). Mainly unconsolidated sand.

Drainage.—Sparse, subparallel.

Elevation.—300–500 ft. Local amplitude approx. 10 ft.

Climate.—Mean annual rainfall 30 in. Mean agricultural growing season 15 wk. Mean pasture growing season 20 wk.

Pasture Land.—Northern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Nearly flat terrace	Sturgeon: sand over clay	Stringybark woodland (*E. tetrodonta, E. miniata, E. dichromophloia, E. polycarpa, E. leptophleba*) with three-awn–ribbon grass (*Aristida ingrata, A. hygrometrica*)
2	Small		Elliott: sand over clay	Frontage woodland (*E. polycarpa, E. confertiflora, E. papuana, E. leptophleba*). Small parts (low rainfall) Georgetown box woodland (*E. microneura*). Both with three-awn–ribbon grass (*Aristida ingrata, A. pruinosa, A. hygrometrica, Perotis rara*)
3	Small		Cargoon: sand over clay	Stringybark woodland (*E. confertiflora, E. dichromophloia*). Small parts (low rainfall) Georgetown box woodland (*E. microneura*). Both with three-awn–ribbon grass (*Aristida* spp.)
4	Small	Rock outcrops	Skeletal sands and outcropping ferruginous zone and sandstone	Downs sparse woodland (*E. microtheca, Bauhinia cunninghamii*). Small parts (low rainfall) paperbark woodland (*Melaleuca acacioides*). Both with solodic soil short grass (*Eriachne armittii, Aristida superpendens*)

(46) Korong Land System* (1200 sq miles)

Timbered plains in the west of the Carpentaria and inland plains.

Geomorphology.—Constructional land surface. Depositional. Outwash plains. Pliocene surface. Gravelly outwash plains or low plateaux which are remnants of a later Tertiary alluvial fan fronting the upwarped Mt. Isa country.

Geology.—Terrestrial deposits (Tertiary). Sand and clay.

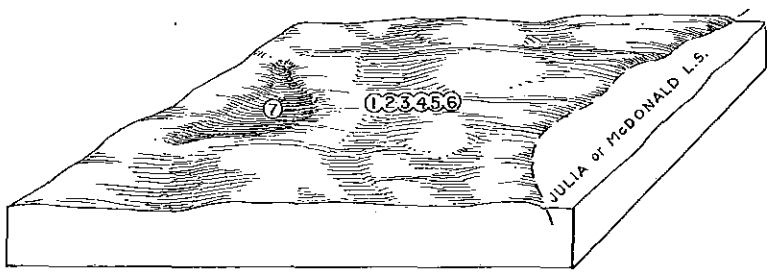
Drainage.—Sparse, subparallel.

Elevation.—200–500 ft. Local amplitude 10 ft.

Climate.—Wettest locality: mean annual rainfall 22 in.; mean agricultural growing season 9 wk; mean pasture growing season 14 wk.

Driest locality: mean annual rainfall 15 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Pasture Land.—Western mid-height grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Plain	Zingari: clay loam over clay	Silverleaf box low woodland (*E. pruinosa*) with western mid-height grass (*Aristida inaequiglumis, A. pruinosa, Sehima nervosum*) and western spinifex (*Triodia pungens*). Small areas (depressions, gilgais, some finer soils) silverleaf box low woodland (*E. pruinosa*) with blue grass–browntop downs (*Eulalia fulva, Dichanthium fecundum, Aristida latifolia*). Small areas (in south of land system) Isa highland sparse low woodland (*E. brevifolia*) with western spinifex (*Triodia pungens, T. molesta*) and arid sparse low woodland (*Grevillea striata, Acacia estrophiolata, Ventilago viminalis*) with arid short grass (*Aristida arenaria*)
2	Medium		Sturgeon: sand over clay, in part underlain by ferruginous zone	
3	Small		Nangum: clay loam over clay, often with gilgai	
4	Very small		Wonorah: clay loam over clay over ferruginous zone	
5	Small		Cockatoo: sand, often with high amounts of gravel	Bylong low woodland (*Bauhinia cunninghamii, Ventilago viminalis, E. pruinosa*) with three-awn–ribbon grass (*Aristida hygrometrica, Chrysopogon fallax*)
6	Very small		Outcropping ferruginous zone	Isa highland sparse low woodland (*E. brevifolia, E. pruinosa*) with western spinifex (*Triodia pungens*)
7	Very small	Depressions in plain	Balootha: calcareous clay	Arid short grass (*Aristida arenaria*, etc.) with patches of blue grass–browntop downs (*Eulalia fulva, Aristida latifolia*). Patches of gidgee low woodland (*Acacia cambagei*)

* In the northern areas of this land system (near Nardoo), sandy soils predominate and units 1, 3, and 4 are of minor importance. Includes the TP, SL, AS ASi, and some areas of LU and MA land associations of Hubble and Beckmann (1957).

(47) PERCOL LAND SYSTEM* (200 SQ MILES)

Very sparsely timbered plains in the south-west of the area.

Geomorphology.—Constructional land surface. Depositional. Outwash plains. Pliocene surface. Faintly dissected gravelly outwash plains which are remnants of a late Tertiary alluvial fan fronting the upwarped Mt. Isa country.

Geology.—Terrestrial deposits (Tertiary). Sand, clay, and gravel.

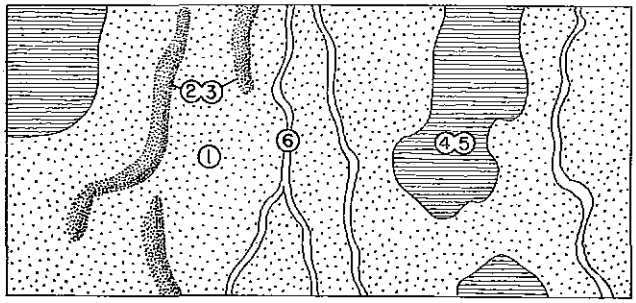
Drainage.—Sparse.

Elevation.—600–800 ft. Local amplitude < 10 ft.

Climate.—Wettest locality: mean annual rainfall 17 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Driest locality: mean annual rainfall < 15 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Pasture Land.—Arid short grass country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Plain	Boorama: sand over alkaline clay	Arid sparse low woodland (*Atalaya hemiglauca, Owenia acidula, Grevillea striata, Ventilago viminalis, E. papuana*) with arid short grass (*Aristida arenaria, Enneapogon* spp., *Tripogon loliiformis, Chloris scariosa*) or bare ground. Small patches of gidgee low woodland (*Acacia cambagei*)
2	Small	Levees	Cockatoo: sand	Frontage woodland (*E. papuana, E. terminalis, Grevillea striata, Ventilago viminalis*) with frontage mid-height grass (*Chloris acicularis, Aristida pruinosa, A. browniana, Bothriochloa decipiens, B. ewartiana, Heteropogon contortus*)
3	Small		Sturgeon: sand over clay	
4	Medium	Slightly depressed areas within plain	Balootha: calcareous clay	Trees absent (occasional *Atalaya hemiglauca, Ventilago viminalis*) with arid short grass (*Aristida arenaria, Brachyachne convergens, Tragus australianus, Cleome viscosa*, bare patches). Small patches gidgee low woodland (*Acacia cambagei*)
5	Small		Wonardo: calcareous cracking clay	Mitchell grass downs (*Astrebla squarrosa, A. lappacea, A. pectinata, Aristida latifolia*). Small patches gidgee low woodland (*Acacia cambagei*)
6	Very small	Small shallow stream channels	—	Fringing woodland (*E. camaldulensis, Acacia cambagei*, heavy soil *E. microtheca*) with fringing grass (*Chloris acicularis, Dichanthium fecundum, Aristida pruinosa*, heavy soil *Astrebla squarrosa, Aristida latifolia*)

* Somewhat comparable with Moonah land system of the Barkly region.

(48) Balbirini Land System* (8100 sq miles)

Grassy plains in the northern part of the Carpentaria plains.

Geomorphology.—Constructional land surface. Depositional. Riverine paludal plains. Pleistocene surface. The plains have been uplifted relative to base level and have consequently suffered slight dissection.

Geology.—Alluvium (Quaternary). Fine-textured.

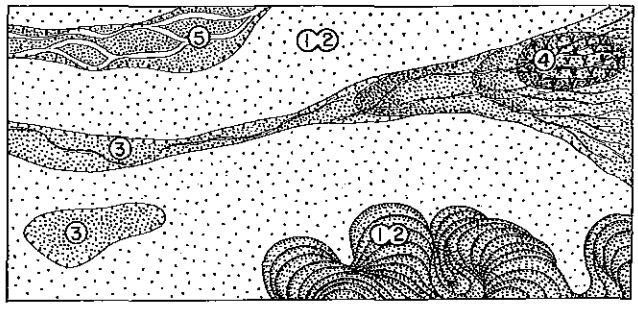
Drainage.—Sparse or absent.

Elevation.—< 500 ft. Local amplitude < 10 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 15 wk; mean pastoral growing season 20 wk.

Driest locality: mean annual rainfall 18 in.; mean agricultural growing season 5 wk; mean pastoral growing season 10 wk.

Pasture Land.—Blue grass–browntop plains.



Unit	Area	Land Forms	Soils	Vegetation
1	Very large	Flat plains sloping gently toward the coast	Barkly with associated Wonardo: calcareous cracking clay locally with gilgai	Blue grass–browntop downs (*Eulalia fulva, Dichanthium fecundum, Aristida latifolia*). Small areas Mitchell grass downs (*Astrebla squarrosa, A. lappacea*). Small areas downs sparse woodland (*E. microtheca, Excoecaria parvifolia*) with blue grass–browntop downs
2	Very small		Balootha: calcareous clay, gravelly and with gilgai locally	Trees absent and arid sparse low woodland (*Atalaya hemiglauca, Grevillea striata*) with arid short grass (*Aristida arenaria, Enneapogon* spp.)
3	Small	Shallow depressions	Barkly with gilgai	Downs sparse woodland (*E. microtheca, Excoecaria parvifolia*) or trees absent with blue grass–browntop downs (*Eulalia fulva, Oryza australiensis, Sesbania* spp., *Dichanthium superciliatum, Chenopodium auricomum*)
4	Very small	Seasonally flooded plains with numerous distributary channels	Endymion: cracking clay with gilgai	Downs sparse woodland (*Excoecaria parvifolia*) with blue grass–browntop downs (*Oryza australiensis, Eleocharis* spp.)
5	Very small	Channels and associated slopes	Barkly: calcareous cracking clay	Fringing woodland (*E. microtheca*) with fringing grass (*Chionachne cyathopoda*). Frontage woodland (*E. microtheca, Excoecaria parvifolia*) with frontage grass (*Brachyachne convergens*)

* Comparable with Balbirini land system of the Barkly region. Includes the GP, BPc, and some areas of FP, BP, and D land associations of Hubble and Beckmann (1957).

(49) Monstraven Land System* (1600 sq miles)

Mitchell grass plains west of the centre of the area.

Geomorphology.—Constructional land surface. Depositional. Riverine paludal plains. Pleistocene surface. The plains have been uplifted relative to base level and have consequently suffered slight dissection.

Geology.—Fine-textured alluvium (Quaternary) over Rolling Downs group (Mesozoic). Slightly calcareous siltstone and fine-grained argillaceous greywacke.

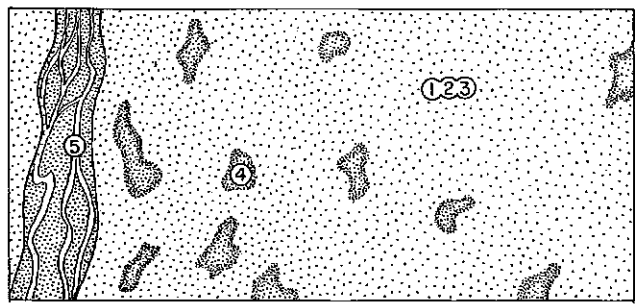
Drainage.—Sparse.

Elevation.—< 500 ft. Local amplitude < 20 ft.

Climate.—Wettest locality: mean annual rainfall 20 in.; mean agricultural growing season 7 wk; mean pastoral growing season 12 wk.

Driest locality: mean annual rainfall 16 in.; mean agricultural growing season < 5 wk; mean pastoral growing season < 10 wk.

Pasture Land.—Mitchell grass plains.



Unit	Area	Land Forms	Soils	Vegetation
1	Very large	Flat plain	Barkly: calcareous cracking clay	Mitchell grass downs (*Astrebla squarrosa, A. lappacea*)
2	Small		Wonardo: calcareous cracking clay	Gidgee low woodland (*Acacia cambagei*) with arid short grass or bare ground
3	Small	Very low rise	Baloottha: gravelly calcareous clay, locally with occasional gilgai holes	Trees absent or arid sparse low woodland (*Atalaya hemiglauca*) with arid short grass. Blue grass–browntop downs (*Eulalia fulva*) in gilgais
4	Small		Gravelly Zingari: clay loam over clay. Gravelly Cockatoo: sand	Arid sparse low woodland (*Atalaya hemiglauca, E. terminalis, Ventilago viminalis*) with western mid-height grass (*Aristida* spp., *Heteropogon contortus*)
5	Very small	Small stream channel and adjacent slopes	Gravelly Cockatoo: sand	Fringing woodland (*Acacia cambagei*) with fringing grass (*Brachyachne convergens*)

* Includes BP_S and some areas of D, BP, and FP land associations of Hubble and Beckmann (1957).

(50) GLENORE LAND SYSTEM* (700 SQ MILES)

Timbered plains near Normanton.

Geomorphology.—Constructional land surface. Depositional. Rivérine paludal plains. Pleistocene surface.

Geology.—Alluvium (Quaternary).

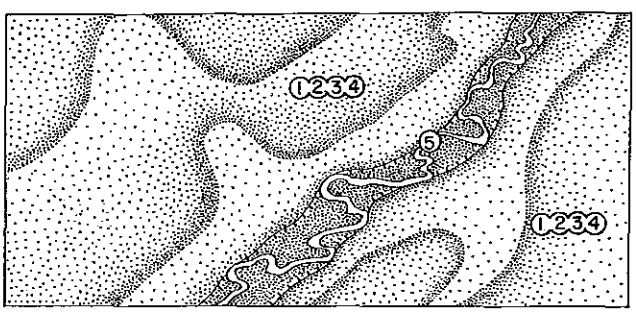
Drainage.—Sparse.

Elevation.—< 100 ft. Local amplitude < 20 ft.

Climate.—Wettest locality: mean annual rainfall 33 in.; mean agricultural growing season 16 wk; mean pastoral growing season 21 wk.

Driest locality: mean annual rainfall 25 in.; mean agricultural growing season 10 wk; mean pastoral growing season 15 wk.

Pasture Land.—Blue grass–browntop plains.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Flat plain	Nangum: clay loam over clay	Western box woodland (*E. argillacea*) with blue grass–browntop downs (*Eulalia fulva, Chrysopogon fallax, Sehima nervosum*)
2	Medium		Miranda: clay loam over alkaline clay	Downs sparse woodland (*E. microtheca, Bauhinia cunninghamii*) with solodic soil short grass (*Aristida hirta, A. superpendens, A. hygrometrica, Eriachne armittii, Chloris pumilio*)
3	Medium		Balootha: calcareous clay. Endymion: cracking clay	Downs sparse woodland (*E. microtheca, Excoecaria parvifolia*) with blue grass–browntop downs (*Eulalia fulva, Dichanthium fecundum, Aristida latifolia, Chrysopogon fallax*)
4	Small		Vanrook: sand over alkaline clay	Western box woodland (*E. argillacea*) with blue grass–browntop downs (*Eulalia fulva, Chrysopogon fallax*)
5	Very small	Stream channels	—	Fringing woodland (*E. microtheca, Excoecaria parvifolia*) with fringing grass (*Panicum seminudum*)

* Somewhat comparable with Keighran land system of the Barkly region.

(51) MIRANDA LAND SYSTEM (1900 SQ MILES)

Very sparsely timbered plains near the Gulf of Carpentaria. Popularly called Gilbert "delta".

Geomorphology.—Constructional land surface. Depositional. Riverine paludal plains with overbank deposits laid down between levees predominantly. Pleistocene surface. Related to the distributary drainage system of the lower Gilbert River. Since formation the plains have suffered slight uplift relative to sea-level.

Geology.—Alluvium (Quaternary).

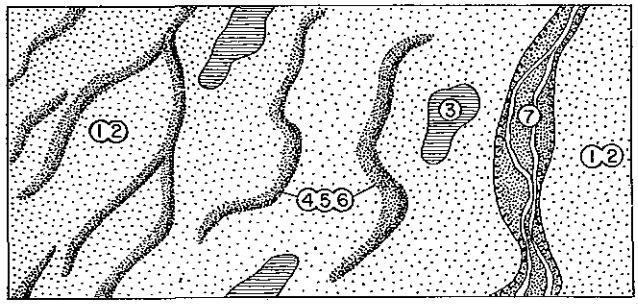
Drainage.—Sparse, subparallel.

Elevation.—<250 ft. Local amplitude <20 ft.

Climate.—Wettest locality: mean annual rainfall 33 in.; mean agricultural growing season 16 wk; mean pastoral growing season 21 wk.

Driest locality: mean annual rainfall 30 in.; mean agricultural growing season 14 wk; mean pastoral growing season 19 wk.

Pasture Land.—Delta country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Extensive plains	Miranda: clay loam over alkaline clay	Trees absent or downs sparse woodland (*E. confertiflora, E. grandifolia, E. microtheca, Bauhinia cunninghamii*) with blue grass–browntop downs (*Dichanthium superciliatum, D. fecundum, Aristida latifolia, Eriachne squarrosa, Chrysopogon fallax*) and solodic soil short grass (*Aristida superpendens, A. hirta, A. hygrometrica, Eriachne armittii, E. squarrosa, Chloris pumilio*)
2	Small		Vanrook: sand over alkaline clay	Downs sparse woodland with solodic soil short grass
3	Small	Very shallow, ill-defined depressions	Endymion: cracking clay	Downs sparse woodland (*E. microtheca*) with blue grass–browntop downs (*Oryza australiensis, Eulalia fulva, Leptochloa brownii, Pennisetum basedowii, Dichanthium superciliatum, Eriachne squarrosa*)
4	Small	Abandoned levees	Cockatoo: sand	Frontage woodland (*E. polycarpa, E. confertiflora, E. leptophleba, E. foelscheana, E. tetrodonta*) with frontage grass (*Heteropogon contortus, H. triticeus, Bothriochloa decipiens, Aristida* spp., *Hyptis suaveolens, Eriachne obtusa, Chrysopogon fallax, Sorghum plumosum, Panicum delicatum*)
5	Small		Sturgeon: sand over clay	
6	Small		Elliott: sand over clay	
7	Small	Channels	—	Fringing woodland (*E. camaldulensis, Melaleuca* spp., *Cathormion umbellatum, Pandanus* spp.) with fringing grass (*Arundinella nepalensis*)

(52) Gregory Land System* (1800 sq miles)

Mitchell grass plains in the north-west of the area.

Geomorphology.—Constructional land surface. Depositional. Covered plains. Early Recent surface. Many of the stream channels have been abandoned and those that are active are incised, leaving the plains perched above base level.

Geology.—Alluvium (Quaternary). Mainly fine-textured.

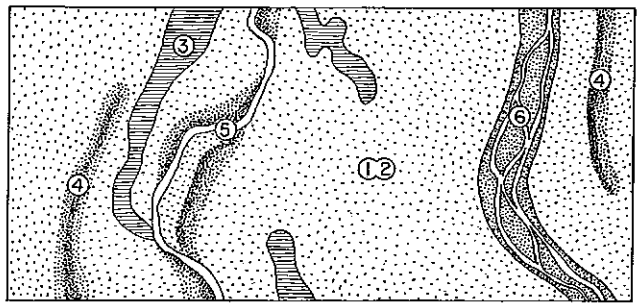
Drainage.—Sparse, subparallel.

Elevation.—< 750 ft. Local amplitude < 20 ft.

Climate.—Wettest locality: mean annual rainfall 28 in.; mean agricultural growing season 14 wk; mean pastoral growing season 19 wk.

Driest locality: mean annual rainfall 20 in.; mean agricultural growing season 5 wk; mean pastoral growing season 10 wk.

Pasture Land.—Mitchell grass plains.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Flat plains	Barkly with associated Wonardo: calcareous cracking clay	Mitchell grass downs (*Astrebla squarrosa, A. lappacea, Aristida latifolia*) or blue grass–browntop downs (*Eulalia fulva, Dichanthium fecundum*). Small patches of gidgee low woodland (*Acacia cambagei*) with Mitchell grass downs (*Astrebla lappacea, A. squarrosa*)
2	Medium		Balootha: calcareous clay	Arid sparse low woodland with arid short grass or Mitchell grass downs (*Aristida latifolia*). Trees absent with arid short grass
3	Small	Depression, characteristically linear, periodically flooded	Barkly: calcareous cracking clay	Downs sparse woodland (*E. microtheca*) with blue grass–browntop downs (*Oryza australiensis, Eulalia fulva*) and Mitchell grass downs (*Astrebla squarrosa, A. lappacea, Aristida latifolia*). Smaller areas trees absent with blue grass–browntop downs (*Oryza australiensis, Chenopodium auricomum*)
4	Medium	Levees	Manbulloo: fine sand. Sturgeon: sand over clay	Frontage woodland (*E. tectifica, E. papuana, E. terminalis, E. pruinosa, E. microtheca*) with frontage grass (*Chrysopogon fallax, Aristida inaequiglumis, A. pruinosa, Bothriochloa decipiens, Dichanthium fecundum*)
5	Very small	Abandoned stream channel	Intermediate-textured alluvial soils	Frontage woodland (*E. terminalis, E. papuana, E. pruinosa, E. microtheca*) with frontage grass (*Aristida pruinosa, A. inaequiglumis, Bothriochloa decipiens, Cenchrus ciliaris*)
6	Very small	Modern, braided, stream channels and associated slopes	—	Fringing woodland (*E. camaldulensis, E. microtheca*) with fringing grass (*Arundinella nepalensis, Chionachne cyathopoda*). Frontage woodland (*E. microtheca*) with frontage grass (*Aristida latifolia, Brachyachne convergens*)

* Comparable with Gregory land system of the Barkly region. Includes the SR, CSG, and some areas of BP and GP land associations of Hubble and Beckmann (1957). The small areas mapped as Gregory land system along the Flinders River near Hughenden and along the Stawell River are atypical; they contain moderate areas of solodized soils.

(53) Cloncurry Land System* (800 sq miles)

Frontage country in the south and west of the area.

Geomorphology.—Constructional land surface. Depositional. Covered plains. Early Recent surface. Levees and interlevee areas.

Geology.—Alluvium (Quaternary). Mainly coarse-textured.

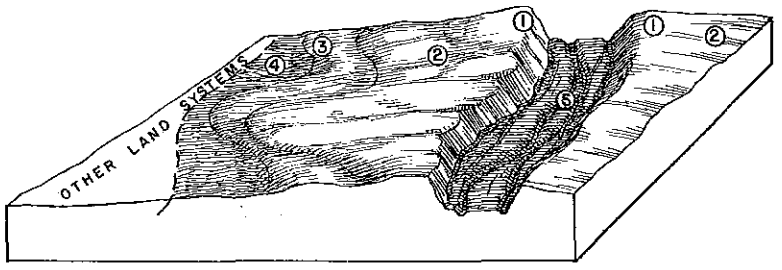
Drainage.—Very sparse—only on back slope of levees.

Elevation.—250–700 ft. Local amplitude < 20 ft.

Climate.—Wettest locality: mean annual rainfall 20 in.; mean agricultural growing season 10 wk; mean pastoral growing season 15 wk.

Driest locality: mean annual rainfall < 15 in.; mean agricultural growing season < 5 wk; mean pastoral growing season < 10 wk.

Pasture Land.—Frontage country.



Unit	Area	Land Forms	Soils	Vegetation
1	Medium	Levee crests adjacent to stream channel	Manbulloo: fine sand	Frontage woodland (*E. terminalis, E. papuana, E. prunosa, E. microtheca, Bauhinia cunninghamii*) with frontage grass (*Aristida inaequiglumis, A. browniana, Bothriochloa decipiens, B. ewartiana, Dichanthium fecundum, Themeda australis, Chrysopogon fallax, Chloris acicularis,* near Cloncurry *Cenchrus ciliaris*)
2	Large	Slightly undulating back slope of levee	Sturgeon: sand over clay	
3	Small	Lower parts of back slope of levee	Moonah: clay loam over alkaline clay	Trees absent or arid sparse low woodland (*Atalaya hemiglauca, Grevillea striata*) with arid short grass (*Brachyachne convergens, Aristida arenaria*)
4	Very small	Flood-plain behind levee	Balootha: calcareous clay. Barkly and Wonardo: calcareous cracking clay	Mitchell grass downs (*Astrebla* spp., *Aristida latifolia*) or downs sparse woodland (*E. microtheca*) with Mitchell grass downs
5†	Very small	Distributary plain near Sedan Dip	Alluvial stratified silt and fine sand	Frontage woodland (*E. microtheca, E. papuana*) with frontage grass (*Cenchrus ciliaris, Dichanthium fecundum*)
6	Small	Channel of major stream	—	Fringing woodland (*E. camaldulensis, E. microtheca*) with fringing grass (*Chloris acicularis, Themeda australis, T. avenacea*)

* Includes the CSD and CSK land associations of Hubble and Beckmann (1957).

† Locally confined, not occurring in other parts of the land system.

(54) Gilbert Land System (500 sq miles)

Frontage country in the north of the area.

Geomorphology.—Constructional land surface. Depositional. Covered plains. Early Recent surface. Levees and interlevee areas.

Geology.—Alluvium (Quaternary). Mainly coarse-textured.

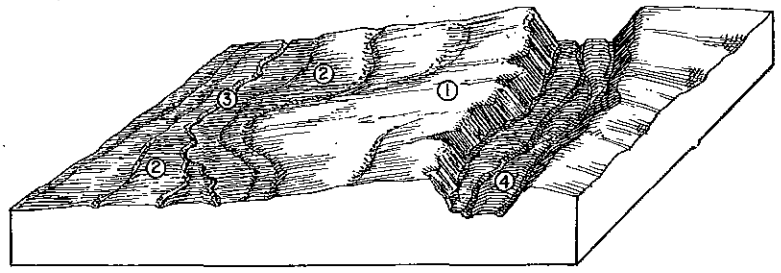
Drainage.—Sparse, subparallel.

Elevation.—50–250 ft. Local amplitude < 20 ft.

Climate.—Wettest locality: mean annual rainfall 33 in.; mean agricultural growing season 15 wk; mean pastoral growing season 20 wk.

Driest locality: mean annual rainfall 30 in.; mean agricultural growing season 13 wk; mean pastoral growing season 18 wk.

Pasture Land.—Frontage country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Levee	Manbulloo: fine sand	Frontage woodland (*E. leptophleba, E. tessellaris, E. confertiflora, E. terminalis, E. papuana*) with frontage grass (*Bothriochloa decipiens, Aristida armata, A. ingrata, A. pruinosa, Heteropogon contortus, Chrysopogon pallidus, Panicum delicatum*)
2	Small	Lower back slope and adjacent flood-plain	Miranda: clay loam over alkaline clay. Vanrook: sand over alkaline clay	Trees absent and downs sparse woodland (*E. microtheca, Bauhinia cunninghamii*) with solodic soil short grass (*Aristida superpendens, Eriachne armittii*)
3	Very small	Abandoned stream channel	—	Fringing woodland (*E. microtheca*) with fringing grass (*Pseudoraphis spinescens, Eulalia fulva*) or lagoon vegetation (waterlilies, *Eleocharis* spp.)
4	Very small	Channel of modern stream	—	Fringing woodland (*E. camaldulensis, Nauclea orientalis, Melaleuca* spp., *Ficus* sp., *Terminalia platyphylla, Cryptostegia grandiflora*) with fringing grass (*Arundinella nepalensis, Chionachne cyathopoda, Achyranthes aspera*)

(55) Georgina Land System* (4000 sq miles)

Heavy clay plains associated with streams and cut by numerous channels.

Geomorphology.—Constructional land surface. Depositional. Bar plains. Late Recent surface. Silty bar plains developed by actively braiding streams.

Geology.—Alluvium (Quaternary). Fine-textured.

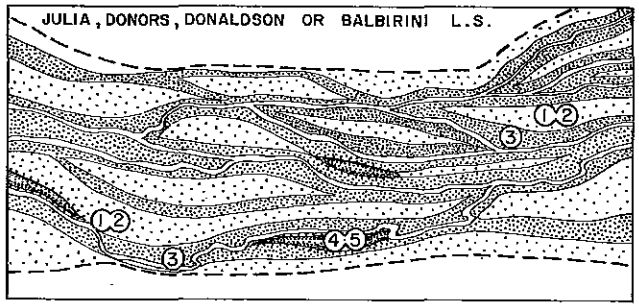
Drainage.—Intense, braided pattern.

Elevation.—< 750 ft. Local amplitude < 30 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 15 wk; mean pasture growing season 20 wk.

Driest locality: mean annual rainfall 15 in.; mean agricultural growing season < 5 wk; mean pasture growing season < 10 wk.

Pasture Land.—Blue grass–browntop plains.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Flat plains	Barkly with associated Wonardo: calcareous cracking clay	Trees absent or downs sparse woodland (*E. microtheca*) with Mitchell grass downs (*Astrebla* spp.) and blue grass–browntop downs (*Eulalia fulva, Dichanthium fecundum, D. superciliatum, Sesbania* sp.). Small patches gidgee low woodland (*Acacia cambagei*)
2	Medium		Balootha: calcareous clay, frequently gravelly	Trees absent or arid sparse woodland (*Atalaya hemiglauca, Grevillea striata*) with arid short grass (*Brachyachne convergens, Dactyloctenium radulans*) and with small areas Mitchell grass downs (*Astrebla* spp.). Small areas gidgee low woodland (*Acacia cambagei*)
3	Small	Flood channels	Barkly: calcareous cracking clay. Endymion: cracking clay	Fringing woodland (*E. microtheca*) with fringing grass (*Sesbania* sp., *Themeda avenacea, Oryza australiensis*). Small areas gidgee low woodland (*Acacia cambagei*)
4	Very small	Levee (only where streams head in sandy source material and then confined to middle tract)	Manbulloo: fine sand	Frontage woodland (*E. camaldulensis*) with frontage grass (*Chrysopogon fallax, Bothriochloa decipiens*)
5	Very small	Back slope of levee	Alluvial: medium texture	Frontage woodland (*E. terminalis, E. papuana*) with frontage grass (*Chloris acicularis*)
6	Medium	Braided river channel	—	Fringing woodland (*E. camaldulensis, E. microtheca*) with fringing grass (*Chionachne cyathopoda, Bothriochloa decipiens*)

* Comparable with the Georgina land system of the Barkly region. Includes the C land association of Hubble and Beckmann (1957).

(56) Armraynald Land System (400 sq miles)

Frontage country near the Gulf of Carpentaria.

Geomorphology.—Constructional land surface. Depositional. Lacine and scroll plains. Late Recent surface.

Geology.—Alluvium (Quaternary). Silts and fine sands.

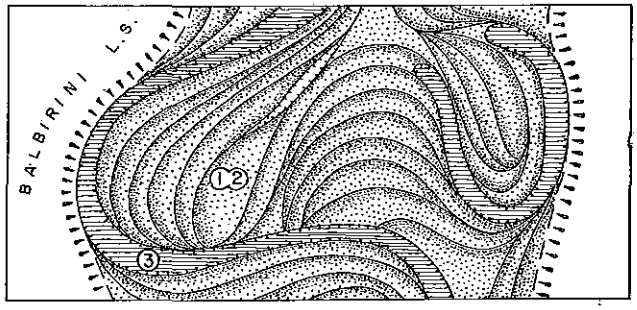
Drainage.—Single major sinuous channel.

Elevation.—< 20 ft. Local amplitude approximately 5 ft.

Climate.—Wettest locality: mean annual rainfall 35 in.; mean agricultural growing season 17 wk; mean pasture growing season > 22 wk.

Driest locality: mean annual rainfall 30 in.; mean agricultural growing season 15 wk; mean pasture growing season 20 wk.

Pasture Land.—Frontage country.



Unit	Area	Land Forms	Soils	Vegetation
1	Medium	Levee ridges	Alluvial: silt and fine sand	Frontage woodland (*E. papuana, E. polycarpa, E. confertiflora, E. leptophleba, Bauhinia cunninghamii*) with frontage mid-height grass (*Heteropogon contortus, Chloris acicularis, Aristida* spp.). Downs sparse woodland (*E. microtheca*) with blue grass–browntop downs (*Eulalia fulva, Astrebla* spp., *Chloris acicularis*)
2	Medium	Swales		Downs sparse woodland (*E. microtheca, Excoecaria parvifolia*) with blue grass–browntop downs (*Oryza australiensis, Sesbania* sp., *Pennisetum basedowii*)
3	Small	Stream channel	—	Fringing woodland (*E. microtheca, Cathormion umbellatum*) or forest (*E. camaldulensis, Nauclea orientalis, Ficus* sp., *Melaleuca saligna, Pandanus* sp.) with fringing grass (*Chionachne cyathopoda, Xanthium chinense*)

(57) Prospect Land System (100 sq miles)

Timbered sandy frontage country north of the centre of the area.

Geomorphology.—Constructional land surface. Depositional. Lacine and scroll plains. Late Recent surface.

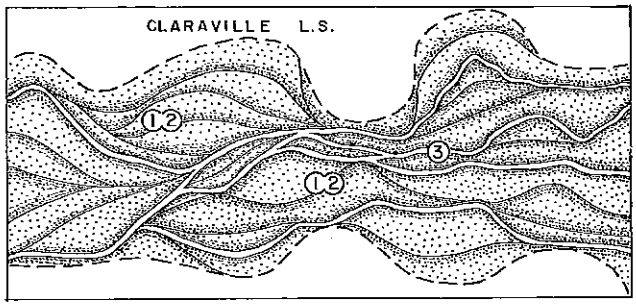
Geology.—Alluvium (Quaternary). Sands.

Drainage.—Single major sinuous channel.

Elevation.—300–400 ft. Local amplitude < 10 ft.

Climate.—Mean annual rainfall 25 in. Mean agricultural growing season 10 wk. Mean pastoral growing season 15 wk.

Pasture Land.—Northern sandy forest country.



Unit	Area	Land Forms	Soils	Vegetation
1	Medium	Levee ridges	Cockatoo: sand	Paperbark low woodland (*Melaleuca viridiflora*). Frontage woodland (*E. polycarpa, Melaleuca viridiflora*). Both with three-awn–ribbon grass (*Aristida ingrata, A. hygrometrica, Chrysopogon fallax*)
2	Medium	Swales		Frontage woodland (*E. microtheca, Melaleuca* spp.) with frontage mid-height grass (*Eulalia fulva, Chrysopogon fallax, Panicum delicatum*)
3	Very small	Numerous small stream channels		Fringing woodland (*E. microtheca, Excoecaria parvifolia*)

(58) Carpentaria Land System* (2000 sq miles)

Saline coastal plains adjacent to the Gulf of Carpentaria.

Geomorphology.—Constructional land surface. Depositional. Marine plains. Late Pliocene-Quaternary surface. The coastline is an aggrading one and has suffered a recent emergence of about 20 ft.

Geology.—Littoral deposits (Quaternary). Mainly saline mud flats with discontinuous ridges of shells and shell fragments.

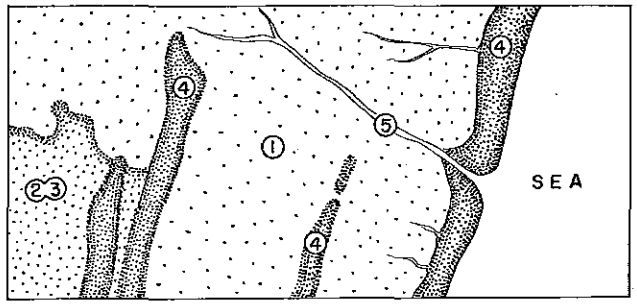
Drainage.—Variable, some intense areas, some devoid of streams.

Elevation.—< 100 ft. Local amplitude < 40 ft.

Climate.—Wettest locality: mean annual rainfall 35 in.; mean agricultural growing season 17 wk; mean pasture growing season 22 wk.

Driest locality: mean annual rainfall 27 in.; mean agricultural growing season 13 wk; mean pasture growing season 18 wk.

Pasture Land.—Coastal country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Saline mud flats covered by high tides	Carpentaria: saline clay	Bare ground. Smaller areas with sparse samphire
2	Small	Slightly elevated plain not subject to tidal flooding	Miranda: clay loam over alkaline clay	Trees absent. Saline soil short grass (*Xerochloa imberbis*) and blue grass–browntop downs (*Eulalia fulva, Ophiuros exaltatus, Dichanthium superciliatum, Astrebla squarrosa, Chrysopogon fallax*)
3	Small	Low plateaux	Solonetzic soils with sandy surfaces, undifferentiated shelly clay or sand exposed in low scarps	Trees absent or downs sparse woodland (*E. microtheca, Excoecaria parvifolia*) with saline soil short grass (*Sporobolus virginicus, Xerochloa imberbis, Chloris divaricata, C. pumilio, Salsola kali, Bassia* spp., *Fimbristylis* spp.)
4	Small	Low linear ridges on units 1 and 2	Aeolian sands: stratified shelly sand and clay	Dune woodland (*E. papuana, Ficus* sp., *Pandanus* sp., *Erythrina vespertilio, Grevillea striata, Myoporum* sp., *Maba humilis, Clerodendron* sp.) with *Sporobolus virginicus, Aristida browniana, Vetiveria pauciflora, Panicum delicatum,* and *Chrysopogon fallax*
5	Small	Stream channels	—	Mangroves

* Comparable with Littoral land system of the Barkly region.

(59) Rosella Land System (2000 sq miles)

Basalt plains and plateaux with black soil.

Geomorphology.—Constructional land surface. Volcanic. Basalt plains and plateaux. Pliocene and Pleistocene surface.

Geology.—Basalt (Tertiary and Quaternary).

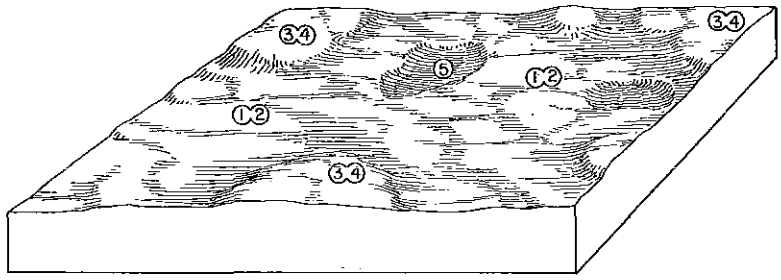
Drainage.—Sparse.

Elevation.—1400–3000 ft. Local amplitude < 200 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 25 wk; mean pastoral growing season 35 wk.

Driest locality: mean annual rainfall 20 in.; mean agricultural growing season 9 wk; mean pastoral growing season 14 wk.

Pasture Land.—Basalt country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Plain	Rosella: calcareous cracking clay, commonly with boulder mantle	Downs woodland (low to moderate rainfall *E. terminalis, E. orgadophila, Atalaya hemiglauca*, high rainfall *E. orgadophila, E. leptophleba, E. crebra, E. howittiana*). Small areas trees absent. Both with blue grass–browntop downs (*Ophiuros exaltatus, Dichanthium fecundum, D. superciliatum, Bothriochloa decipiens, Astrebla squarrosa, Themeda australis, Heteropogon contortus*)
2	Small		Glendhu: clay	Ironbark woodland (*E. crebra, E. dichromophloia, E. papuana, E. leptophleba*) with eastern mid-height grass (*Themeda australis, Heteropogon contortus, Bothriochloa ewartiana, B. decipiens*)
3	Small	Very low rises	Lang: clay	Ironbark woodland (*E. crebra, E. dichromophloia, E. papuana*, high rainfall also *E. orgadophila, E. leptophleba*) with eastern mid-height grass (*Themeda australis, Heteropogon contortus, H. triticeus, Aristida* spp.)
4	Small		Skeletal: clay, and rock outcrop	
5	Small	Very shallow depressions	Spring and Tobermorey: calcareous clay loam	Couch grass short grass (*Cynodon dactylon*) and lagoon vegetation (*Imperata cylindrica, Cyperus* spp., *Leersia hexandra, Ophiuros exaltatus, Cynodon dactylon*)

(60) Boonderoo Land System (5000 sq miles)

Red basalt country in the east of the area.

Geomorphology.—Constructional land surface. Volcanic. Basalt plains and plateaux. Pliocene and Pleistocene surface.

Geology.—Basalt (Tertiary and Quaternary).

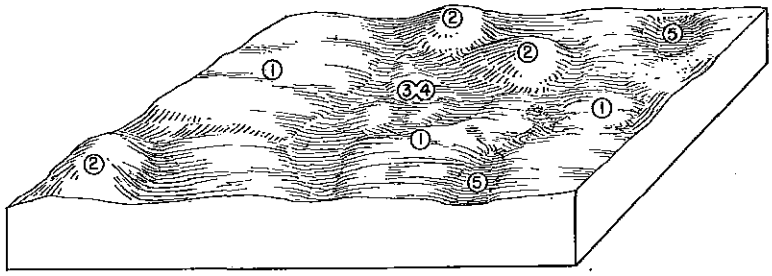
Drainage.—Sparse.

Elevation.—1400–3050 ft. Local amplitude < 200 ft.

Climate.—Wettest locality: mean annual rainfall 30 in.; mean agricultural growing season 25 wk; mean pastoral growing season 35 wk.

Driest locality: mean annual rainfall 20 in.; mean agricultural growing season 10 wk; mean pastoral growing season 15 wk.

Pasture Land.—Basalt country.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Plain	Lang: clay	Ironbark woodland (*E. crebra, E. dichromophloia, E. papuana*, high rainfall also *E. orgadophila, E. leptophleba*) with eastern mid-height grass (*Themeda australis, Heteropogon contortus, H. triticeus, Aristida* spp.)
2	Small	Very low rises	Skeletal: clay and rock outcrop	
3	Small	Lower areas in plain	Rosella: calcareous cracking clay commonly with boulder mantle	Downs woodland (low to moderate rainfall *E. terminalis, E. orgadophila, Atalaya hemiglauca*, high rainfall *E. orgadophila, E. leptophleba, E. crebra, E. howittiana*). Small areas trees absent. Both with blue grass–browntop downs (*Ophiuros exaltatus, Dichanthium fecundum, D. superciliatum, Bothriochloa decipiens, Astrebla squarrosa, Themeda australis, Heteropogon contortus*)
4	Small		Glendhu: clay	Ironbark woodland (*E. crebra, E. dichromophloia, E. papuana, E. leptophleba*) with eastern mid-height grass (*Themeda australis, Heteropogon contortus, Bothriochloa ewartiana, B. decipiens*)
5	Small	Very shallow depressions	Spring and Tobermorey: calcareous clay loam	Couch grass short grass (*Cynodon dactylon*) and lagoon vegetation (*Imperata cylindrica, Cyperus* spp., *Leersia hexandra, Ophiuros exaltatus, Cynodon dactylon*)

(61) Toomba Land System (300 sq miles)

Rough lava country in the east of the area.

Geomorphology.—Constructional land surface. Volcanic. Little-weathered lava flows. Early Recent surface.

Geology.—Basalt (Quaternary). Probably early Recent age.

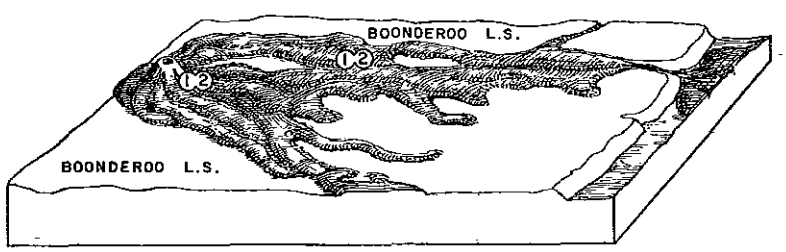
Drainage.—Nil. All subsurface.

Elevation.—1000–2500. Local amplitude < 100 ft.

Climate.—Wettest locality: mean annual rainfall 27 in.; mean agricultural growing season 22 wk; mean pastoral growing season 27 wk.

Driest locality: mean annual rainfall 23 in.; mean agricultural growing season 15 wk; mean pastoral growing season 20 wk.

Pasture Land.—Non-range country—rugged, stony, or barren.



Unit	Area	Land Forms	Soils	Vegetation
1	Large	Very rough, little-weathered basalt plateaux and plains	Rock	Microphyll vine woodland
2	Very small	Central-type vents		

PART IV. CLIMATE OF THE LEICHHARDT–GILBERT AREA

By R. O. SLATYER*

I. INTRODUCTION

The Leichhardt–Gilbert area has been classified climatically by Köppen (1936) as semi-arid steppe ranging in a generally south–north direction to tropical savannah. Thornthwaite's (1931) classification is generally similar, although slightly more specific. He considers the climate of the area changes from semi-arid tropical to humid tropical, in a south-west to north-east direction.

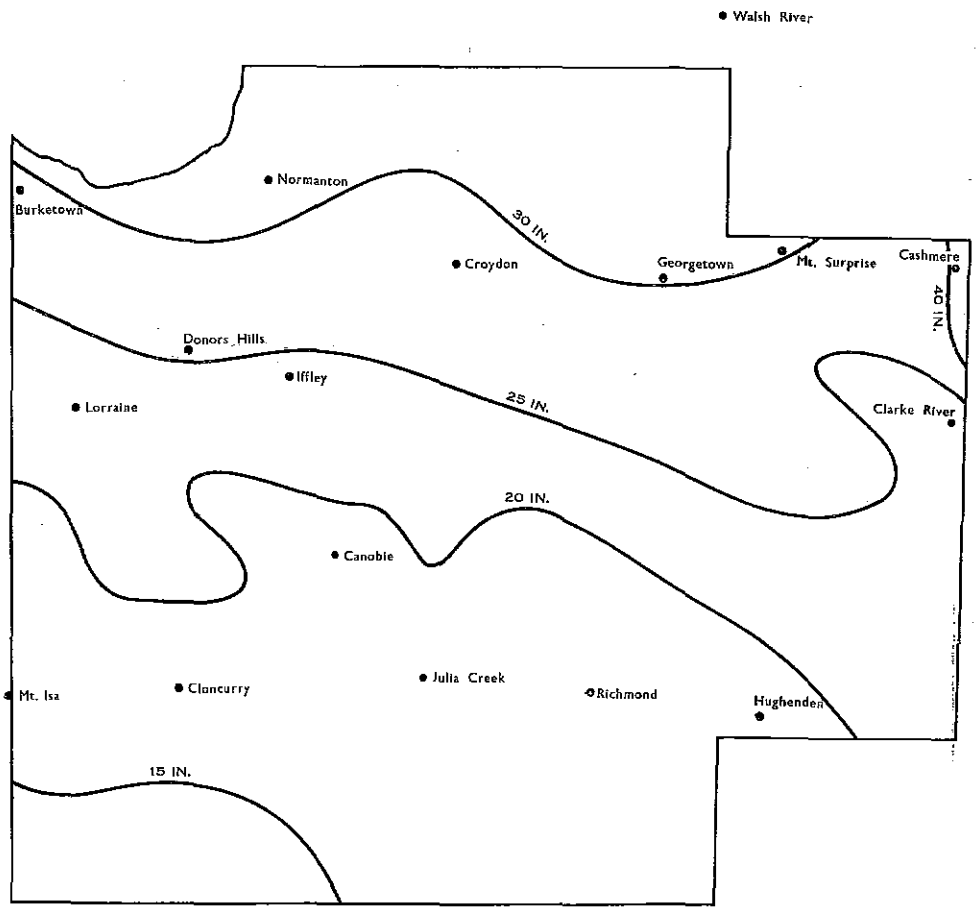


Fig. 3.—Isohyets of annual rainfall (after Bureau of Meteorology 1940).

Closer examination, however, indicates that no simple climatic trend is evident through the area, because two rainfall influences—one from the north-west and one from the east—are of importance in determining the major climatic characteristics.

* Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T.

The north-west influence is responsible for the bulk of the rainfall over the major part of the area, particularly that of the sections west of the main divide. Rain from this influence occurs mainly in the period December to April. It is associated with high temperatures and low humidities, even during the wettest months. The eastern influence is provided by the various rainfall sources which bring rain to the coast of north-eastern Queensland. Although it falls mainly in the January–April period, frequent light falls extend through the months of May and June. The part of the area receiving this influence is mainly the north-eastern corner, and because of its high altitude, proximity to the adjacent wet coastline, and better-distributed rainfall, it is appreciably cooler and more humid than the rest of the area.

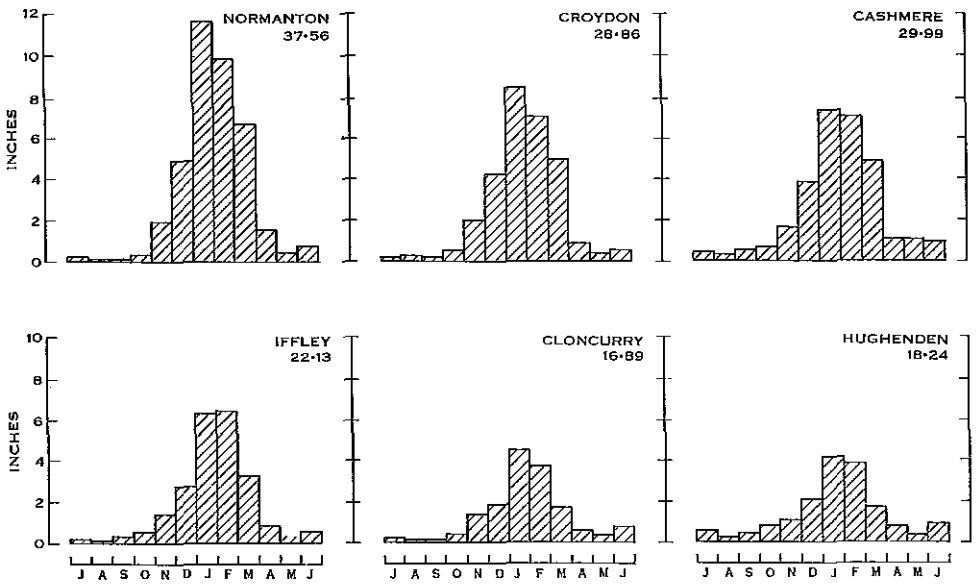


Fig. 4.—Histograms of monthly rainfall at six stations, expressed on a July to June basis.

II. General Climatic Characteristics

(*a*) *Rainfall*

Average annual rainfall ranges from approximately 15 in. in the south-west to more than 40 in. in the north. In Figure 3 the annual isohyets are shown and in Figure 4 histograms of monthly rainfall for representative stations are presented. It can be seen that only about half of the area receives more than 25 in. of rain per year and the semi-arid classification applied by Köppen and Thornthwaite to the southern part can be appreciated. Besides the information contained in the figures, additional rainfall data for 14 stations are given in Table 3.

Perhaps the most striking feature of the rainfall, evident from Table 3 and the histograms in Figure 4, is its marked seasonal distribution. In most of the area, more than 10 times as much rainfall is received between November and April as between May and September and more than 80% of the total rainfall usually falls in the four-month period December to March. This is most pronounced in the western

TABLE 3

GENERAL RAINFALL CHARACTERISTICS FOR 14 STATIONS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Burketown													
Rain (in.)	8·13	6·60	4·48	1·12	0·21	0·32	0·03	0·04	0·06	0·44	1·37	4·11	26·91
No. of wet days	10	10	7	2	1	1	0	0	0	1	3	6	41
Rain per wet day (in.)	0·81	0·66	0·64	0·56							0·46	0·69	
Cashmere													
Rain (in.)	7·33	6·91	4·87	1·10	1·14	1·04	0·59	0·40	0·46	0·69	1·61	3·85	29·99
No. of wet days	12	11	10	6	6	5	4	3	2	2	4	7	72
Rain per wet day (in.)	0·61	0·62	0·49	0·13	0·19	0·21	0·15	0·13	0·23	0·34	0·40	0·55	
Clarke River													
Rain (in.)	6·06	5·80	3·37	1·05	0·72	1·06	0·43	0·41	0·55	0·86	1·50	3·36	25·17
No. of wet days	9	8	5	2	2	2	1	1	1	2	3	5	41
Rain per wet day (in.)	0·67	0·72	0·67	0·53	0·36	0·53				0·43	0·50	0·67	
Cloncurry													
Rain (in.)	4·73	3·96	1·86	0·62	0·48	0·80	0·23	0·12	0·16	0·44	1·59	1·90	16·89
No. of wet days	7	7	4	2	1	2	1	0	1	2	3	5	35
Rain per wet day (in.)	0·68	0·57	0·47	0·31						0·22	0·53	0·38	
Croydon													
Rain (in.)	8·41	6·95	4·91	0·88	0·31	0·52	0·10	0·13	0·10	0·46	1·85	4·24	28·86
No. of wet days	12	12	8	2	1	2	0	0	0	2	5	9	53
Rain per wet day (in.)	0·70	0·58	0·61	0·44						0·23	0·37	0·47	
Donors Hills													
Rain (in.)	7·58	5·99	3·24	0·96	0·37	0·57	0·17	0·13	0·14	0·59	1·67	3·18	24·59
No. of wet days	11	9	6	2	1	1	0	0	0	2	4	7	43
Rain per wet day (in.)	0·69	0·67	0·54	0·48						0·29	0·42	0·45	
Hughenden													
Rain (in.)	4·39	3·99	1·80	0·88	0·57	0·98	0·47	0·27	0·36	0·89	1·29	2·35	18·24
No. of wet days	7	7	4	2	1	2	1	1	1	2	4	5	37
Rain per wet day (in.)	0·63	0·57	0·45	0·44						0·44	0·32	0·47	

Iffley													
Rain (in.)	6·25	6·28	3·28	0·78	0·15	0·54	0·09	0·04	0·11	0·53	1·45	2·63	22·13
No. of wet days	8	7	4	1	0	1	0	0	0	1	3	5	30
Rain per wet day (in.)	0·78	0·90	0·82								0·48	0·53	
Lorraine													
Rain (in.)	6·07	4·54	3·01	0·89	0·30	0·51	0·10	0·06	0·06	0·54	1·50	2·81	20·39
No. of wet days	10	8	6	1	1	1	1	0	0	2	4	6	40
Rain per wet day (in.)	0·61	0·57	0·50							0·27	0·37	0·47	
Lyndhurst													
Rain (in.)	6·64	6·22	3·39	1·06	0·59	0·93	0·52	0·37	0·29	0·82	1·91	3·93	26·67
No. of wet days	11	8	6	2	1	2	1	1	1	2	5	7	47
Rain per wet day (in.)	0·60	0·78	0·57	0·53						0·41	0·38	0·56	
Mt. Surprise													
Rain (in.)	7·57	7·56	3·65	0·92	0·66	0·81	0·30	0·16	0·14	0·79	1·63	3·99	28·18
No. of wet days	12	11	7	2	2	2	1	0	1	2	4	9	53
Rain per wet day (in.)	0·63	0·69	0·52	0·46	0·33	0·40					0·41	0·44	
Normanton													
Rain (in.)	11·63	9·83	6·70	1·38	0·26	0·63	0·10	0·05	0·08	0·25	1·81	4·84	37·56
No. of wet days	14	13	9	3	1	1	1	0	0	1	4	9	56
Rain per wet day (in.)	0·83	0·76	0·74	0·46							0·45	0.54	
Richmond													
Rain (in.)	4·20	4·66	1·91	0·85	0·62	0·72	0·40	0·10	0·15	0·64	1·47	2·59	18·31
No. of wet days	7	7	4	2	1	2	1	1	1	2	4	6	38
Rain per wet day (in.)	0·69	0·67	0·48	0·43						0·32	0·37	0·43	
Walsh River													
Rain (in.)	8·39	8·15	6·42	1·24	0·40	0·41	0·25	0·05	0·06	0·47	2·03	5·22	33·09
No. of wet days	13	12	9	2	1	1	1	0	0	1	4	9	53
Rain per wet day (in.)	0·65	0·68	0·71	0·62							0·51	0·58	

* Sources of data: Bureau of Meteorology (1950); daily rainfall data.

and northern portions. In a west-to-east direction, there is a slight tendency for the seasonal rainfall to commence later, probably owing to the fact that rains from the north-west commence earlier than those from the east.

As almost all winter rainfall is associated with eastern Australian rainfall systems, it is not surprising to find that what rain is received during the winter months is heaviest in the east. The wettest winter month is June, but at those stations receiving most winter rain, useful falls may be recorded in almost any month.

Variability in annual rainfall is fairly high, even in the wetter areas of most reliable rainfall. Expressed as a mean deviation from the mean, variability ranges from less than 25% to more than 35%. Variability increases both with decreasing rainfall and as the proportion of rainfall from the more erratic eastern sources increases. Therefore, a general increase in variability occurs geographically in a south-easterly direction.

Rainfall intensity, on a rain-per-wet-day basis, is high throughout the area. The average fall per wet day increases from about 0·50 in. in the areas of lightest rainfall to almost 0·70 in. in the wettest parts. Through the year, the intensity pattern is related in general to monthly rainfall, the light winter rains being of lower intensity than the heavier summer falls. Rainfall per wet day at several of the wetter localities exceeds 0·80 in. A closer examination of the rainfall at Normanton shows that although average levels are high, very heavy daily falls are most uncommon, and registrations in excess of 2·00 in. seldom occur more than once per season. Falls of more than 3·00 in. occur with a frequency of slightly less than once each two years.

(*b*) *Temperature*

The annual temperature regime in the western part of the area is illustrated in Figure 5. Unfortunately, the absence of temperature recording stations in the north-east precludes a comparison with this portion of the area. The data for Normanton are typical of stations in the wetter coastal areas surrounding the Gulf of Carpentaria. The temperature extremes of the more inland stations are not experienced there, maxima being lower in the summer and higher in the winter and minima being higher throughout the year. Diurnal variation is also much smaller. A further feature is that the wet-season rains are of sufficient intensity at Normanton to cause a depression of maxima during the summer. This is slightly evident at Donors Hills, but it is not apparent at Cloncurry. The data for these latter two stations provide a typical illustration of more extreme temperatures as distance from the coast increases. Thus, at Cloncurry both maxima and minima are higher in the summer and lower in the winter than at Donors Hills.

General temperature levels in the area are very high and even in the coolest winter months, monthly minima at Cloncurry remain at about 50°F. However, Foley (1945) reports that although frosts have not been recorded in the northern parts of the area and in the western areas of low relief, they occur in winter in the higher country to the south and east. At the temperature stations existing in the area, infrequent frosts are recorded from mid May to mid August but are normally confined to the period from mid June to the end of July. During the winter dews are of common occurrence, particularly in the cooler and more humid areas to the north-east.

Daily temperature data have not been examined in detail for this study, but information on temperature extremes is available for some stations (Bureau of Meteorology 1940). These data indicate that the occurrence of periods of several consecutive days with maxima in excess of 100 °F is highly probable in the months of November and December in most parts of the area, but that their incidence decreases sharply in the areas of higher rainfall once the wet season commences. In the drier parts of the area, daily maxima in excess of 100 °F are of frequent occurrence throughout the summer months.

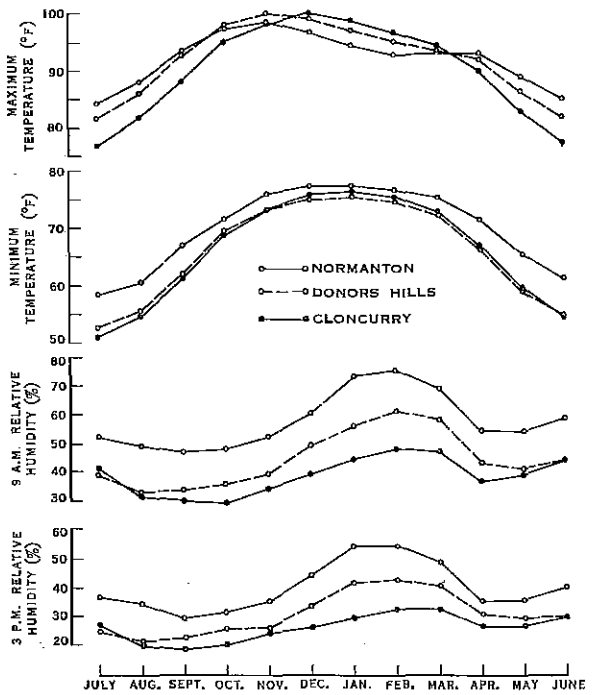


Fig. 5.—Annual curves of mean monthly maximum and minimum temperatures and 9 a.m. and 3 p.m. relative humidity at three stations.

In Table 4, temperature and relative humidity information additional to that contained in Figure 5 is given for six stations.

(*c*) *Humidity*

Relative humidity data are available for several stations in the area. These are tabulated in Table 4 and figures for representative stations, Normanton, Donors Hills, and Cloncurry, are presented diagrammatically in Figure 5.

There is a close relationship between annual rainfall distribution and relative humidity, the levels at Normanton being appreciably higher than at either of the other stations. Even at Normanton, however, the relative humidity is low for most of the year, rising only during the wet season.

TABLE 4

GENERAL TEMPERATURE AND RELATIVE HUMIDITY CHARACTERISTICS FOR SIX STATIONS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Cloncurry													
Maximum temperature (°F)	98·8	96·8	94·6	90·3	83·1	77·4	76·7	81·7	88·3	95·1	98·3	99·7	90·1
Minimum temperature (°F)	76·3	75·4	72·8	67·0	59·7	54·1	51·5	54·8	61·2	68·6	73·4	75·9	65·9
9 a.m. relative humidity (%)	44	48	47	37	39	44	41	32	30	29	34	39	39
3 p.m. relative humidity (%)	29	32	32	26	27	30	27	20	19	20	24	26	26
Croydon													
Maximum temperature (°F)	96·2	95·2	94·2	94·0	89·0	84·8	84·8	88·5	93·7	98·7	100·9	99·3	93·3
Minimum temperature (°F)	75·0	75·0	73·8	70·1	63·8	58·8	57·2	60·6	66·8	72·2	76·0	76·1	68·8
9 a.m. relative humidity (%)	66	67	62	49	49	50	46	41	40	40	45	54	51
3 p.m. relative humidity (%)	45	45	44	31	32	34	29	25	23	23	27	33	33
Donors Hills													
Maximum temperature (°F)	97·2	95·3	93·7	92·3	86·6	81·9	81·8	86·0	92·3	97·5	100·1	99·3	92·0
Minimum temperature (°F)	75·6	75·2	72·4	66·3	59·4	54·8	52·7	55·4	62·2	69·1	73·4	75·3	66·0
9 a.m. relative humidity (%)	56	61	58	43	41	44	39	33	34	36	39	49	44
3 p.m. relative humidity (%)	41	42	40	30	29	30	25	21	22	25	26	33	30
Georgetown													
Maximum temperature (°F)	93·2	92·4	91·1	90·1	85·8	82·3	82·1	85·3	90·7	95·9	97·4	95·7	90·2
Minimum temperature (°F)	73·4	72·8	70·4	65·8	59·7	55·6	53·1	55·5	61·5	57·8	71·5	72·9	65·0
9 a.m. relative humidity (%)	63	65	61	52	50	52	50	45	42	41	45	54	52
3 p.m. relative humidity (%)	45	47	45	36	34	35	31	26	22	21	25	35	33
Normanton													
Maximum temperature (°F)	94·6	93·1	93·5	92·9	88·9	84·8	84·3	87·8	93·2	97·0	98·5	96·8	92·1
Minimum temperature (°F)	77·0	76·6	75·3	71·4	65·5	60·9	58·6	60·6	67·1	71·7	75·9	77·0	69·8
9 a.m. relative humidity (%)	73	75	69	54	54	59	52	49	47	48	52	60	58
3 p.m. relative humidity (%)	54	54	48	35	35	40	37	34	29	31	35	44	40
Richmond													
Maximum temperature (°F)	98·8	96·5	95·1	91·4	84·3	79·1	78·5	83·6	90·3	96·6	99·3	100·4	91·2
Minimum temperature (°F)	73·3	71·9	69·2	62·2	54·9	50·0	47·3	50·2	57·1	64·4	69·5	72·2	61·8
9 a.m. relative humidity (%)	51	55	52	45	48	53	47	39	34	32	36	42	44
3 p.m. relative humidity (%)	31	36	33	27	30	33	27	22	20	18	21	26	27

* Data from Commonwealth Meteorological Bureau (1940).

Because they occur at about the hottest time of each day, the 3 p.m. figures are the most significant in relation to plant growth. These figures are much lower than those for 9 a.m. and at times may be low enough in some areas to interfere with the growth of exotic plants. This will be discussed in a later section of this Part, but it is appropriate to mention here that the figures in the diagram are expressed on a mean monthly basis, and both in individual years and during periods of dry weather much lower daily levels are recorded. Thus, at Cloncurry (Bureau of Meteorology 1940) monthly 3 p.m. relative humidity figures of 14% have been recorded in individual years. Moreover, 3 p.m. figures are frequently 10% higher than the minimum figures recorded on any one day. At Katherine, N.T., with similar rainfall characteristics to Normanton, the author (unpublished data) has observed that even in the middle of the wet season, minimum humidity levels will drop to 54% after 3 days of rainless weather, to 30% after 10 days, and to 15% after 14 days.

(*d*) *Evaporation*

No evaporation data are available from within the area, but mean monthly and annual estimates of evaporation from the standard Australian tank have been made for a number of stations from mean maximum temperatures and vapour pressure data (Fitzpatrick 1963). These estimates show that both monthly and annual levels differ markedly over the area, being highest in the south-west and decreasing generally toward the north and east.

At Cloncurry the estimated annual tank evaporation is 112 in. and the monthly rates range from about 13 in. in December to about 5 in. in June. At Normanton annual tank evaporation is estimated to be 93 in. Here a period with very high evaporation—approximately 9 to 10 in. per month—occurs from September to December inclusive. Between January and March, the estimated rate falls to about 6 in. per month. This is followed by a brief increase to approximately 8 in. per month during April and May before the comparatively low rates of from 6 to 7 in. between June and August. No data are available from which direct estimates can be made for Cashmere in the extreme north-east; however, from tank observation at Mareeba and observed regional trends, it is apparent that evaporation is considerably lower in this area. Annual evaporation here is estimated to be approximately 53 in., and the estimated monthly rates range from about 6·5 in. during the November–December period to about 3 in. during the period April to August.

III. Climate in Relation to Plant Growth

It is evident from the histograms of Figure 4 that the distribution of rainfall places a severe limitation on the period during which sufficient soil moisture is available for plant growth in most of this area. Moreover, even during the wet season the intermittent nature of the rainfall means that moisture is the most important factor limiting growth and in many of the drier localities the rainfall is too light and sporadic to support any form of agriculture.

(a) *Growing Period for Agricultural Plants*

In early publications in this series the "adequate rainfall" method of assessing length of growing season (Christian and Stewart 1953; Slatyer and Christian 1954) was utilized primarily because it enabled rainfall data alone to be utilized, an important factor in areas with few climatic records other than rainfall. It also provided greater sensitivity than methods using monthly data and in most respects provided a valid, if somewhat empirical analysis of growing season attributes. More recently the accumulation of experimental agro-climatic data has enabled models of water

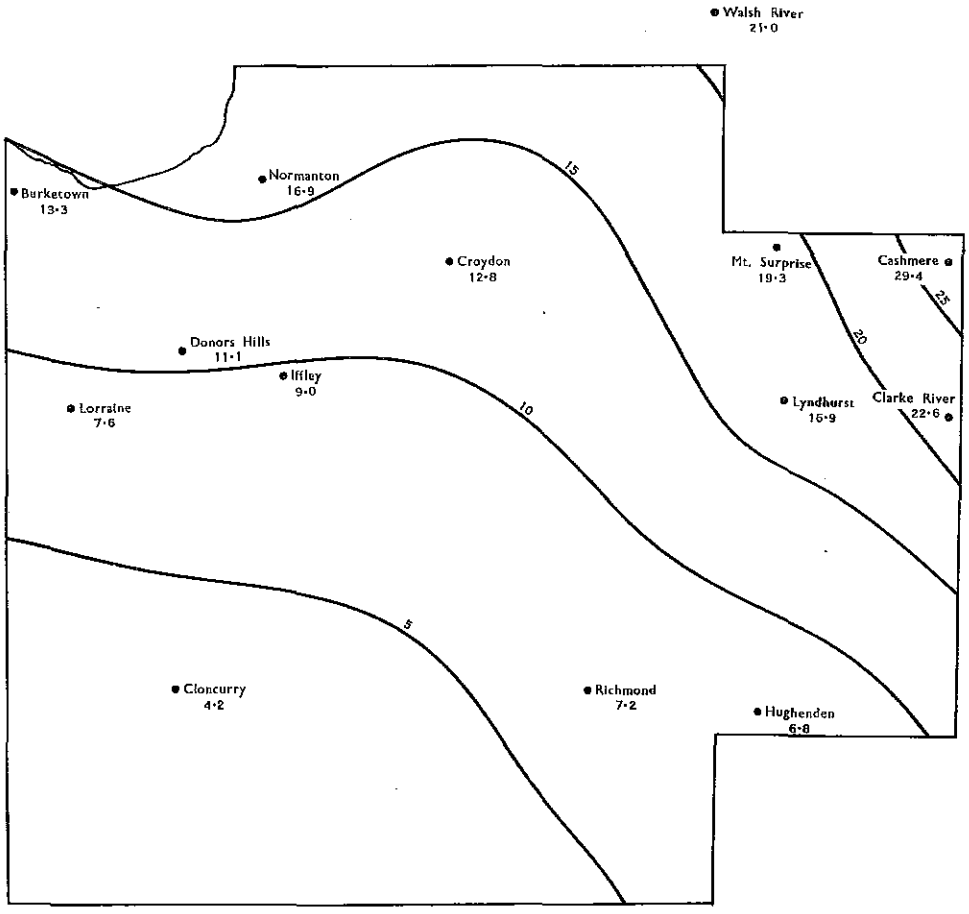


Fig. 6.—Estimated length (wk) of the agricultural growing period.

use to be developed (Slatyer 1960) which, with improved methods of evaporation estimation from crude climatic data (Fitzpatrick 1963), can provide more sensitive growing season estimates. With the incorporation of these procedures into digital computer programmes it is now possible to carry out the lengthy calculations involved for a larger number of stations in a short period.

For the present study separate models have been developed for assessing the pastoral and agricultural growing periods and related characteristics (Slatyer 1960;

TABLE 5

PRIMARY CHARACTERISTICS OF THE AGRICULTURAL GROWING PERIOD AT 14 STATIONS

	Cashmere	Clarke River	Walsh River	Mt. Surprise	Lyndhurst	Croydon	Normanton	Burketown	Donors Hills	Iffley	Lorraine	Hughenden	Richmond	Cloncurry
Date of pre-sowing rains														
Mean	Nov. 30	Dec. 7	Nov. 30	Nov. 23	Nov. 30	Dec. 14	Dec. 7	Dec. 21	Dec. 21	Dec. 28	Dec. 21	Dec. 14	Dec. 14	Dec 21
Standard deviation	5·2	5·8	5·1	5·3	5·3	3·9	3·9	3·7	3·3	4·4	4·3	6·4	6·9	5·1
No. of yr without pre-sowing rains	0	0	0	0	1	0	0	0	0	0	0	1	2	4
Date of sowing rains														
Mean	Jan. 4	Jan. 4	Dec. 28	Dec. 28	Jan. 4	Jan. 4	Dec. 28	Jan. 11	Jan. 18	Jan. 25	Jan. 18	Jan. 25	Jan. 18	Jan. 31
Standard deviation	4·0	5·0	3·0	5·1	3·4	2·9	2·8	3·5	2·9	4·2	3·1	5·3	4·6	4·2
No. of yr without sowing rains	0	2	0	0	1	0	0	0	0	0	1	4	5	5
Length of agricultural growing season (wk)														
Mean	29·4	22·6	21·0	19·3	16·9	12·8	16·9	13·3	11·1	9·0	7·6	6·8	7·2	4·2
Standard deviation	—	—	5·5	7·3	8·9	5·9	5·4	5·9	6·4	5·2	4·6	3·2	6·0	4·6
Mean no. of wk within 12 wk following sowing date with accumulated deficit > 1·00 in.	2·88	3·33	2·86	3·53	4·41	4·64	2·83	5·77	5·55	6·34	5·66	5·00	4·94	5·37
% of yr with agricultural growing period > 8 wk	100	87	97	93	78	77	93	83	64	44	31	33	28	13
> 12 wk	100	80	97	90	71	61	86	50	38	34	17	20	15	3
> 16 wk	96	73	83	57	49	29	55	23	22	10	7	3	9	3
> 20 wk	96	66	52	47	45	6	14	13	6	0	0	0	3	3
> 24 wk	96	63	28	27	30	0	7	3	3	0	0	0	0	0

Fitzpatrick and Arnold 1963). Briefly, the agricultural water-use model represents the water-use pattern during land preparation, establishment, growth, and maturation of the crop, with special emphasis on periods of water stress which interfere with normal crop water use. The pastoral water-use model is based on less detailed information but similarly represents the growth pattern of perennial pastures from the critical stage of regrowth commencement through periods of active growth and induced dormancy to maturation. Full details are given in the papers cited.

Using these techniques, the time of commencement of the agricultural growing period is estimated to range from late December in the northern areas of highest rainfall to late January in the extreme south. The length of the growing season is likewise greatest in the wettest areas and decreases progressively as annual rainfall decreases. These trends are illustrated in Figure 6, where the data for all stations have been mapped, and in Table 5, where detailed information for representative stations is given.

If a growing period of 16 weeks or more in at least 4 years out of 5 is required for a safe agricultural area it would appear that only a small portion of the area can be regarded as being in this category. On the other hand, that part of the area in which a growing period of 12 weeks can be expected in 4 years out of 5 is larger, corresponding approximately to the 25-in. isohyet to the east of about Einasleigh and to the 30-in. isohyet to the west. This part of the area should be suitable, from the climatic point of view at least, for the cultivation of short-season fodder crops.

Also included in Table 5 is an estimate of the number of weeks with deficits exceeding 1 in. which occurred in the 12-week period following sowing. As mentioned previously, weekly deficits greater than 1 in. are considered to cause some decrease in plant growth, so that the total period involved can be expected to provide some indication of the degree to which growth and yield are reduced below those potential levels. The figures demonstrate that although the most favourable conditions occur in the north-east of the area, the rainfall at Normanton during the peak of the growing period appears to be reliable from this point of view.

(*b*) *Growing Period of Natural Pastures*

Using the technique already described, the time of commencement of the period of initial pasture growth is found to range from early December in the wettest areas to late January in the driest. These dates are earlier than those for the agricultural growing period, and the range between dates for the wettest and driest localities is wider. This is because light falls of rain at the beginning of the season which are not adequate for crop establishment may be sufficient to initiate pasture growth. There is usually a wider variation from year to year in both the time of such falls and their distribution throughout the area than there is in the occurrence of falls heavy enough to permit the sowing of crops.

The length of the useful growing period for natural pastures is likewise appreciably longer than the agricultural growing period, the driest localities having an average period of about nine weeks and the wettest of over eight months. These general trends are illustrated in Figure 7 and additional data for representative stations are given in Table 6.

TABLE 6

CHARACTERISTICS OF THE PERIOD OF USEFUL PASTURE GROWTH AT 14 STATIONS

	Cashmere	Clarke River	Walsh River	Mt. Surprise	Lyndhurst	Croydon	Normanton	Burketown	Donors Hills	Iffley	Lorraine	Hughenden	Richmond	Cloncurry
Years of record	24	30	29	30	27	31	29	30	30	29	29	30	31	30
Commencement of pasture growth period														
Mean date	Dec. 7	Dec. 28	Dec. 21	Dec. 28	Dec. 28	Jan. 4	Dec. 14	Dec. 28	Jan. 18	Jan. 25	Jan. 18	Dec. 14	Jan. 25	Jan. 11
Standard deviation	3·4	4·1	2·5	2·9	4·8	2·2	2·7	3·7	3·2	2·8	3·9	6·7	6·1	6·6
Total duration of useful pasture growth (wk)														
Mean	36·5	28·1	22·7	22·5	21·2	17·3	20·2	17·4	14.6	12·9	11·8	14·5	12·7	9·0
Standard deviation	6·5	10·0	3·8	5·7	6·9	3·8	3·1	4·4	4·3	3·8	4·4	6·4	6·1	4·6
Duration of pasture growth with available water exceeding 2·5 in. (wk)														
Mean	14·4	10·0	13·3	11·1	8·1	8·8	12·8	8·8	6·6	6·2	4·7	4·1	4·5	3·9
Standard deviation	5·7	6·6	3·4	4·4	4·5	3·2	3·6	3·7	3·0	3·7	2·5	3·1	3·5	2·8
% of yr with total duration of pasture growth > 8 wk	100	100	100	100	89	100	100	97	90	86	72	80	74	47
> 12 wk	100	93	100	97	89	87	97	90	67	55	48	70	52	17
> 16 wk	100	87	93	83	82	68	86	60	40	28	17	40	29	7
> 20 wk	100	73	72	60	70	19	48	27	10	0	3	17	13	3
> 24 wk	96	67	31	43	0	0	0	0	0	0	0	0	0	0

The period of useful pasture growth may be made up not only of one main period, but of several short periods. In general, there is only one period of growth, although the tendency for more than one period to occur increases with decreasing rainfall. In the years of record which were examined there were seldom more than two growth periods in any one season, and when a "break" in the season occurred between periods it only rarely exceeded four weeks.

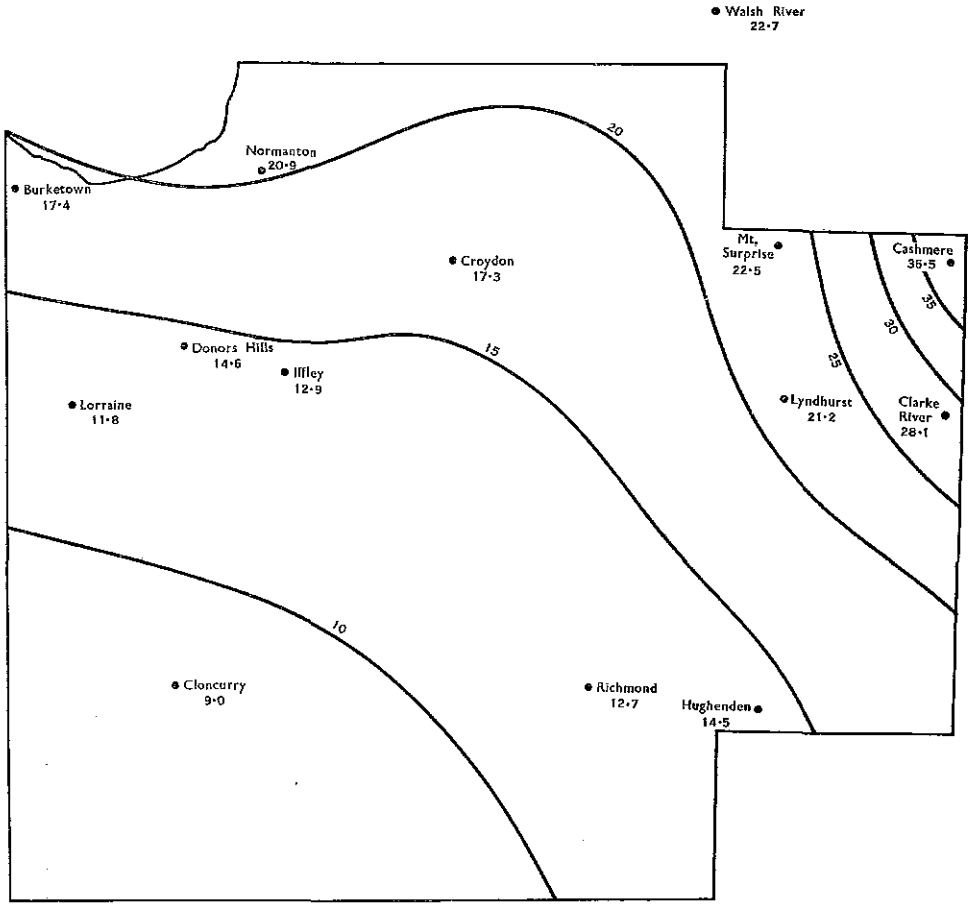


Fig. 7.—Estimated length (wk) of the period of useful pasture growth.

The period of useful pasture growth, as shown in Figure 7, not only represents the summation of several periods of growth but also includes periods of varying pasture activity. It is therefore essentially a total period during which a "green pick" is available for stock rather than one in which a uniformly high rate of growth can be expected. For this reason additional data are included in Table 6 to give a more realistic estimate of the period during which a high rate of pasture production occurred.

These data represent the period during which soil water storage exceeded 2·5 in. The assumed maximum storage capacity is equivalent to a 4-in. depth of surface water stored in the soil and experimental evidence (Slatyer 1956, 1960) suggests that

only slight reductions in growth rate can be expected until storage falls below 2·5 in. The values calculated in this way suggest that on the average only 4 weeks of rapid pasture growth can be expected in the driest areas, even though a "green pick" may be available for 2–3 months. Likewise, in the wetter areas the rapid growth phase seldom appears to last longer than 3 months even though some activity may continue for up to 8 months.

(c) *Water Requirements for Irrigation*

Generalized irrigation requirements for representative stations are presented in Figure 8. This shows generalized water needs in terms of mean values, assuming a continually and actively transpiring plant surface over the whole year transpiring at

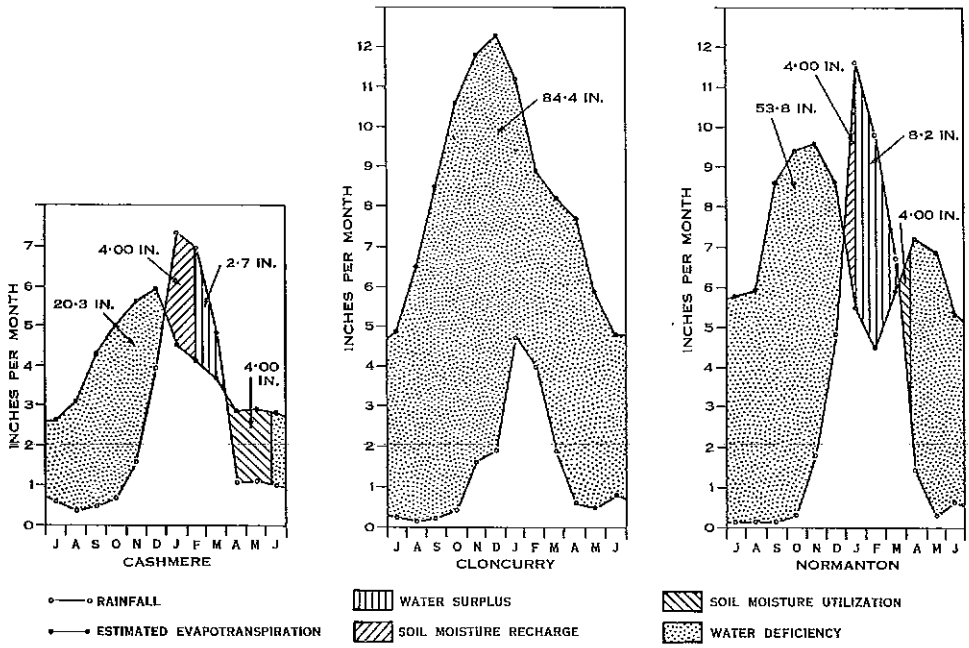


Fig. 8.—Water balance diagrams for three stations (after Thornthwaite 1948).

a rate of 0·9 times the estimated mean tank evaporation, for Cashmere, Normanton, and Cloncurry. These data represent only the requirement for evapotranspiration rather than the total water need for an irrigation area as a whole. Delivery losses must be added to obtain these figures. Even so, the net annual requirements at Cloncurry are very high, of the order of 84 in. By comparison the requirements for the whole year at Cashmere are only about 20 in.

More sensitive estimates of supplementary wet-season irrigation (Table 7) are given using the method of Fitzpatrick and Arnold (1963) and assuming the irrigation period extends from the last week in November to the third week in March. Not including possible pre-irrigation requirements the average additional irrigation needed to meet the total water demand was only 4·21 in. at Cashmere, in no year did it exceed 9·52 in., and it was as low as 1·16 in. on one occasion. On one occasion during the years of record available it is estimated that irrigation would have been

required for only 2 weeks and only in the driest year would an irrigation period of 12 weeks have been required. By contrast, the average irrigation need at Cloncurry was 25·15 in. and the extreme high and low requirements were 32·23 and 14·47 in. Moreover, in only 1 year was the estimated irrigation period as short as 10 weeks and on 5 occasions it was as long as 16 weeks.

TABLE 7
WET SEASON IRRIGATION CHARACTERISTICS FOR THREE STATIONS

	Cashmere	Normanton	Cloncurry
Seasonal irrigation need			
Mean seasonal need (in.)	4·21	6·72	25·15
Standard deviation	2·35	3·84	4·25
Highest in one season (in.)	9·52	15·11	32·23
Lowest in one season (in.)	1·16	1·80	14·47
Mean no. of weeks having additional water need	6·6	7·3	13·7
Smallest no. of weeks in one season having irrigation need	2 (in 1 case)	3 (in 1 case)	10 (in 1 case)
Largest no. of weeks in one season having irrigation need	12 (in 1 case)	15 (in 1 case)	16 (in 5 cases)

IV. ACKNOWLEDGMENTS

It is desired to acknowledge the valuable help of officers of the Commonwealth Meteorological Branch, in particular Mr. R. C. L. White, who prepared many of the rainfall data for use in this paper. Mr. E. A. Fitzpatrick, CSIRO, developed the computer programme used in data processing as well as contributing data interpretation and discussion. The assistance of Mrs. A. Komarowski in data tabulation is also gratefully acknowledged.

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PART V. OUTLINE OF THE GEOLOGY OF THE LEICHHARDT–GILBERT AREA

By C. E. PRICHARD*

I. INTRODUCTION

(*a*) *General*

A general picture of the geology of the area is given in Figure 9. The western margin adjoins the Barkly region, the geology of which has been outlined by Noakes and Traves (1954). The Proterozoic rocks extending across the junction of the two areas are overlain on the east by the Cretaceous sediments of the Great Artesian Basin; from the southern boundary of the area an embayment of Cambrian beds extends north about 60 miles into the Pre-Cambrian rocks. The Great Artesian Basin consists of Cretaceous marine sediments with younger terrestrial deposits overlying them. East of the Great Artesian Basin a second large area of Proterozoic rocks occurs, and along the eastern margin of the area Palaeozoic beds of the Tasman Geosyncline crop out. Extensive sheets of Tertiary basalt overlie the Proterozoic rocks in the eastern part of the area.† Quaternary alluvia cover much of the lower parts of the Carpentaria plains.

(*b*) *Geological History*

The geological history of the Leichhardt–Gilbert area is characterized by a number of periods of rock formation separated by long periods of erosion. During the Proterozoic the two areas of Pre-Cambrian rocks were deposited, folded, and metamorphosed. Within an arm of the Cambrian transgressive sea fossiliferous sediments were deposited on the southern part of the western area of Proterozoic rocks, and Palaeozoic beds were deposited in the Tasman Geosyncline, near the eastern boundary of the area. The beds of the Great Artesian Basin were laid down beneath a Mesozoic transgressive sea, in a gentle downwarp between the two areas of outcropping Pre-Cambrian. Finally, in the Tertiary great outpourings of basalt occurred approximately along the Great Divide, and extensive thin terrestrial deposits were formed chiefly on the surface of the Great Artesian Basin.

(*c*) *Resources*

The resources of the area are broadly governed by these events in its history. Though several deposits of metallic ores have been located in the Palaeozoic rocks near the eastern boundary, the mineral wealth is chiefly in the Proterozoic rocks, where uranium, copper, lead, and gold are the main metals of interest. Coal has been found in Permian and Cretaceous beds but has not proved economic.

* Bureau of Mineral Resources, Geology and Geophysics, Canberra, A.C.T.

† Further mapping done after the field work on which this report is based has greatly increased knowledge of the geology of much of the area. Most of the units described herein have been subdivided and the age assigned some of them corrected (Hill and Denmead 1960).

The unmineralized Cambrian and Cretaceous sediments and the Tertiary basalt provide good soils, and the Great Artesian Basin stores great supplies of water. These factors have been most important in the development of the pastoral industry.

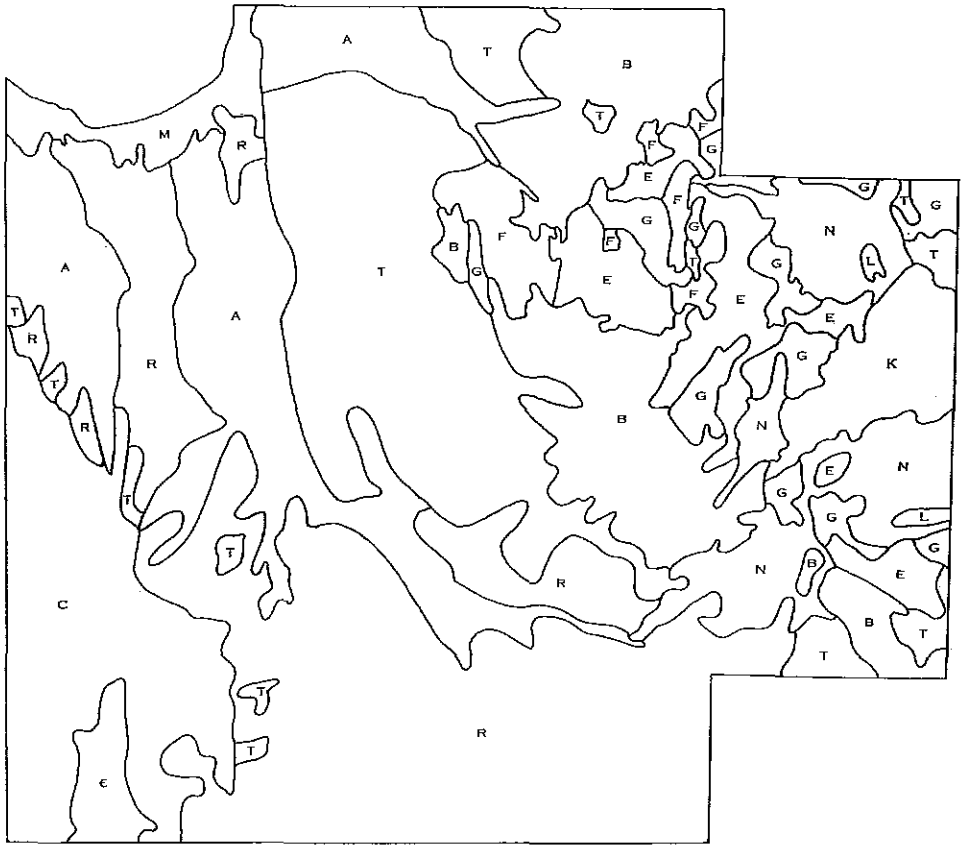

Fig. 9.—Geology map.

(*d*) *Geology and Land Systems*

Geology, particularly lithology, is an important factor in landscape and soil formation and in the distribution of vegetation. It is thus an important determinative factor for land systems. The relation between geology and the land systems is shown in Table 8.

II. Pre-Cambrian

All Pre-Cambrian rocks in the Leichhardt–Gilbert area are referred to the Proterozoic.

TABLE 8

GEOLOGICAL UNITS AND LAND SYSTEMS

Geological Unit	Land Systems Confined to the Unit	Land Systems in which the Unit forms a Major Part	Land Systems in which the Unit forms a Medium Part
Cainozoic			
Quaternary			
Alluvium	Armraynald, Balbirini, Cloncurry, Georgina, Gilbert, Glenore, Gregory, Miranda, Prospect	Monstraven	
Littoral deposits	Carpentaria		
Basalt	Toomba		
Tertiary			
Terrestrial deposits	Abingdon, Bylong, Claraville, Eurunga, Korong, Mayvale, Percol, Warrigal	Karoon, Murgulla	Boorooman
Basalt	Boonderoo, Rosella		
Mesozoic			
Rolling Downs group	Cowan, Donaldson, Donors, Julia, Manrika, Normanton, Punchbowl		Monstraven Murgulla Torwood
Blythesdale group	Dandry, Esmeralda, Hampstead, Strathmore, Strathpark	Boorooman, Ortona, Torwood	Karoon
Palaeozoic			
Permian			
Permian sediments			
Croydon felsite			Belmore Leichhardt Georgetown
Silurian–Devonian			
Broken River group	Lyall, Niall, Wairuna		Leichhardt
Gilberton beds			
Cambrian	Collis, Merlin, Wonardo, Wonomo		
Pre-Cambrian and Palaeozoic			
Plutonic rocks	Glenharding, Heidelberg, Reedy Springs, Stanhill	Georgetown	Leichhardt Yanman
Pre-Cambrian			
Cloncurry complex	Argylla, Kuridala, Mt. Elliott, Quamby		
Etheridge complex	Kilbogie, McKinnon, Townley	Belmore, Leichhardt, Yanman	Ortona

(*a*) *Cloncurry Complex*

The folded and metamorphosed rocks cropping out along the western margin of the area are called the Cloncurry complex on the Geological Map of Queensland (Anon. 1953). This is the same unit as the Carpentaria complex of Noakes and Traves (1954).

The Cloncurry complex consists of folded and metamorphosed sediments, basic and acidic lavas, basic dykes and sills, and granite. The original sediments included shale, limestone, sandstone, and greywacke, now generally metamorphosed to quartzite, slate, phyllite, schist, calc-silicate rocks, and locally to gneiss. Basic dykes are commonly now amphibolite. Granite intimately intrudes the rocks. The complex is steeply folded, with the trend of both bedding and fold axes approximately meridional. The most conspicuous faults strike about north-north-east.

(*b*) *Etheridge Complex*

The closely folded, metamorphosed, unfossiliferous rocks east of the Great Artesian Basin are called the Etheridge complex on the Geological Map of Queensland (Anon. 1953). Metamorphosed shale and greywacke are the most common lithogical types; quartz sandstone is rare and no limestone was seen. Metamorphism varies but mica schist and quartz mica schist are common; gneiss, generally fine, is less frequently seen. Basic dykes and interbedded flows have been converted to amphibolite; granite intrudes the complex.

The sediments have been steeply, in places isoclinally, folded. The trend is generally between north and north-west, but there are many small areas with an easterly strike, and along the Cape River the strike is west-north-west.

(*c*) *Plutonic Rocks*

All plutonic rocks not included in the Cloncurry complex or the Etheridge complex have been mapped as plutonic rocks. The granite which intrudes the Cloncurry complex does not affect the overlying Cambrian beds; it is regarded as Proterozoic. East of the Great Artesian Basin granite intrudes rocks of the Etheridge complex and a granite-granodiorite-diorite complex intrudes both the Proterozoic rocks and the Palaeozoic rocks. Insufficient is known to give the age of every granite mass but in general most of those west of Hann Highway (Hughenden-Mt. Garnet road) are probably Proterozoic and those east of that road include Proterozoic and Palaeozoic intrusions.

III. Palaeozoic

At no time during the Palaeozoic was sedimentation extensive over the area. Cambrian sediments occur in the south-west corner, Silurian–Devonian in the east, and Permian sediments and volcanics in the east and north-east.

(*a*) *Cambrian*

Fossiliferous rocks of Middle and Upper Cambrian age extend in a belt about 30 miles wide from the southern boundary of the area near Chatsworth north along the Burke River to Malbon. Blue and grey thin-bedded limestone, argillaceous and

quartz siltstone, and some arenaceous beds are present. They are gently folded with dips generally not exceeding 5° and form a shallow syncline pitching gently to the south. They are unconformable on the near-vertical rocks of the Cloncurry complex. East of the Mort River near Chatsworth homestead Cretaceous beds overlie Cambrian limestone with very slight angular unconformity.

(*b*) *Silurian–Devonian*

Rocks containing Devonian fossils occur in two separate localities. The Broken River group of marine rocks crops out in the valleys of the Clarke and Broken Rivers, and the Gilberton beds occur near Gilberton, on the upper Gilbert River. Little is known about the age limits of either unit, but the Broken River group ranges at least from Silurian to Devonian and the Gilberton beds possibly extend into the Lower Carboniferous.

(i) *Gilberton Beds.*—These beds were not visited in the field nor could they be recognized on aerial photographs. The Geological Map of Queensland (Anon. 1953) shows the approximate extent of the beds, names them the Gilberton beds, and refers them to the Carboniferous–Devonian. Hill (1951) writes: "A small freshwater basin developed on the Pre-Cambrian of the northern region around Gilberton in the Middle Devonian from which an antiarchan fish is known. Plants from the Gilberton district suggest that this basin continued at least into the Upper Devonian".

(ii) *Broken River Group.*—The Geological Map of Queensland names those rocks which crop out in the Clarke River valley the Broken River group. The group consists of over 25,000 ft of marine sediments which have been steeply folded and slightly metamorphosed. Along the Broken River greywacke, siltstone, shale, limestone, and conglomerate are present but east of the Burdekin River conglomerate and limestone do not seem to be present and slate and phyllite have formed from shale and siltstone. The trend of both bedding and structure is north-north-east to north-east. Granite intrudes the sediments in the headwaters of the Broken River and diorite intrudes them near Gray Creek.

(*c*) *Permian*

Sediments containing Permian fossils have been found only in the south-eastern part of the area. A sequence of acid volcanics and pyroclastics forms the Gregory and Newcastle Ranges but their age is not established by fossil content. They crop out near Croydon and Einasleigh.

(i) *Croydon Felsite.*—The rocks called Croydon felsite on the Geological Map of Queensland had not previously been formally named. The name is here extended to include the porphyries at Einasleigh and other lithologically similar outcrops.

The Croydon felsite is predominantly pinkish grey, massive rhyolite, porphyritic in quartz and pink orthoclase; flow-banded rhyolite, and sediments, have also been recognized. It forms the major part of the Gregory Range near Croydon and the Newcastle Range near Einasleigh. Structure is not clear but in each case the range appears to be synclinal. The marginal dip reaches 20° along the east side of the Newcastle Range but the main body of felsite is almost horizontal. About 3000 ft stratigraphical thickness is exposed 10 miles north of Einasleigh. Near the base of

this section, in greywacke interbedded with typical massive porphyritic rhyolite, carbonized plant fragments were found. Because of the poor material and state of preservation these can be identified only as *Equisitales*. Dr. R. O. Brunnschweiler (personal communication) states that they indicate a Palaeozoic age.

(ii) *Permian Sediments*.—Along Betts Creek, in Spear Creek (near Pentland), and in Galah Gorge (north of Hughenden), Permian sediments were found. Pebble conglomerate and thin beds and lenses of siltstone are generally present but current-bedded quartz greywacke is the dominant lithology.

They occur from the south-east corner of the area north-west to the head of the Dutton River but are almost entirely covered by younger deposits. The greatest known thickness of these beds is along Oxley Creek, near its junction with the Flinders River. Here Reid (1918) measured 1300 ft of section in which sandstone is dominant; shale, in beds up to 30 ft thick, occurs throughout; conglomerate and coal are found only in the top 100 ft. In the coaly beds and clay shales near the top of the section *Glossopteris*, *Vertebraria*, and *Phyllotheca* are common. The dip is generally steep near the Pre-Cambrian Etheridge complex where the boundary is, in part at least, faulted, but flattens to less than 5° half a mile away. The Blythesdale group overlies the Permian sediments in places with an angular unconformity but commonly no unconformity can be seen.

These beds are probably equivalent to the Upper Bowen coal measures and are lacustrine. Possibly they extend into the Great Artesian Basin to the west.

IV. Mesozoic

Early in the Mesozoic the sagging of the Pre-Cambrian basement, which has developed into the Great Artesian Basin, commenced. In southern Queensland Triassic and Jurassic sediments are present but in the Leichhardt–Gilbert area the development seems to have been mainly within the Cretaceous. The basin extends from west of Pentland almost to Cloncurry and from the Gulf of Carpentaria to the southern boundary of the area. It contains the Blythesdale group and the Rolling Downs group.

(*a*) *Blythesdale Group*

The oldest Mesozoic deposit in the area is a widespread arenaceous unit which crops out from the south-east corner in an arc through Croydon to the north-east corner. This is the Blythesdale group. Outliers are found to the east of the arc on the Etheridge complex and on the Croydon felsite while to the west younger deposits cover the junction with the Rolling Downs group. The dominant lithology is medium- to coarse-grained silty quartz sandstone, which is usually pebbly and current bedded; thin beds and lenses of siltstone are common, and pebble conglomerate is also present.

Near Croydon the Blythesdale group is rich in marine brachiopods; one was also found near Woolgar. Poorly preserved wood fragments are occasionally found but the absence of freshwater fauna suggests that the group in the Leichhardt–Gilbert area may all be marine.

In outcrop no more than 200 ft thickness is present in any one locality but bores to the west indicate that up to 500 ft is present below the Rolling Downs group.

All the major aquifers of this northern part of the Great Artesian Basin are in the Blythesdale group. It has been recognized in bores as far west as the Williams River (40 miles east of Cloncurry) but it is not known to crop out west of the Great Artesian Basin.

(*b*) *Rolling Downs Group*

The downwarp of the basement continued after the formation of the Blythesdale group, and the Rolling Downs group was deposited in three phases: the Roma formation, the Tambo formation, and the Winton formation were laid down in that order.

In the first phase the Roma formation succeeded the Blythesdale group without interruption but the axis of deposition probably moved slightly to the west. Siltstone and fine-grained argillaceous greywacke are the dominant lithologies; most are slightly calcareous. Shale, thin limestone lenses, and occasional glauconite beds also occur.

The Tambo formation followed without apparent unconformity, but fossil evidence indicates a disconformity which possibly represents complete retreat of the sea between the deposition of the two formations. The axis of the deposition had now moved westward, and the Tambo formation has Roma formation and Blythesdale group exposed east of it; on the west it overlaps onto the Cloncurry complex. Lenses of coquinoidal *Inoceramus* limestone are characteristic of the Tambo formation but it is otherwise lithologically almost indistinguishable from the Roma formation.

The deposition of the Tambo formation is the last record of marine transgression in the northern part of the Great Artesian Basin. The Winton formation, which overlies the Tambo formation, contains scattered freshwater, but no marine, fossils and is relatively rich in plant remains, so it is certainly lacustrine. Within the Leichhardt–Gilbert area it crops out south of the Townsville–Cloncurry railway in the central part of the Great Artesian Basin. Predominantly it consists of fine-grained greywacke, together with siltstone and widely distributed thin lime-cemented greywacke beds. Though the Winton formation contains more fine quartz sand than the older marine formations it is generally not possible on lithological grounds to recognize which of the three formations is present at any locality.

Within the Leichhardt–Gilbert area no estimates of the separate thickness of the Roma formation and the Tambo formation have been made but bore sections indicate a combined thickness of about 1000 ft in the Julia Creek–Nonda area and about 2000 ft near the Gulf of Carpentaria.

V. Cainozoic

Most Cainozoic rocks in the area are unfossiliferous terrestrial deposits or volcanics. Beds of similar lithology and environment have been mapped as units although it is apparent that not all deposits in each unit are precisely the same age.

(*a*) *Tertiary*

(i) *Terrestrial Deposits.*—A large area of fluviatile and sheet-flow deposits occurs along the north-eastern margin of the Great Artesian Basin. The material was derived chiefly from the Blythesdale group, which caps the elevated country north-east of the basin. The deposits range in age from pre-basalt (?Miocene) near

Hughenden to Recent towards Claraville, and consists mostly of sand—either loose, medium hard, or ferruginized to a hard rock. Gravel and conglomerate occur locally.

Although very extensive, this unit is thin; drillers' logs of water bores indicate a thickness up to about 40 ft.

Along the western margin of the Great Artesian Basin alternations of sand, gravel, and clay occur. Excavation for earth tanks shows that their thickness locally exceeds 25 ft.

(ii) *Basalt.*—Much of the north-eastern part of the area is covered by basalt. These basalt areas are built up from numerous flows from many different vents. There are three main areas and one smaller area, named by Twidale (1956*b*) McBride, Nulla, Sturgeon, and Chudleigh provinces.

Lithologically the lavas are olivine basalts; no pyroclastics were recognized during the reconnaissance. Deposits of diatomite occur with the basalt in the McBride province.

The basalt typically forms low domes with tongues extending down pre-existing valleys. Erosion has provided sections through the basalt only towards the margins. The maximum thickness measured was in the gorge of the Basalt River in the Nulla province where 130 ft of basalt, consisting of at least six flows, is present. Several of the flows were deeply weathered before being covered by a younger flow and the accumulation of the basalt obviously required a long period.

Two flows are much younger than any of the others. Twidale (1956*b*) has named these Kinrara basalt (McBride province) and Toomba basalt (Nulla province). Both these flows were of very fluid (pahoehoe) lava; they preserve their original form and no soil has yet formed on them. The Kinrara flow occupies two shallow valleys in the surface of the older basalt tableland for over 20 miles, and extends beyond the scarp into the Burdekin valley near Valley of Lagoons homestead. The Toomba flow also fills an older shallow valley that trends east, from north of Toomba homestead, for about 30 miles.

The basalts are much younger than the Cretaceous beds on which they have flowed near Hughenden. Vulcanism must have commenced before the oldest known associated diatomite deposit (Pliocene) and probably continued after the diatomite deposit whose age has been determined as Pleistocene to Recent (White and Crespin 1959).

Twidale (1956*b*) discusses the indirect evidence and suggests that the basalts range in age from late Pliocene to mid Pleistocene and the Kinrara and Toomba basalts from late Pleistocene to early Recent.

(iii) *Lateritization.*—Lateritization occurred over most, if not all, of the Leichhardt–Gilbert area. The ferruginous, mottled, or pallid zones can be recognized at many places but at few localities are all three zones of the profile well developed and preserved.

The effects of the lateritization vary widely. Part of this variation is due to the lithological differences in the parent rock. Thus the thickness of the individual zones and the total thickness of visibly altered Lower Cretaceous fine-grained greywacke near Normanton are considerably greater than that of Lower Cretaceous

quartz sandstone lateritized near Croydon. However, not all differences in profiles observed are due to differences in parent rock. Fine-grained greywacke similar to that at Normanton has a thinner and less well-developed profile near Crocodile Creek (north-east of Boomera). These differences are probably due to differences in local conditions (e.g. climate or topography) or to the process acting longer in some areas than in others.

The youngest lateritized fossiliferous beds are Upper Cretaceous. No fossiliferous beds are known to overlie laterite.

Lateritization occurred during early and mid Tertiary but was not necessarily active at every locality for precisely the same interval of time.

(*b*) *Quaternary*

(i) *Alluvium.*—Large sheets of alluvium border the Gilbert and Einasleigh Rivers in the north-eastern part of the area, the Flinders, Saxby, and Cloncurry Rivers in the central part, and the Leichhardt and Nicholson Rivers in the north-west. All alluvium mapped is related to existing drainage channels, but the boundary between this unit and Tertiary terrestrial deposits is rather arbitrary as regards both location and age.

Coarse-textured alluvium occurs along the Gilbert and Cloncurry Rivers and chiefly medium- and fine-textured alluvium elsewhere. The latter often forms deep "black" soils and is difficult to distinguish from similar residual soils formed on the Rolling Downs group.

(ii) *Littoral Deposits.*—The littoral deposits, which consist essentially of saline mud flats and discontinuous ridges of shell and shell fragments, form a strip about 20 miles wide along the southern coast of the Gulf of Carpentaria. It is at present being slowly extended; Twidale (1956*a*) considers deposition began about the end of the Tertiary.

(iii) *Basalt.*—All basalts have been described under "Tertiary". However, there is no doubt that the Kinrara and Toomba basalts are younger. Vulcanism, which commenced in the Tertiary, has continued intermittently until Recent time.

VI. Economic Geology

No major producing mines were operating in the area at the time of the survey. Subsequently the Mary Kathleen mine became an important producer of uranium but closed in 1963.

The Cloncurry complex is a copper province from which many tons of copper were produced between 1867 and 1920. Cobalt, gold, and silver-lead have also been mined but in recent years only small amounts of ore have been won by prospectors. In 1953 a search for uranium deposits commenced. Many prospects were located but only the Mary Kathleen had been put into production by 1959.

From the Etheridge complex and nearby rocks, gold and copper have been produced. Croydon, Georgetown, Cape River, Gilberton, and Woolgar districts were gold-fields at the beginning of the century. Einasleigh produced copper, with some gold, from 1898 to 1922. Small tonnages of many other metals and minerals were produced from various localities.

Coal has been encountered in many water bores penetrating Cretaceous beds, and Permian coal measures crop out along Oxley Creek (north of Torrens Creek). No coal has been mined.

Diatomite occurs associated with the basalt in the north-eastern part of the region (White and Crespin 1959). Quite extensive deposits occur near Conjuboy. They have not been exploited because they are so far from transport and markets.

The Mesozoic beds of the Great Artesian Basin contain possible source and reservoir beds for oil. Several oil companies hold concessions in the area.

VII. Underground Water

The northern part of the Great Artesian Basin occupies considerably more than half of the Leichhardt–Gilbert area. Only the Pre-Cambrian and Cambrian outcrop area in the south-west corner and the Pre-Cambrian and Palaeozoic in the east and north-east of the region are outside the artesian basin.

Throughout the artesian basin pressure water is available at depths of several hundred feet or more. Most bores are artesian (i.e. flow without requiring pumping) and generally do not exceed 1200 ft in depth except towards the Gulf of Carpentaria and towards the southern boundary of the area. Bores at Normanton and Burketown are each about 2300 ft deep.

Flows obtained mostly exceed 100,000 gallons per day; Pelham bore, which is 630 ft deep, had an initial flow exceeding 1,000,000 gallons per day. In general, good-quality water can be obtained in quantities adequate for stock purposes throughout the artesian area. Very few of the bores provide water of quality suitable for irrigation.

Reasonable supplies of good stock water generally can be obtained throughout the area from alluvial deposits adjacent to rivers. Elsewhere, outside the artesian area, water can often be obtained from depths of less than 300 ft but both quantity and quality are variable. No general indications can be given as bores differ even from others nearby and each requires to be carefully sited.

The Cambrian beds south of Malbon provide reasonable chances of obtaining adequate supplies of stock water from depths less than 500 ft.

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PART VI. GEOMORPHOLOGY OF THE LEICHHARDT–GILBERT AREA

By C. R. TWIDALE*

I. GENERAL

(*a*) *Regional Considerations*

The area consists essentially of the basins of the Leichhardt, Flinders, and Gilbert–Einasleigh river systems, all of which flow into the Gulf of Carpentaria and are components of the gulf drainage system. Relatively minor elements of the Pacific and inland systems are also contained within the area.

Within the gulf system the Flinders River flows over open plains for the greater part of its course, in contrast to the Leichhardt and Gilbert–Einasleigh Rivers which flow for long distances through rugged ridge and plateau country.

(*b*) *Physiographic Divisions*

Three topographic divisions have been defined and are shown in Figure 10. Each is a part of the major physiographic divisions of the Australian continent, namely, the shield, central plains, and eastern highlands.

(i) *Isa Highlands.*—The Isa highlands consist of a huge upland block projecting in a north-north-westerly direction to within a relatively short distance from the coast. They are drained by the upper Leichhardt River and form a complex ridge which averages about 1200 ft above sea-level but locally exceeds 1650 ft. They are coincident with the outcrop of the igneous and metamorphic rocks of the Cloncurry complex and have a large relief amplitude. The contortions and convolutions of the orogenic structures are expressed in the topography and the drainage patterns.

The uplands end abruptly on their eastern edge in a steeply inclined downwarp or a complex series of faults.

(ii) *Carpentaria and Inland Plains.*—These broad plains are drained mostly by the Flinders and lower Leichhardt Rivers. They connect the main portion of the Great Artesian Basin with the Gulf of Carpentaria.

Gradients are low and between the coast and the divide between gulf and inland drainage, a distance of about 300 miles, the land rises only 700 ft. Several low lateritic plateaux occur within the plains and, throughout late Tertiary and Quaternary times, extensive alluviation occurred in the middle reaches of the river valleys.

(iii) *Einasleigh Uplands.*—These consist of a complex, dissected, topographic dome elongated in a NNW.–SSE. direction. The dome is mostly above the 2000-ft contour and locally exceeds 3000 ft in height. The highest point is near Cheviot Hills. The uplands merge gently into the Carpentaria plains to the west.

* Formerly Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T. Present address: Geography Department, University of Adelaide.

(c) *Structure and Relief*

This tripartite division is fundamentally structural. The structural framework is of great antiquity for the orogenic trends of the Isa highlands are of Pre-Cambrian age (Hills 1946) and it appears that later earth movements, whether orogenic or epeirogenic, have been moulded to this rigid frame. The minimal two periods of orogeny which have affected the Einasleigh uplands (Jones 1953) are believed to have acquired their trend by being compressed against the NNW.–SSE.-trending

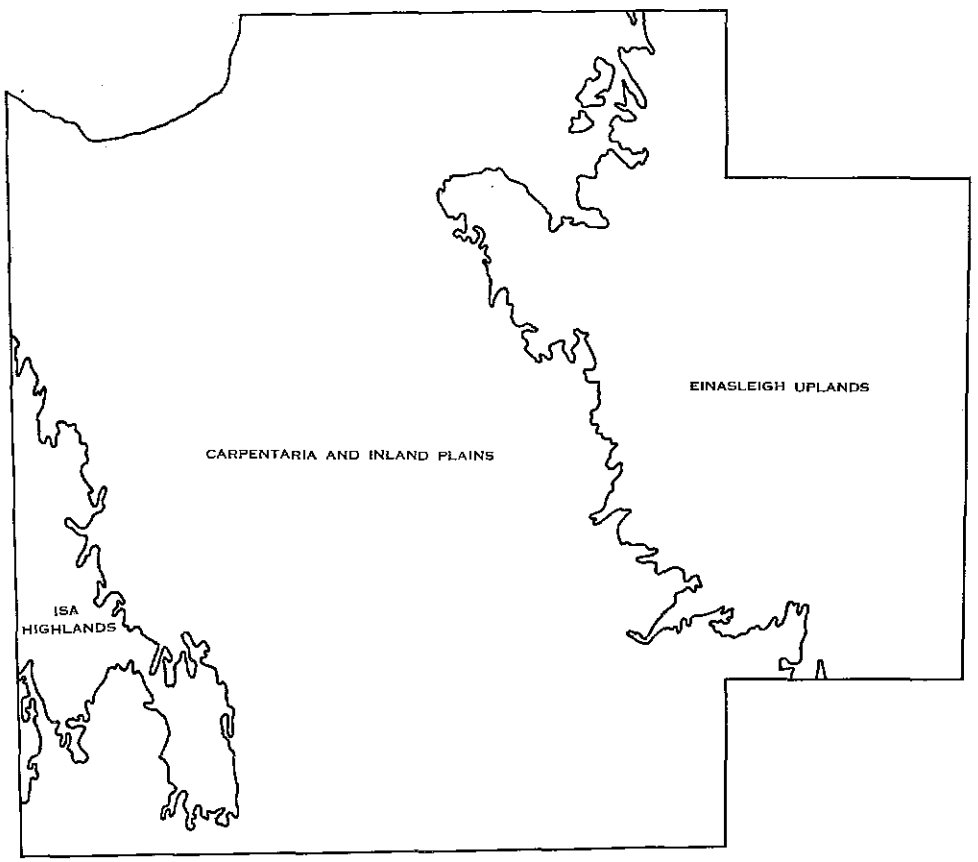

Fig. 10.—Physiographic divisions.

stable block of the Isa highlands, and the epeirogenic earth movements—of Nullagine, mid Mesozoic, late Cretaceous or early Tertiary, mid Tertiary, and Pleistocene ages—are all fitted to this ancient framework.

The influence of structure on relief is both direct and indirect. Upthrust structures and upstanding ground are directly correlated and a similar relationship exists between low areas and downwarped or downfaulted structures. Structure indirectly influences relief through drainage as the major drainage basins have been determined by structure, and it is in the already low-lying areas that maximum erosion has occurred.

(*d*) *Drainage*

The major rivers form an incomplete centripetal pattern (Fig. 11). They are consequent streams following the regional slope and flowing towards a downwarped area now partially occupied by the Gulf of Carpentaria. In the Isa highlands the major drainage elements are subsequent, flowing along lines of structural weakness, while in the Einasleigh uplands the overall pattern is radial from the dome. Many types of drainage pattern occur within the area. Of these, pinnate patterns are

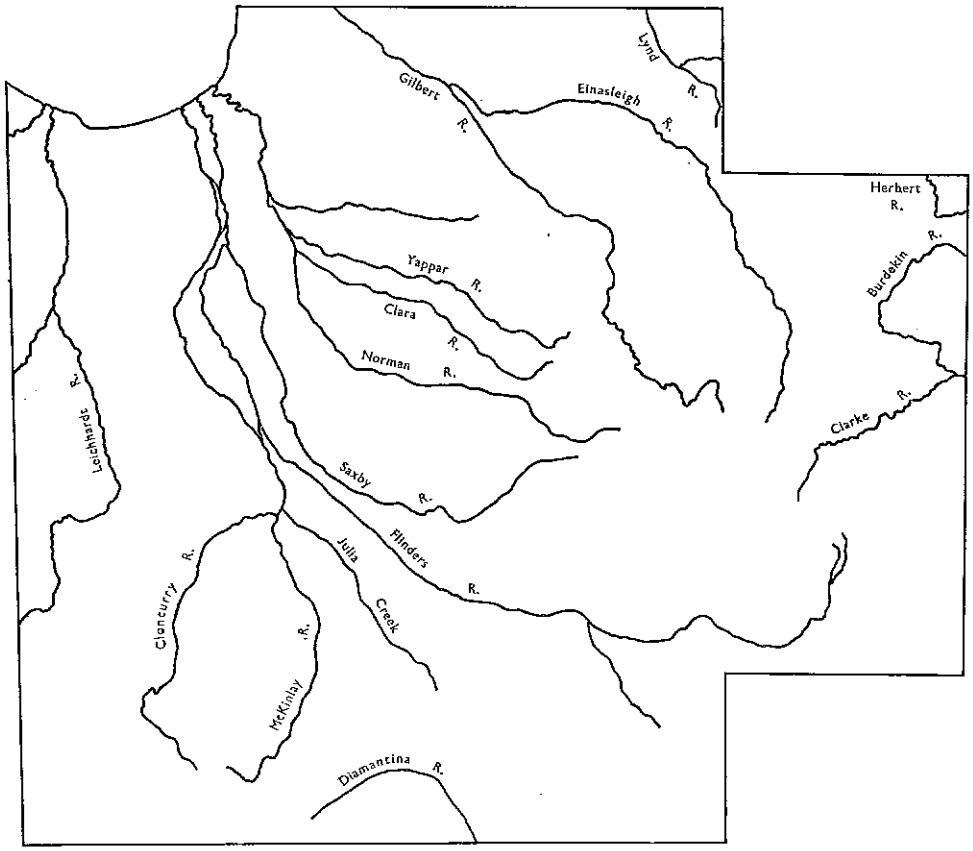

Fig. 11.—Pattern of major rivers.

known from the granite lowlands of the south-west, rectangular patterns occur in the porphyry areas of the Einasleigh uplands, and trellis patterns in areas of trended metamorphic and tilted sedimentary outcrop. The intensity of drainage shows a similar relationship to structure and is greatest in parts of the rocky upland areas.

(*e*) *Relief and Climate*

Climate is important since it influences river regimes, weathering, and slope development. Of these, the effects of climate on rivers are the most significant. The rainfall is seasonal in its distribution and over 80% of the total precipitation

is received in the months November to March inclusive. Because the rains occur after a long dry season during which vegetation is depleted, run-off rates are high, soil erosion is severe, and river flow is intermittent. Large volumes of water pass down river channels within a few weeks and flash floods are common. Stream channels develop a trench-like form, varying in width and containing many debris islands. This is the braided river, which is believed to be due to intermittent heavy flow, low gradients, and an abundance of available load.

II. Geomorphology

(*a*) *General*

In this section an attempt is made to correlate the major facts in chronological sequence. The land systems are related to this sequence in Table 1 and the distribution of the various surfaces is shown in Figure 12.

The oldest events are the least distinct. Proterozoic sediments occur in the Isa highlands and Einasleigh uplands and have been affected by igneous activity of both intrusive and extrusive types.

The crust of the earth in the present locality of the Isa highlands was thrust up into a series of high mountain ranges, probably at the end of the Proterozoic. The main axes of folding followed a NNW.–SSE. direction. In immediate post-Pre-Cambrian times there was planation in the south-west and small remnants of the erosional surface so created remain as part of the present landscape in the extreme south-west, but marine sediments were deposited there during Cambrian and Ordovician times.

(*b*) *Destructional Land Surfaces*

(i) *Pre-Mid Mesozoic Cycle of Denudation.*—A long period of denudation occurred between Ordovician and Jurassic ages. Small, low erosional benches, observed in the south-west of the area, are believed to be remnants of this surface (Twidale 1956*a*).

In the east, deposition continued for some time, the material eroded in the Isa highlands possibly being transported eastward and laid down in the east of the area, but by early Jurassic times an irregular plain of low relief extended over the whole area.

The surface was probably multiphase or polycyclic and has a wide age range, being Silurian to Jurassic age in the west and Triassic age in the east. It has been named the pre-mid Mesozoic plain of erosion.

(ii) *Early to Mid Tertiary Cycle of Denudation.*—An extensive marine incursion, possibly initiated by warping, occurred in late Jurassic and Cretaceous times. The Cretaceous sea extended over the whole area (except for the coastal ranges in the extreme east) and covered it with sediments. Erosion ceased except in the present coastal ranges, which remained above the sea level.

A relative uplift of the land, without appreciable distortion, followed towards or at the end of the Cretaceous age. A long period of comparatively stable conditions ensued, during which the whole area (except the present coastal ranges) was reduced

to a plain of low relief. Peneplanation was helped by the soft nature of the sediments, which were easily eroded. The late Mesozoic sediments were stripped almost entirely from the Isa highlands. During this early to mid Tertiary period, the plain of low relief was deeply weathered and laterite profiles can still be observed on remnants.

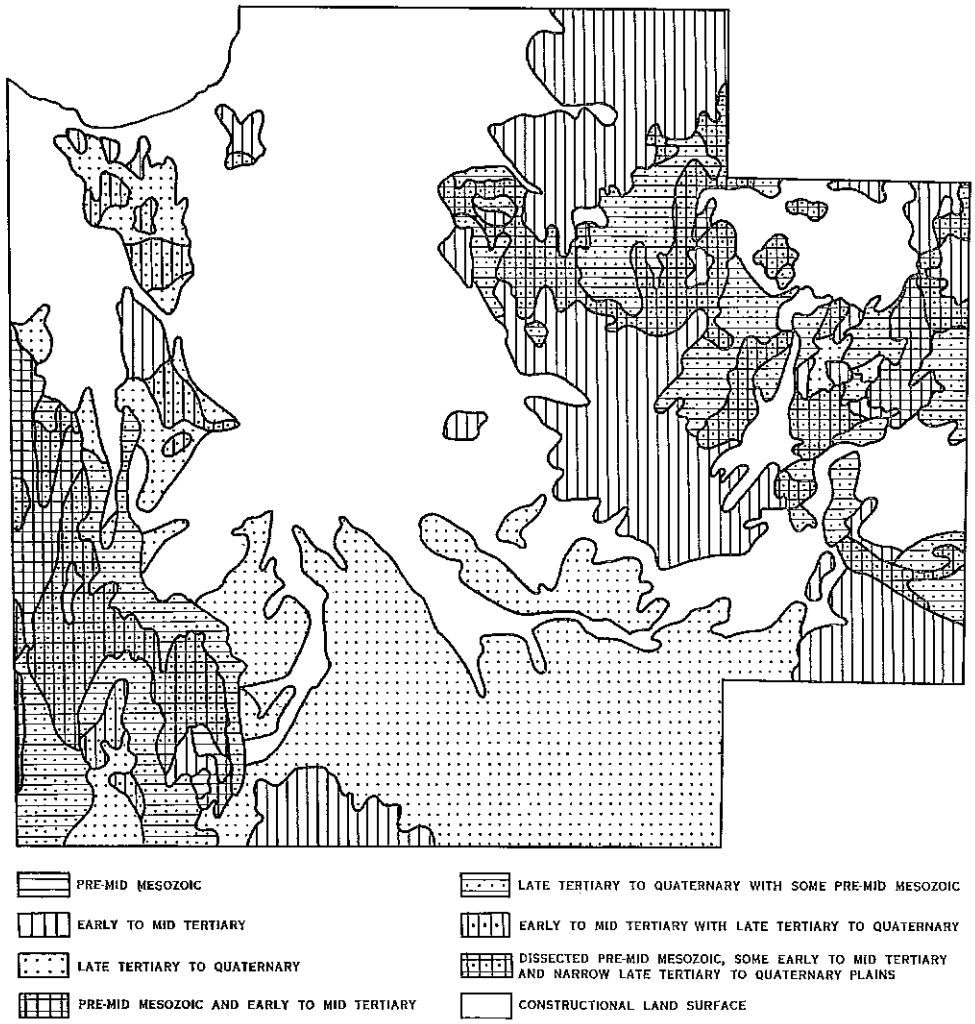

Fig. 12.—Distribution of erosional surfaces.

(iii) *Late Tertiary to Quaternary Cycle of Denudation.*—In Miocene times another relative uplift of the land surface occurred. Warping, which followed previous NNW.-SSE. trends, accompanied the uplift and the laterite surface was distorted. The uplift and warping caused rejuvenation of the streams and the lateritic surface was dissected. Remnants occur only on interfluves or where lithological factors have mitigated against erosion. The lateritic capping contributed to the formation of steep scarps bounding plateaux and mesas.

Many of the major streams flowed in the downwarp of the Carpentaria plains. They penetrated the hard duricrusted capping and reached the soft sediments, after which undercutting of the capping and lateral corrosion were swift so that no trace of the former lateritic capping remains over wide areas. On the borders of the central basin the pre-mid Mesozoic surface, developed on Pre-Cambrian strata, was exhumed and dissected. Elsewhere the new surface of low relief tongued headward up the valleys of major streams. Over most of the Carpentaria and inland plains denudation has progressed to the stage at which they may be considered, morphologically at any rate, a peneplain.

(c) *Constructional Land Surfaces*

Meanwhile, as a direct result of the uplift, warping, and erosion of the lateritic surface, sandy and gravelly lateritic detrital material was deposited in the form of low-angle alluvial fans on both sides of the downwarped Carpentaria plains. In Pleistocene times, the drainage of the plains was impeded and swampy conditions prevailed over wide areas. Extensive uniform silty deposits were spread over the middle reaches of the plains. The major rivers developed covered plains but in late Recent times the Selwyn upwarp developed, stream gradients were increased, and the major streams of the plains were incised and other channels abandoned. A large majority of the present streams are braided. In Recent times further incision has occurred as a result of a 20-ft emergence of the land.

In the far east of the area several phases of post-Miocene vulcanicity also occurred, possibly as an after-effect of the mid Tertiary epeirogenic movements, and on the east coast downfaulting took place (Cotton 1949) with the result that base level was lowered and stream rejuvenation occurred.

III. Geomorphological Units

The geomorphological units into which the area has been resolved are shown in Figure 13. The primary subdivision is into destructional and constructional land form assemblages, the latter being further divided into depositional and volcanic types.

The destructional assemblages comprise an erosional sequence from undissected plateaux through immaturely dissected plateaux and hill country to erosional low plains. The depositional plains, which are classified according to age as well as morphology, are, with one exception, fluviatile and may be regarded as the latest stage in the sequence.

The relation between geomorphological units and land systems is shown in Table 1.

(a) *Destructional Land Forms*

(i) *Plateaux and High Plains.*—The only continuous areas of undissected plateaux are located in the Gilberton and Baronta plateaux, but small areas occur in the Isa highlands, on Newcastle Range, and near the Tate and Herbert Rivers. The unit covers only a relatively small area.

The plateaux are developed mostly on sandstones of lower Cretaceous (Blythesdale) age but in the Baronta plateau are partly formed on sandstones of early Tertiary age. Near the Herbert River and in the upper Burdekin valley, they occur on sandstones of Devonian and possibly early Tertiary ages. They are best preserved on arenaceous strata.

Fig. 13.—Geomorphological units.

The plateaux have an undulating or low rolling relief and the lack of channels indicates a lack of external run-off. They are considered to be remnants of the early to mid Tertiary plain of erosion which was dissected following Miocene uplift and warping.

(ii) *Immaturely Dissected Plateaux and High Plains.*—These occur over wide areas and in all three physiographic divisions. They are best preserved on arenaceous rocks ranging from Pre-Cambrian in the west through Devonian in the east to Cretaceous and early Tertiary in the central areas.

Areas of undulating or rolling plain occur on the tops of plateaux but they are small and are separated by deep gorge-like valleys. In the valley slopes the hillside elements described by King (1951), the waxing slope, the free face, the debris slope, and the pediment are present in many places and in varying proportions. Valley pediments are particularly common on granitic rocks in the Isa highlands.

The plateaux mostly represent immaturely dissected remnants of the early to mid Tertiary plain of erosion but in some land systems appreciable elements of the late Tertiary to Quaternary plains occur. In smaller areas the plateau surfaces represent the pre-mid Mesozoic plain of erosion.

(iii) *Maturely Dissected Hill Country.*—The maturely dissected hill country occurs in the Isa highlands and Einasleigh uplands. Mostly the unit occurs on contorted and steeply inclined metamorphic rocks of Pre-Cambrian or Palaeozoic ages or on igneous rocks.

Ridges coincident with resistant strata and hogbacks and cuestas related to dykes and veins are common and concordant crests are usual. Pediments are common in the broad valleys. The drainage is structurally controlled and trellis, angular, and rectangular patterns are common.

Generally, the hill country represents a further stage in the denudation of the uplifted and warped early to mid Tertiary plain of erosion. In some localities to the east of the area it may be more ancient.

(iv) *Plains of Erosion.*—Plains of erosion occupy extensive areas in the Carpentaria and inland plains and smaller areas in the Einasleigh uplands. They are eroded in Pre-Cambrian, Palaeozoic, and Cretaceous rocks of lithologies varying between granites and shale.

Where metamorphic and igneous rocks crop out, the plains of erosion are irregular and contain widely spaced hills and ridges. The drainage patterns reflect structure and the pinnate patterns developed on the granite plains of the south-west are noteworthy. Also in the south-west, pediments are well developed on granitic rocks. On the Cretaceous strata of the Julia and Diamantina plains, the plains are rolling and convex slopes predominate. Streams are braided and the plains are considered to be a peneplain.

In many areas the plains are intrinsically pre-mid Mesozoic stripped or exhumed surfaces from which a Cretaceous sedimentary cover was removed in late Tertiary to Quaternary times. Elsewhere, the plains are purely of late Tertiary to Quaternary age, having developed as a result of the uplift and dissection of the lateritic surface, or are of early to mid Tertiary age. They are most extensive on the soft Cretaceous shales.

(*b*) *Constructional Land Forms*

(i) *Alluvial Types.*—These six types owe their present form to the deposition of alluvia.

(1) Outwash plains occur on both margins of the Carpentaria and inland plains and are more extensive on the eastern than on the western side. The fans occupy piedmont situations and are composed of rudaceous and arenaceous deposits

derived from the Isa highlands (in the west) and the Gilberton plateau and Gregory Range (in the east).

Small levees and backslopes occur but generally the plains are monotonously flat with little or no relief. Drainage is sparse although in the eastern plains numerous former stream-lines with north-westerly courses occur.

The plains were deposited in Pliocene times in the downwarped Carpentaria and inland plains as a direct result of the uplift and dissection of adjacent areas.

(2) Riverine paludal plains occupy the lower and middle reaches of the Flinders and Leichhardt valleys and the entire lower portion of the Gilbert valley. Vertebrate fossils of Pleistocene age and of fluviatile origin have been found at Floraville, Riversleigh, and Leichhardt River (Bryan and Jones 1946).

The plains are nearly flat, and lack relief except for gilgais. Drainage is disorganized, shallow, and sparse, except for major streams which are deeply incised and in the vicinity of which gullying has occurred.

The uniformity of the material of which the plains are constructed indicates lacustrine or similar conditions, but the fluviatile fossils and ancient river lines suggest that the deposits were laid down in bogs through which meandered a few low-gradient streams. The widespread alluviation may be attributed to a heavier rainfall than at present (Whitehouse 1940) and to an impedance due to consistently higher tides in the Pleistocene.

(3) Covered plains occupy portions of the Leichhardt, Cloncurry, Gilbert, and Einasleigh valleys and are relatively small. They consist mainly of silty alluvium with small areas of sandy material. In the lower Gilbert area they have a distributary pattern.

The land form assemblage comprises a repetition of levees and inter-levee flood-plains occupied by overbank deposits. However, the individual elements divide and rejoin to form a braided pattern containing the elements of a bar plain. The major streams are incised and the minor ones are no longer used save in time of exceptional flood.

In many areas the covered plains are developed over the riverine plains of Pleistocene age but in some places they may be contemporaneous. Since their formation base level has been lowered.

(4) Bar plains occur near the channels and valleys of present rivers and are formed of silty alluvia. They comprise a series of alternating debris or levee ridges and channels. They have developed in late Recent times under the influence of markedly seasonal rainfall.

(5) Lacine and scroll plains are located on the Clara, Bynoe, Flinders, and Gilbert Rivers and on Armraynald Creek, and are developed on late Recent alluvia deposited by low-gradient streams.

The land form assemblage comprises scrolls or arcuate ridges with sloughs or depressions between. The scrolls and sloughs vary in their parallelism and spacing.

(6) Marine plains fringe the Gulf of Carpentaria (Karumba plain) and consist of beach rock and muds of late Pliocene and Quaternary ages.

The major land forms are low plateaux, barrier beaches and islands, saline mud flats, lagoons, and dunes (Twidale 1956*b*). Following marine erosion of the downwarped lateritic surface along the shores of the Gulf of Carpentaria, a marine bench formed on which detrital material was deposited in Pleistocene times. Offshore submarine bars developed and were driven inshore until they emerged and became barrier beaches and islands.

An emergence of the order of 20 ft occurred in Recent times. This has resulted in the excavation of the marine terrace and in the development of extensive areas of mud flats on which further barrier bars and islands have formed and are forming.

(ii) *Volcanic Types.*—These two types owe their present form to outpourings of lava.

(1) Basalt plains and plateaux are situated in the east of the Leichhardt–Gilbert area. They are built of successive flows of olivine basalt lava which were extruded in at least three separate phases during late Pliocene and Pleistocene times (Twidale 1956*c*).

The volcanic areas form domes from which drainage is radial. The main land forms are stony rises similar to those of Skeats and James (1937), local black soil plains, stony, deeply weathered undulating plains, and ancient volcanoes or centres of eruptions. The plains and plateaux were developed as a result of the vulcanicity of the multiple vent type (Tyrrell 1937).

(2) Little-weathered lava flows of early Recent age are located in the Nulla and McBride plateaux, near Toomba, between Mt. McBride and the Burdekin valley, and in several other small areas of the McBride region. They are composed of olivine basalts.

The lavas give rise to rough plains and plateaux, in which aa and pahoehoe structures and caverns are common. Surface drainage is non-existent, owing to the extremely permeable rock.

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PART VII. SURFACE HYDROLOGY OF THE LEICHHARDT–GILBERT AREA

By C. R. TWIDALE*

The underground water resources of the area have been briefly dealt with in Part V. The purpose of this Part is to give a brief account of the nature and distribution of waters in the rivers and river channels together with an assessment of the possibilities of water conservation. The account is partly the result of field surveys carried out by the writer but also incorporates the results of research by the Queensland Bureau of Investigation. An unpublished report by Whitehouse, Atherton, and Johnston† was especially valuable. They state that "with the exception of the Flinders River above the Cloncurry junction, parts of the Saxby, and some tributaries, all the large rivers have sufficient water to serve the needs of the cattle industry in their immediate vicinity".

I. GENERAL CONSIDERATIONS

The catchment areas, mean annual rainfall, and estimated mean annual run-off of the principal streams which are confined within the borders of the area are shown in Table 9.

It has been estimated (Nimmo 1947) that the part of Queensland which is drained by streams flowing into the Gulf of Carpentaria receives approximately 285 million acre-feet of water per annum and this writer estimates that of this total the Leichhardt–Gilbert area receives approximately 133 million acre-feet. This water is received in markedly seasonal rainfall which is moderate in the north and east (35 to 40 in. per annum) and lower (15 in. per annum) in the south and west. Temperatures and evapotranspiration are high and of the 133 million acre-feet less than 4% runs off to the sea.

River flow is intermittent and the large amount of debris transported during strong flows is deposited *en masse* with the cessation of flow. Because of the rapidity and heaviness of run-off, floods are common.

II. SURFACE WATER RESOURCES

(*a*) *Natural Waters*

Of the rainfall which enters the rivers a large proportion reaches the sea but a large quantity is retained in water-holes and flows in the debris of the beds of river channels. This latter supply is the underflow (Dixey 1931, p. 348).

* Formerly Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T. Present address: Geography Department, University of Adelaide.

† WHITEHOUSE, F. W., ATHERTON, D. O., and JOHNSTON, D. G. (1947).—The gulf country between the Gregory and Gilbert Rivers. Report of the committee to recommend a site for an agricultural experiment station. Unpublished report, Bureau of Investigation, Queensland.

(i) *Soakage in River Sands.*—Some areas retain more water than others and clearly the greater the quantity of alluvium, and particularly of sandy debris, the better will be the chances of obtaining adequate and reliable amounts of subsurface river water. In this respect the lower Gilbert, particularly in the area commonly known as the "delta", appears to be the best prospect.

There are several other river sectors, particularly where alluvium has accumulated behind rock bars, where the supply of river water could be tapped, e.g. the channels of the Woolgar and Stawell and the middle reaches of the Gilbert and the Langdon valley.

Water flows in the sands and other debris of the major rivers all the year round and although its quality, quantity, and the depth at which it is available depend upon the time of year and local circumstances, it is an important source of water for the cattle industry. The utilization of this supply for localized irrigation is worth investigating.

TABLE 9
ESTIMATED MEAN ANNUAL RUN-OFF OF THE PRINCIPAL STREAMS
(After Nimmo 1947)

Stream System	Catchment Area (sq miles)	Mean Annual Rainfall		Est imated Mean Annual Run-off	
		(ac ft)	(in.)	(ac ft)	(in.)
Leichhardt	12,199	13,660,000	21·0	195,000	0·3
Morning Inlet	1,714	2,365,000	25·9	64,000	0·7
Flinders, Cloncurry, Saxby	41,604	43,500,000	19·6	555,000	0·25
Norman, Clara, Yappar	19,566	27,050,000	25·9	731,000	0·7
Gilbert, Einasleigh, Staaten	28,032	46,600,000	31·1	2,392,000	1·6

(ii) *Water-holes.*—Water-holes, which are the last surface remnants of rivers and which are of common occurrence along river channels, are a limited and unreliable supply of water. Some are located along the main channel, others outside, and the rivers vary considerably as regards the amount, permanence, and accessibility of water from this source. The Norman and Leichhardt contain numerous permanent water-holes (though in the latter instance the water is difficult of access for cattle on account of the steep banks), while the Flinders and Gilbert have few (Whitehouse, unpublished data). Except in the "delta" area of the lower Gilbert few water-holes occur away from the main river courses. Everywhere water-holes are particularly common at tributary junctions. Some are capricious in their incidence, being dammed temporarily by river debris. Others, such as Company's Lagoon near Neumayer valley, are permanent and reliable, being due to more permanent causes, such as rock bars. In such cases the fencing and installation of pumping machinery would improve the watering facilities for stock. This is particularly true of water-holes along the Leichhardt River, which has steep-sided banks.

(iii) *Springs.*—In the basalt provinces located in the east of the area springs are common. They are permanent sources of water and the basis of a thriving cattle industry. Some progressive owners and managers are experimenting with small-scale irrigation.

Elsewhere springs are uncommon and are small and insignificant.

(*b*) *Made Waters*

In an area with such marked seasonal rainfall, river flow control and conservation of water are important.

(i) *Dams.*—Numerous small dams have been erected. They are mostly built of earth, but some are of concrete. They are especially useful near the coast, where their construction would prevent the influx of salt water up the channels of major streams at high tide.

Another possibility is the erection of subsurface dams (Dixey 1931, p. 482), which have the advantage of lower evaporative losses.

(ii) *Surface Catchment Tanks.*—In those areas which are distant from available river waters, the construction of surface catchment tanks is an alternative to the sinking of bores or wells. Such tanks have been of great assistance to the cattle industry. There is scope for great development of tanks in the gently undulating parts of the Carpentaria and inland plains, e.g. Donors and Julia land systems.

III. Problems

(*a*) *Dam Construction*

Numerous observed breached dams of both earth and concrete construction testify to the hazards and difficulties of dam building. Such projects encounter considerable difficulties because of:

(1) The predominantly braided nature of the streams.

(2) The great volumes of water which intermittently flow down the rivers.

(3) The heavy silting that occurs.

(4) The pronounced scour that takes place.

Provision must be made for a structure of sufficient strength, and storage of sufficient capacity, to withstand the maximum, not the average flow, while the catchment must be of sufficient size to ensure a reliable filling. The braided nature of the streams presents special difficulties when the siting, construction, and cost of dams are being considered. Whether the braids are separated by rock or debris is a factor of obvious importance.

The materials used in, and the siting of, dam walls and overflow channels require special study and attention. As an instance of mistaken policy in both these aspects, dams sited just downstream from a major tributary junction and built of cracking clay are doomed to failure.

In many of the areas most suitable for grazing or cultivation good dam sites are scarce because of the flat nature of the country.

(*b*) *Evaporation*

Where potential evaporation rates are so high, deep storages of small surface area are more efficient than broad, shallow storages. Monomolecular films may be used more in the future.

IV. Conclusion

Because of the lack of data the account of the surface water resources of the area is preponderantly qualitative. However, the main resources present and some of the problems inherent in their utilization have been indicated.

The amount and quality of water available in rivers, either on the surface or at a very shallow depth, contribute much to supporting settlement and industry at the present time, and the intelligent development of this large potential supply could undoubtedly do much to further settlement.

V. References

Dixey, F. (1931).—"A Practical Handbook of Water Supply." (Murby: London.)

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PART VIII. SOILS OF THE LEICHHARDT–GILBERT AREA

By J. R. SLEEMAN*

I. INTRODUCTION

Previous broad-scale soil investigations by Prescott (1931, 1944), Prescott and Skewes (1941), Whitehouse (1940), and Whitehouse, Atherton, and Johnston† by their very nature have yielded generalized maps and soil descriptions with very few type profile descriptions or analytical results. Prescott and Skewes (1941) quote laboratory analyses for three profiles sampled within the area, viz. a grey and brown soil of heavy texture on Millungera, a brown soil of light texture from Saxby Downs, and a red earth from Chudleigh Park, and Whitehouse, Atherton, and Johnston quote limited analyses for surface samples from the "black soil plains". On small areas within the limits of the Leichhardt–Gilbert area more detailed work has been carried out by Hubble and Beckmann (1957) and Simonett (1957). Hosking (1935) in his study of the black earths quotes analytical results for a profile sampled near Chudleigh Park.

In the present report the soils are described in terms of 32 families representing 15 great soil groups. Profiles sampled for laboratory analysis at 29 sites include representatives of 22 families. The range of soils is quite wide, including calcareous cracking clays, sands over clays, acid sands and clays, and saline and marsh soils. The distribution of the various soils appears to be largely controlled by the lithology and topography. The extensive continuous areas of calcareous cracking clays (grey and brown soils of heavy texture) and acid sands (brown soils of light texture) in the central plain are related to the uniformity of the underlying rock types or sediments and topography over these large areas. In the Einasleigh uplands and the Isa highlands, which are dominated by steep slopes and skeletal soils, the areas with deeper soils are more restricted and change rapidly in dominants with changes in lithology and topography.

The nutrient status of the soils roughly parallels their clay content, i.e. the higher the clay content the higher the nutrient status. In general the soils have a low to moderate nutrient content, the exception being the basaltic soils of the north-eastern corner, which have a high nutrient content. If the saline tidal flats and the soils of the lower Gilbert River are excluded, salinity should not be a limiting factor in agricultural usage, but some soils might demand certain precautionary measures if irrigated.

The soil family is the unit used in the description of the land systems (Part III). Since land systems are equivalent to soil associations, the land system map can be used to show the distribution of the various soil families. Its use as a soil map

* Division of Soils, CSIRO, Canberra, A.C.T.

† WHITEHOUSE, F. W., ATHERTON, D. O., and JOHNSTON, D. G. (1947).—The gulf country between the Gregory and Gilbert Rivers. Report of the committee to recommend a site for an agricultural experiment station. Unpublished report, Bureau of Investigation, Queensland.

TABLE 10

RELATION BETWEEN SOILS* AND LAND SYSTEMS OF HILLY AND MOUNTAINOUS EROSIONAL SURFACES

Land form	Plateaux and High Plains						Immaturely Dissected Plateaux and High Plains								Maturely Dissected Hill Country		
Age of surface	Early to mid Tertiary						Pre-mid Mesozoic	Pre-mid Mesozoic and early to mid Tertiary		Early to mid Tertiary		Early to mid Tertiary with late Tertiary to Quaternary			Dissected pre-mid Mesozoic, some early to mid Tertiary, and late Tertiary to Quaternary		
Land system	Normanton	Karoon	Eurunga	Boorooman	Hampstead	Warrigal	Mt. Elliott	Argylla	Wairuna	Ortona	Torwood	Punchbowl	Merlin	Cowan	Collis	Leichhardt	Belmore	Kuridala
Brown soils of light texture																		
Manbulloo										m								m
Cockatoo			S	S	*D*	A				A						m		
Cullen																m		
Norman																		
Currajong			m	m		A												
Red and yellow earths																		
Sturgeon		A	A	*D*		*D*						m	A			m		m
Elliott		*D*	*D*	m		A												
Stawell				A														
Zingari		A											m					
Wonorah	S																	
Nangum	m			m								A		*D*				
Clarina	*D*			A														
Forsayth		m								m			A			m	m	m
Krasnozems																		
Lang																		

Red and yellow podzolics																		
Wyandotte										m						m	m	
Cargoon				A						m						m	m	
Wallabadah	m																	
Mayvale																		
Red-brown earths																		
Moonah																		
Solodized solonetz																		
Miranda																	m	
Vanrook					m													
Boorama																		
Solonchaks																		
Carpentaria																		
Grey and brown soils of heavy texture																		
Barkly		A										A		A	A			
Wonardo												m			A			
Endymion			m									m		A				
Balootha														A				
Black earths																		
Rosella																		
Wiesenbodens																		
Spring																		
Rendzinas																		
Duchess															A			
Grey-brown and red calcareous desert soils																		
Tobermorey																		
Aeolian sands																		
Alluvial soils																		
Skeletal soils	M	M	M	A	M	A	*D*	*D*	*D*	*D*	*D*	*D*	*D*	S	*D*	*D*	*D*	*D*
Miscellaneous																		
Glendhu																		

*D, dominant; S, subdominant; A, associated; m, minor.

TABLE 11

RELATION BETWEEN SOILS* AND LAND SYSTEMS OF PLAINS OF EROSION

Age of surface	Early to Mid Tertiary								Late Tertiary to Quaternary							Late Tertiary to Quaternary with Some Pre-mid Mesozoic							
Land system	Strathpark	Manrika	Dandry	Esmeralda	Strathmore	Murgulla	Yanman	Glenharding	Julia	Donors	Donaldson	Wonardo	Wonomo	Lyall	McKinnon	Quamby	Heidelberg	Stanhill	Niall	Georgetown	Reedy Springs	Kilbogie	Townley
Brown soils of light texture																							
Manbulloo																m			m				
Cockatoo	*D*		*D*	*D*	A	*D*		A			m				m		*D*			A	A	m	
Cullen																		*D*				m	
Norman					*D*																		
Currajong					m		m																
Red and yellow earths																							
Sturgeon			S				A	*D*								S						m	
Elliott			A	m	S	S													m			A	
Stawell						m																	
Zingari							A				m												
Wonorah		m																					
Nangum		*D*	m				A			S									m				
Clarina																							
Forsayth													*D*	*D*	A	*D*			m			m	*D*
Krasnozems																							
Lang																							
Red and yellow podzolics																							
Wyandotte							m								A				m			*D*	A
Cargoon							*D*	A							A					m	m	S	
Wallabadah						m	m																
Mayvale																							

Red-brown earths															m							
Moonah																						
Solodized solonetz																						
Miranda							m												m			
Vanrook	m			A	m										m	m	A	m				
Boorama																						
Solonchaks																						
Carpentaria																						
Grey and brown soils of heavy texture																						
Barkly		m					m		*D*	*D*	*D*	S				m						
Wonardo									m	m	m	*D*	m			m						
Endymion																	m					
Balootha		m									m				m	m						
Black earths																						
Rosella														m	*D*						m	m
Wiesenbodens																						
Spring																						
Rendzinas																						
Duchess												A										
Grey-brown and red calcareous desert soils																						
Tobermorey									m							m						
Aeolian sands																						
Alluvial soils																						
Skeletal soils	m	m	m					A	m	m		m		m		A	A	A	*D*	*D*	*D*	A	m
Miscellaneous																						
Glendhu															S							

*D, dominant; S, subdominant; A, associated; m, minor.

TABLE 12

RELATION BETWEEN SOILS* AND LAND SYSTEMS OF CONSTRUCTIONAL SURFACES

Land form	Outwash Plains						Riverine Paludal Plains				Covered Plains			Bar Plains	Lacine and Scroll Plains		Marine Plains	Basalt Plains and Plateaux		Little-weathered Lava Flows
Age of surface	Pliocene						Pleistocene				Early Recent			Late Recent	Late Recent		Late Pliocene and Quaternary	Pliocene and Pleistocene		Early Recent
Land system	Mayvale	Claraville	Bylong	Abingdon	Korong	Percol	Balbirini	Monstraven	Glenore	Miranda	Gregory	Cloncurry	Gilbert	Georgina	Armraynald	Prospect	Carpentaria	Rosella	Boonderoo	Toomba
Brown soils of light texture																				
Manbulloo		m									m	S	*D*	m						
Cockatoo		*D*	*D*		A	m		m		m						*D*				
Cullen		m	A																	
Norman		m	m																	
Currajong			m																	
Red and yellow earths																				
Sturgeon				*D*	S	m				m	m	*D*								
Elliott	S	A	m	A						m										
Stawell	m																			
Zingari					*D*			m												
Wonorah					m															
Nangum		m	m		A				*D*											
Clarina																				
Forsayth																				
Krasnozems																				
Lang																		m	*D*	

Red and yellow podzolics																			
Wyandotte				m															
Cargoon																			
Wallabadah	*D*	A	m																
Mayvale	m																		
Red-brown earths																			
Moonah											m								
Solodized solonetz																			
Miranda			m						A	*D*		m				A			
Vanrook			m						m	m		m							
Boorama						*D*													
Solonchaks																			
Carpentaria																*D*			
Grey and brown soils of heavy texture																			
Barkly							*D*	*D*			*D*	m		*D*					
Wonardo						m	A	m			m	m		m					
Endymion			m				m		m	A				m					
Balootha			m		m	A	m	A	A		S	m		S					
Black earths																			
Rosella																	*D*	m	
Wiesenbodens																			
Spring																	m	m	
Rendzinas																			
Duchess																			
Grey-brown and red calcareous desert soils																			
Tobermorey																	m	m	
Aeolian sands																m			
Alluvial soils											m	m		m	*D*				
Skeletal soils				m	m												m	m	
Miscellaneous																			
Glendhu																	m	m	

* *D*, dominant; S, subdominant; A, associated; m, minor.

is facilitated by Tables 10–12 and by the small-scale soils map inset on the land system map. This soils map has been constructed by grouping the land systems according to their dominant soils—minor soils have not been taken into account.

II. The Soils and Their Agricultural Characteristics

As far as possible, the scheme and terminology proposed by Stephens (1956) have been used in classifying the soils, due recognition being given to the usage of terms by Stewart (1954, 1956) in previous surveys in northern Australia. In some instances the great soil group names are used with reservations because modification of published descriptions has been necessary to include local soils. In a survey of this nature it is obvious that the basic units recognized and mapped, viz. the soil families, are merely distinctive broad groupings within a great soil group and have not been arrived at by the grouping of similar soil series. Geographical names, such as those of towns, properties, parishes, or rivers associated with extensive occurrences, are given to the soil families; but for units morphologically similar to those previously described in northern Australia, the earlier name is retained. Although the family name is retained the soil may be classified in a different great soil group.

The following description and discussion of the soils are mainly concerned with the broader units, viz. great soil groups. However, the essential morphological characteristics of each family* are given in the text and their relationships to environmental factors shown in the tabulation of the land systems. The usage of terms in soil descriptions follows that proposed by the United States Department of Agriculture (1951). Soil colour and consistence refer to the dry state, and the soil surface is to be taken as smooth and uniform unless otherwise stated. What would be referred to by most authors as laterite is herein called ferruginous zone in an attempt to avoid confusion between the presence of the latter and the process of lateritization. The presence of two or more of the ferruginous, mottled, and pallid zones is taken to indicate lateritization.

(*a*) *Brown Soils of Light Texture* (*Prescott 1944*; *Stephens 1956*)

These are coarse-textured soils, either uniform throughout or with a slight increase in texture (not exceeding one texture grade) down the profile. Horizonation is not readily detected, since all boundaries are diffuse. The soil is apedal and reaction can range from strongly acid to neutral.

They are associated with landscapes of low to moderate relief carrying various woodlands. The parent material is always coarse-textured and acidic although of diverse origin, viz. alluvial or colluvial materials, sedimentary or igneous rocks. Surface run-off is low, being limited by the high infiltration, and internal drainage is medium or very rapid. Mean annual rainfall ranges from 14 to 35 in.

Five families have been recognized.

* Detailed descriptions of specimen profiles together with analytical data and a key for differentiating the various soil families are available from the Division of Land Research and Regional Survey, CSIRO, Canberra.

Manbulloo (Stewart 1956).—Fine sandy profiles, almost invariably micaceous; light brown to reddish brown; structure massive; consistence soft; reaction neutral to slightly acid.

Cockatoo (Burvill, unpublished data*; Stewart 1956).—Coarse sandy profiles; colour variable from red to yellow and light grey; structure single-grain or massive; consistence loose or soft; reaction strongly acid to neutral.

Cullen (Stewart 1956).—Similar to pale brown and yellow members of Cockatoo but distinguished from them by red, reddish yellow, or light grey mottling in the subsoil; structure in surface single-grained, in subsoil massive; consistence in surface loose, in subsoil soft to slightly hard.

Norman.—Comparable with Cullen but with a sharply defined cemented horizon in the subsoil at depths between 16 and 32 in.; structure in surface single-grained, in subsoil massive; consistence in surface loose, in subsoil very hard to strongly cemented; reaction slightly acid to neutral.

Currajong.—Comparable with Cockatoo but with incipient bleaching in the subsurface horizon; overlying massive ferruginous zone at depths varying from 18 to 33 in.

Agricultural Characteristics.—The Manbulloo soils are well drained with a good infiltration rate and a moderate available moisture range, low salts, and low nutrient status. Slopes are very gentle and suitable for cultivation but rainfall is the limiting factor in most areas of occurrence. However, these soils normally occur on the levees of the major streams and, as has been demonstrated on the Gilbert and Cape Rivers, can support a wide range of horticultural and agricultural crops under irrigation.

Cockatoo, Cullen, Norman, and Currajong soils are similar and all have a low nutrient status. In the surface horizons the total nitrogen and phosphate contents are low and the available phosphate is very low. Although no analyses are available, the calcium and potassium contents are expected to be low. On Pelham station, where Cockatoo soils predominate, the cattle are subject to a disease locally known as "hooky-hooky" which is considered to be caused by a deficiency of calcium and/or phosphate in the pastures.

These soils have good aeration, rapid internal drainage (with the exception of Cullen), a narrow available moisture range, and a low wilting point. In granite areas the slopes are generally too steep for cultivation, but elsewhere slopes are extremely gentle and clearing would not be a problem. The low rainfall and, to a less extent, the low fertility of the soils would militate against successful dry-land cropping.

(*b*) *Red and Yellow Earths*

With the qualification that laterite and associated mottled and pallid zones are not regarded as an essential part of the profile, this group is essentially an extension of the red earth group of Stephens (1956) to include yellow soils with otherwise similar characteristics. With the exception of those formed on sandy parent materials in the more arid sections the red and yellow earths of the Leichhardt–Gilbert area generally do not show the extreme vesicular structure described by Stewart (1954).

* Burvill, G. H. (1945).—Soil surveys, Kimberley Division, Western Australia. Unpublished report, Western Australian Department of Agriculture.

These are massive soils with a medium acid to neutral reaction, lacking bleached horizons or any other form of marked horizonation. All boundaries are either gradual or diffuse. The consistence in the subsoil is either hard or very hard.

They are associated with landscapes of low relief carrying *Eucalyptus* forest or various woodlands or grasslands. The parent materials are diverse, being alluvial or colluvial materials or derived from sedimentary or metamorphic or igneous rocks *in situ*. Surface run-off and internal drainage are variable. The mean annual rainfall ranges from less than 15 to 30 in.

Two major groups including eight families have been recognized: firstly, those soils having coarse-textured surface horizons and a range of at least two texture grades within the profile (Sturgeon, Elliott, and Stawell families) and secondly, those fine-textured profiles with less texture contrast than above (Zingari, Wonorah, Nangum, Clarina, and Forsayth families).

Sturgeon.—Sands or sandy loams grading into clays at depths varying from 6 to 48 in. The clays are frequently subplastic. Most commonly they are deep, red or reddish, and there may be traces of fine mottling in the deep subsoil. The surface soil is either single-grained and loose or massive with a soft consistence. In the eastern section of the area the soil surface is uniform and free of stone but in the western section it is frequently uneven, owing to local deflation and surface accumulation, and frequently has a moderate stone mantle. These soils are similar to the coarse-textured Bundella soils of Stewart (1954).

Elliott (Stewart 1954, 1956).—Comparable with Sturgeon except for colour, which is brownish in the surface while the subsoil is yellow or yellowish brown with red inclusions.

Stawell.—As for Elliott but with ferruginous nodules in the subsoil in increasing amounts with increasing depth and underlain by ferruginous zone at depths of 24 to 42 in.

Zingari.—Profiles show only slight texture differentiation; reddish to brownish sandy clay loams to light clays—structure massive except for top inch, which has a weak grade of coarse to very coarse platy structure—grading into red sandy clay or medium clay at less than 10 in. depth. The subsoils have a very hard consistence and few fine distinct yellowish mottles in the deeper parts. These soils are similar to the fine-textured Bundella soils of Stewart (1954).

Wonorah (Stewart 1954).—As for Zingari but underlain by ferruginous or mottled zones and the subsoil contains ferruginous nodules which become more frequent with depth—present in very high amounts at 24 in.

Nangum.—Comparable with Zingari except for colour and presence of variable amounts of ferruginous nodules in the profile—decreasing amounts with increasing depth. Surface colours are yellow or brown and the subsoil yellowish with red and light grey mottling.

Clarina.—Similar to Nangum but surface may be light grey; subsoil contains ferruginous nodules that increase in amount with depth; underlain by ferruginous zone at depths of 12 to 30 in.

Forsayth.—Comparable with Zingari but redder, lack mottling in the deep subsoil, slightly better structured, and consistence not as hard. The surface is massive, the subsoil has a very weak irregular medium to coarse angular or subangular blocky structure, and below this the structure is massive. When thin coarser-textured surfaces (sandy clay loam) are present they have very weak, coarse to very coarse platy structure. These soils appear to be similar to the amphibolite red soils of Stewart (1956).

Agricultural Characteristics.—The presence of clay B horizons in this group ensures better moisture-holding characteristics than those of the brown soils of light texture. In general they are at least moderately well-drained soils, the exception being the Nangum soils which are poorly drained and in many instances subject to periodic waterlogging. They have a low nutrient status, very low in the group of soils showing a marked texture contrast, and a very low salt content. Slopes are gentle and suitable for cultivation but Wonorah and Clarina soils are very gravelly and some of the Forsayth soils, particularly in the west, are stony. In general cultivation is limited by low rainfall. The soils with coarser-textured surface horizons, in particular the Sturgeon soils, appear to be suitable for the growing of a wide range of crops under irrigation. The finer-textured soils, in particular those of the Zingari family, appear to be reasonable agricultural soils but may have cultivation problems (e.g. surface crusting similar to those of the finer-textured soils at Katherine, N.T.).

(*c*) *Krasnozems* (*Stephens 1956*)

These are moderately structured fine-textured soils with a neutral to slightly acid reaction, lacking bleached horizons or any other form of marked horizonation. All changes are gradual.

They are associated with basalt landscapes of low relief carrying *Eucalyptus* woodland. Run-off is medium to low and the internal drainage is medium to rapid. The mean annual rainfall ranges from 20 to more than 30 in.

Lang.—Surfaces vary from greyish brown to reddish brown and subsoils from reddish brown to red. The surface has a moderate grade of medium crumb structure which coarsens with depth, passing to a weak grade of fine angular blocky structure, and finally is massive within a depth of 16 in. The consistence is soft in the surface and hard in the subsoil. In general the shallower profiles, of the order of 1–2 ft, are more poorly structured than the deeper profiles.

Drabber, better-structured variants of the above which occur in more poorly drained situations towards the southern and eastern boundary of the Tertiary basalt sheet are of minor areal importance and have been included with this family for convenience.

Agricultural Characteristics.—These are permeable, moderately to well drained, moderately structured clay soils with presumably good water-holding characteristics. They have a moderate to high nutrient status and a very low salt content. Although slopes are suitable, in many areas cultivation would not be practicable because of the bouldery nature of the soil and frequent outcrops. However, to the north of Conjuboy in the higher-rainfall section there appear to be extensive areas of deep members of the Lang family with very few basalt floaters or outcrops. These areas have a growing season for agricultural plants which exceeds 16 weeks in 4 years out of 5 and are regarded as the best prospects in the area for dry-land agricultural development.

(*d*) *Red and Yellow Podzolics* (*Stephens 1956*)

These soils show a marked texture contrast between the surface and subsoil, which are separated by an abrupt or clear, smooth boundary. Reaction increases slightly down the profile but always falls within the range medium acid to neutral. Although most commonly apedal throughout, the B_{21} horizon may be weakly structured. Surface consistence varies from loose to hard.

They occur in landscapes of variable relief—flat to hilly—carrying woodlands. The parent materials consist of alluvium or colluvium or are derived from sandstones, meta-sediments, or granite. Run-off is medium to low and the internal drainage is medium to slow. The mean annual rainfall ranges from 20 in. to more than 30 in.

There are two major groups, viz. the red podzolics with one family (Wyandotte) and the yellow podzolics with three families (Cargoon, Wallabadah, and Mayvale).

Wyandotte.—The surfaces vary from fine sand to loam and overlie fine sandy clay or medium clay horizons at depths varying from 4 to 12 in. Surfaces are reddish and subsoils are red or yellow-red with few distinct fine mottles and there is no bleached horizon. The surface horizons are apedal, apart from the top inch which may show a weakly developed laminar structure, and the subsoils are either massive or weakly structured—medium angular prismatic in the B_{21} and coarse angular blocky in the B_{22} horizon. Subsoil consistence is hard or very hard.

Cargoon.—Brownish or greyish apedal sands or sandy loams overlying mottled yellowish massive clays at depths varying from 6 to 28 in. The A_2 horizon may be slightly bleached and compact. Subsoil consistence is hard or very hard.

Wallabadah.—Similar to Cargoon but with well-developed bleached A_2 horizon, paler subsoil colours, and an extremely hard consistence—weakly cemented—in the subsoil.

Mayvale.—As for Wallabadah but with very high amounts of ferruginous nodules in the deep subsoil.

Agricultural Characteristics.—The Wyandotte soils are well drained, have a moderate available moisture range, a moderate nutrient status, and an extremely low salt content. However, agricultural development would be limited by slope, stony A horizons, and rather common outcrops. The gentler slopes in higher-rainfall areas may be suitable for cultivation.

The Cargoon soils occurring in association with Wyandotte soils on metamorphic rocks have similar potential usage but those developed on granites and sandstones have less permeable subsoils and in usage have greater affinities with the Wallabadah and Mayvale soils. The latter soils have a very low nutrient status and an extremely low salt content. Although slopes are suitable for cultivation, being flat for the greater part, and the climate is reasonable, particularly to the north, these soils have a low agricultural potential as they may be waterlogged during the wet season and have a low nutrient status.

(*e*) *Red-brown Earths* (*Prescott 1944*; *Stephens 1956*)

This group is of minor importance in the area and is confined to the extreme south-west corner.

They occur in an undulating or low hilly landscape carrying a short grassland or open woodland. The surface is uniform and "scalded", with a moderate stone mantle. Run-off is rapid to medium and the internal drainage is medium. The parent material is derived from basic metamorphic rocks or granite and the mean annual rainfall ranges from less than 15 in. to 20 in.

Moonah (Stewart 1954).—Surface horizons of reddish or brownish sandy clay loam overlie red medium clay subsoils at depths of 3 to 10 in. with carbonate nodules at depths of 18 to 24 in. The A–B horizon boundary is abrupt or clear. The surface is massive and slightly vesicular with a soft consistence. The subsoil is massive with a tendency towards a weak grade of coarse angular blocky structure in the B_{21} horizon; the consistence is hard.

Agricultural Characteristics.—Agriculturally these soils are comparable to the Wyandotte family of the red and yellow podzolics but they occur only in areas of low rainfall.

(*f*) *Solodized Solonetz* (*Stephens 1956*)

These soils have a bleached surface or subsurface horizon, and abrupt boundaries between slightly acid to strongly acid surface soils and clay subsoils that in the lower reaches are moderately or strongly alkaline.

They are most commonly associated with flat or slightly depressed alluvial areas carrying woodlands or grasslands, but also occur to a limited extent on granite in an undulating landscape. Run-off is very low or nil and the internal drainage is very slow or slow. The mean annual rainfall ranges from 15 in. to 35 in.

Miranda and Vanrook families have drab-coloured subsoils whilst the Boorama family has a reddish brown subsoil.

Miranda.—Surface horizons are sandy, fine sandy, or silty clay loams or clays, light grey to greyish brown in the upper portion and bleached below, with a massive structure and hard consistence. At depths of 1 to 6 in. the subsoils are massive silty clays or heavy clays with an extremely hard consistence, mottled in olive browns and browns and becoming yellower with depth. Carbonate nodules commonly occur at depths of 10 to 36 in. The surface horizons tend to be vesicular with reddish yellow coatings on root channels and the top inch may exhibit a vesicular platy structure.

Vanrook.—Dark brown to white massive sands or sandy loams with hard consistence, bleached in the lower parts, overlying mottled olive-brown and brown clays with carbonate nodules in the lower subsoil. The B_{21} horizon has an extremely coarse columnar macrostructure, the columns being 8 to 12 in. in diameter.

Boorama.—Reddish yellow or pale brown massive sands or sandy loams with a soft to slightly hard consistence overlying reddish brown clay with a thin strongly bleached coating on top of the B_{21} horizon and with carbonate nodules in the lower subsoil. They are either massive throughout or the B_{21} horizon may have a strongly developed very coarse columnar structure with units 4 to 12 in. across. The consistence in the subsoil is hard or extremely hard.

Agricultural Characteristics.—The Miranda and Vanrook soils are poorly drained with dense impermeable subsoils that have a moderate salt content and

significant amounts of sodium in the exchange complex. They have a moderate available moisture range and a very low nutrient status, and for the greater part are subject to seasonal flooding. Although the major area of Miranda and Vanrook soils, to the north of Croydon, has a rainfall greater than 30 in. and is commandable by water pumped from lagoons in the major streams, the soils are not considered suitable for agricultural development at this stage. Similar but more strongly developed soils occur extensively in the lower Burdekin valley (Hubble and Thompson 1953) and when more is known of their behaviour under irrigation the Gilbert areas may be reconsidered. The Boorama soils are confined to the southern low-rainfall section of the area, where they occur interspersed among grey and brown soils of heavy texture.

(*g*) *Solonchaks* (*Stephens 1956*)

These are saline clay soils occurring on fine-textured transported material of the saline mud flats and associated low plateaux fringing the Gulf of Carpentaria. For the greater part they are devoid of vegetation but the inland margins and associated low plateaux have a sparse cover of grass or samphire. The mud flats are situated above low-tide level but are inundated during the wet season and high tides. Run-off is very low and there is virtually no internal drainage because the water-table is shallow—less than 2 ft. The mean annual rainfall ranges from 30 to 40 in.

Carpentaria.—Thin salt crust overlying dark brown or grey clays with carbonate nodules and/or gypsum at shallow depths, and mottled at depth. The structure in the top of the clay is a weak grade of coarse prismatic passing to massive. Consistence is plastic in the wet state.

Agricultural Characteristics.—The extreme salinity and regular inundation prevent any agricultural utilization.

(*h*) *Grey and Brown Soils of Heavy Texture* (*Prescott 1944; Stephens 1956*)

The major group of these soils (Barkly and Wonardo families) are essentially alkaline clay soils with no texture contrast, uniform colour (i.e. not mottled), a self-mulching uneven surface, and carbonate and/or sulphate within a depth of 12 in. Two minor subgroups have been included, viz. mottled neutral variants of the above (Endymion family) and uniformly coloured variants with thin (up to 3 in.) "scalded" coarser-textured surface horizons (Balootha family). In general the mottled variants have a much poorer structure.

These soils occur in broadly rolling or flat landscapes mostly under grasslands. The parent material is either alluvium or derived from greywacke, limestone, calcareous shales, or metamorphic rocks. Run-off is low, except for Balootha soils in undulating country, and the internal drainage is slow. The mean annual rainfall ranges from 15 to 30 in.

Barkly (Stewart 1954).—Frequently there is a thin (up to $\frac{1}{8}$ in.) crust of laminated light brown fine sand and silt at the surface. Colours vary from dark grey to olive-brown. Structure in the surface inch or so varies from a weak to strong grade of very fine subangular blocky which gradually coarsens through a weak to moderate grade

of subangular blocky to massive at depths of 4 to 6 in. Consistence in the crust is loose, in the surface soft or very hard, and the remainder is extremely hard. Carbonate nodules may occur at the surface.

Wonardo (Stewart 1954).—Comparable with Barkly but dark reddish grey to dark reddish brown, with thicker self-mulching surfaces.

Endymion.—Structure less well developed than in the above, with rusty staining in top 12 in. and with mottled subsoils containing trace amounts of ferruginous or soft black nodules. Reaction in the surface is slightly acid and that in the subsoil neutral. Frequently deeply cracked with gilgai microrelief.

Balootha.—Similar to Barkly and Wonardo except for the surface and a tendency to be more gravelly with carbonate deeper in the profile. The surface is a pale sandy loam or sandy clay; vesicular; either massive or with a moderate grade of medium platy structure, and with a slightly hard to hard consistence. The A–B boundary is abrupt. The surface reaction is medium acid rising to moderately alkaline in the subsoil.

Agricultural Characteristics.—The Barkly family and to a lesser extent the Wonardo family are the more important of this group, occupying most of the extensive Carpentaria and inland plains. The Wonardo soils are mainly confined to the southern and south-western sections. They are rather impermeable, high-swelling clay soils with a moderate nutrient status and a high salt content. As suggested by Hubble and Beckmann (1957), nitrogen and phosphorus are rather low and could be limiting but the former may be overcome to some extent by fallowing and the latter by use of the sedentary soils which have a higher phosphate content than those developed on alluvium. Potash and calcium contents are adequate but there may be other minor-element deficiencies as suggested by the occurrence of "steely wool"—due to copper deficiency—in sheep grazed in areas of sedentary soils to the south of Julia Creek.

In minor areas gilgai development is extreme enough to limit cultivation. Although the available moisture range is good, the growing season is too short over most of the area of these soils and little prospect exists for extensive irrigation. However, if required, it should be feasible to develop small irrigated plots adjacent to trunk streams. The requirements would be a good-quality water applied in adequate amounts to maintain a downward leaching and thus move the high salt concentrations to lower depths rather than to the surface. Similar soils, of lower salt content, are being developed for irrigation along the Ord River in Western Australia.

The Balootha soils which occur in small isolated patches associated with the Barkly and Wonardo soils are less attractive agriculturally because of the shallow compact and impermeable surface horizon. The Endymion soils are similar to the Barkly and Wonardo soils but they are subject to periodic inundation and commonly have gilgai microrelief. Further observations on the agricultural potential of the grey and brown soils of heavy texture are available in reports of Whitehouse, Atherton, and Johnston*, Hubble and Beckmann (1957), and Skerman (1958).

* WHITEHOUSE, F. W., ATHERTON, D. O., and JOHNSTON, D. G. (1947).—The gulf country between the Gregory and Gilbert Rivers. Report of the committee to recommend a site for an agricultural experiment station. Unpublished report, Bureau of Investigation, Queensland.

(*i*) *Black Earths* (*Prescott 1944*; *Stephens 1956*)

These are dark calcareous clay soils with uniform texture profiles, a self-mulching surface, and carbonate nodules below a depth of 12 in.

They occur in very gently undulating or undulating landscapes on very gentle slopes carrying grassland. The surface is uneven, sometimes showing slight gilgai development, and usually has a stone mantle varying from sparse to almost complete boulder coverage. Run-off and internal drainage are very slow. They are formed on basalt and basic metamorphic rocks *in situ* or alluvium derived from those rocks. The mean annual rainfall ranges from less than 20 in. to more than 30 in.

Rosella.—Structure in the surface inch is a strong grade of very fine subangular blocky which gradually coarsens through a strong grade of coarse angular or subangular blocky to massive at depths of 4 to 12 in. Consistence at the surface is soft to very hard and below this it is extremely hard.

Agricultural Characteristics.—Physically these soils are similar to the Barkly family but have a high organic content, high nutrient status, and low salt content. The main factor limiting cultivation is their bouldery nature but where stone-free they should be suitable for dry-land agricultural development in the higher-rainfall areas. Under irrigation they would be suitable for the growing of pastures and lucerne, as shown by a small plot irrigated with spring water at Conjuboy. In general, large-scale irrigation would not be feasible because of the general bouldery nature of the soils and the impracticability of getting water onto them.

(*j*) *Wiesenbodens* (*Stephens 1956*)

These are strongly alkaline fine-textured soils showing only slight texture differentiation—of the order of one grade—with carbonate in the fine earth throughout and a water-table within 3 ft of the surface. Surfaces vary from dark grey to dark greyish brown and the deep subsoil is light grey.

These soils occur in small spring-fed swampy areas within basalt country. The vegetation consists of a *Melaleuca* forest or *Cynodon* grassland. Both run-off and internal drainage are very slow. The parent material is basaltic alluvium enriched with bases from spring waters. The mean annual rainfall ranges from 23 to 30 in.

Spring.—The surface horizon is either an organic clay loam or silty clay loam and the subsoil, at depths of 18 to 24 in., a heavy silty clay loam or light clay. In the moist state the surface appears to have a fine crumb or granular structure. In the dry state the profile is massive throughout with a slightly firm to friable consistence in the surface and an extremely hard consistence in the very vesicular deep subsoil.

Agricultural Characteristics.—These soils occupy a very minor area, they are subject to flooding, and the surface of the less organic members tends to pack down when dry. Although suitable for agricultural development if the flooding could be controlled, they are better suited for sown pastures.

(*k*) *Rendzinas* (*Prescott 1944*; *Stephens 1956*)

These are shallow, dark, well-structured, calcareous, fine-textured soils lacking texture contrast and overlying calcareous silty horizons at depths of 7 to 14 in. They

are associated with very gentle slopes carrying short grassland. The parent material is derived from limestone or the more basic metamorphic rocks. Both run-off and internal drainage vary from moderate to slow. The mean annual rainfall ranges from 13 to 25 in.

Duchess.—The soil surface is smooth, the surface horizon has a strong grade of medium subangular blocky structure and a slightly hard consistence.

Agricultural Characteristics.—These are moderately well-drained soils, with moderate available moisture range and nutrient status, and low salt content. Although slopes are gentle, frequent limestone outcrops would make cultivation difficult. These soils are of minor extent and largely confined to the low-rainfall sector in the south-west corner of the area.

(*l*) *Grey-brown and Red Calcareous Desert Soils* (*Stephens 1956*)

These are shallow strongly alkaline calcareous soils of intermediate or fine texture with a soft to slightly hard consistence. Texture profiles are essentially uniform and all horizon boundaries are diffuse. They occur within an undulating landscape on crests carrying short grassland or sparse woodland. The parent material is derived from limestone or travertine *in situ*. Run-off is rather rapid owing to the presence of a surface seal and the internal drainage is medium. Mean annual rainfall ranges from less than 15 to 30 in.

Tobermorey (Stewart 1954).—Textures range from silty loam to clay and colours are pale and either uniform throughout the profile or becoming paler with depth. The surface has a weak grade of medium platy structure and the subsurface a weak grade of medium angular blocky. Profiles are underlain by limestone or travertine at depths varying from 12 to 36 in.

Agricultural Characteristics.—They occur in small isolated patches, commonly with numerous outcrops, and are unsuitable for agricultural development, but in general would have properties comparable with the Duchess family.

(*m*) *Aeolian Sands* (*Stephens 1956*)

These are undifferentiated profiles consisting of sand, shell grit, and shells associated with dunes fringing the Gulf of Carpentaria. Further inland the dunes have similar profiles but are of silty clay loam texture.

Agricultural Characteristics.—Although the soils would appear suitable for limited agricultural development providing moisture is not limiting, the removal of vegetation and cultivation might lead to wind erosion.

(*n*) *Alluvial Soils* (*Stephens 1956*)

These are materials with obvious sedimentary stratification in the surface 4 ft, i.e. unaltered alluvial deposits of variable texture associated with streams. The vegetation consists of *Eucalyptus* woodland. They occur as very small areas, the largest being the outwash areas of the Cloncurry River near its junction with the Williams River and recent levees on the lower reaches of the Leichhardt and Bynoe Rivers.

Agricultural Characteristics.—For the greater part these soils appear to be unsuitable for agricultural development owing to periodic flooding and the silty compact nature of the surface soil.

(*o*) *Skeletal Soils* (*Stephens 1956*)

These are shallow soils, less than 12 in. deep, frequently stony and lacking profile differentiation, normally occurring on the steeper slopes of the landscape. Textures are variable and depend on the parent rock.

Agricultural Characteristics.—Slopes normally too steep for cultivation and soils too shallow and stony.

(*p*) *Miscellaneous Soils*

Glendhu.—These soils are comparable to the Lang family (krasnozems) but are drabber—surfaces dark grey-brown and subsoils yellow-brown to brownish yellow, frequently mottled—and include manganiferous nodules in increasing amounts with increasing depth. They may overlie a yellow calcareous plastic clay at depth.

They occur in a landscape of low relief on the present margins of basalt sheets and presumably have been formed on mixed parent materials. The vegetation consists of a *Eucalyptus* woodland, run-off is low, and the internal drainage is slow. The mean annual rainfall ranges from 20 to 30 in.

Agricultural Characteristics.—As for Lang but somewhat poorer drainage status.

III. Laterite

Neither laterite nor companion horizons have been mapped as such, and much of the latter, e.g. extensive areas on Cretaceous sediments to the south of Kynuna and in the Warung–Burketown area, have been included in the map with skeletal soils. Extensive occurrences of companion horizons are common throughout the area, particularly in the Einasleigh uplands, but sheet laterite or ferruginous zone is very restricted in occurrence.

The only significant extent of sheet laterite or ferruginous zone occurs in the Normanton land system, near Normanton and Warung. At Normanton the sequence is: ferruginous gravel (1 ft) overlying soft ferruginous zone (2 ft) over mottled fine-grained sandstone of Cretaceous age (greater than 3 ft). It is assumed that the extensive area of companion horizons between Normanton, Warung, and Burketown was previously covered by a complete laterite profile which has since been truncated and dissected.

In the Einasleigh uplands the most convincing lateritic profiles occur on Tertiary deposits on Newcastle Range and in the Coalbrook scarp. The latter consists of ferruginous zone (2 ft) over mottled and pallid zone (30+ ft). However, a cutting in Tertiary deposits 5 miles north of Wairuna reveals a repeated sequence of mottled zone over pallid over mottled etc., suggesting a geologic rather than pedologic origin in this instance, at least, and possibly for other so-called laterites on Tertiary deposits of the area. Throughout the remainder of the area, on most parent materials but particularly on sandstones of Cretaceous age, there are spasmodic occurrences of ferruginous zone. However, as these are frequently associated with drainage lines

and depressions they probably have an origin similar to the creek and lake laterites of Christian and Stewart (1953). Although lacking sheet laterite, most of these Cretaceous sandstone areas show deep exposures of what appear to be companion horizons (e.g. 12 miles east of Torrens Creek), suggesting that these areas have been lateritized but that the siliceous nature of the parent material has precluded strong development of ferruginous zone materials (Stewart 1956). Further, the ferruginous nodules observed in some of these soils may, in part at least, be of geologic origin, as sandstones outcropping between Forsayth and Ortona contain such nodules.

Within the Pliocene outwash plains there are numerous outcrops of ferruginous zone. The more extensive occurrences, e.g. at Mt. Norman and near Burleigh No. 4 bore, suggest that these may be exposed portions of the downwarped early to mid Tertiary lateritized surface. At the Burleigh site, a Sturgeon profile (6 ft) overlies ferruginous zone (1½ ft) over mottled zone (3 ft) over pallid zone (5 ft). However, other outcrops in this area and fringing the Isa highlands are limited and spasmodic and suggest a second subsequent mild re-lateritization phase.

On the Kynuna plateau, apart from silicified greywacke stones on the surface of the skeletal soil the only evidence of lateritization consists of a deeply weathered (15 ft) zone of greywacke and siltstone still showing bedding.

In the Selwyn–Chatsworth area there are minor occurrences of silicified porcellanitic pallid-zone material, in subhorizontally bedded Mesozoic sediments and in part on steeply dipping Pre-Cambrian beds.

IV. The Soils in Relation to Environment

(*a*) *Lithology*

Whilst the effects of topography can be seen in many districts, over the area as a whole there is an apparent correlation between soils and parent rock. The common parent rocks and their associated soils are listed in Table 13.

The kind of profile developed on igneous rocks appears to depend on the mineral composition. With increasing ferromagnesian minerals and plagioclase the following sequence is encountered: brown soils of light texture (Cockatoo, Cullen, Norman), red and yellow earths (Sturgeon), solodized solonetz (Vanrook, Boorama), red and yellow podzolics (Cargoon, Wallabadah), red-brown earths (Moonah), red and yellow earths (Forsayth), black earths (Rosella), krasnozems (Lang), Glendhu. The brown soils of light texture, red and yellow podzolics, black earths, and krasnozems are confined to the Einasleigh uplands whilst the red-brown earths and Boorama soils are confined to the Isa highlands. The red and yellow earths occur in both areas but are more common in the latter.

Likewise on the metamorphic rocks with increasing ferromagnesian minerals the sequence appears to be red and yellow earths (Sturgeon, Elliott, Nangum), red and yellow podzolics (Cargoon, Wyandotte), red-brown earths (Moonah), red and yellow earths (Forsayth), grey and brown soils of heavy texture (Wonardo). The red and yellow podzolics and the Elliott and Nangum soils are confined to the Einasleigh uplands, whilst the red-brown earths and grey and brown soils of heavy texture are confined to the Isa highlands. Again the red and yellow earths (Sturgeon and Forsayth) are more common in the latter area.

TABLE 13
PARENT ROCK AND SOILS*

Parent Rock	Soil Family	Great Soil Group
Unconsolidated coarse sediments		
Source mainly sandstone	Cockatoo, Cullen, Currajong, Norman	Brown soils of light texture
	Sturgeon, Elliott	Red and yellow earths
	Wallabadah, Mayvale	Red and yellow podzolics
Source mainly metamorphic	Manbulloo	Brown soils of light texture
	Wyandotte	Red and yellow podzolics
	—	Alluvial soils
Source beach sands	—	Aeolian sands
Unconsolidated fine sediments		
Littoral saline muds	Carpentaria	Solonchaks
Source mainly basalt	Spring	Wiesenbodens
Source mainly calcareous shales	Barkly, Balootha, Endymion, Wonardo	Grey and brown soils of heavy texture
Source mainly metamorphics	Miranda, Vanrook	Solodized solonetz
	Zingari, Nangum, Wonorah, Forsayth	Red and yellow earths
Sandstones	Cockatoo, Cullen, Currajong, Norman	Brown soils of light texture
	Sturgeon, Elliott	Red and yellow earths
	Wyandotte, Wallabadah, Stawell	Red and yellow podzolics
Shales	Nangum, Wonorah, Clarina, Sturgeon	Red and yellow earths
	Barkly, Balootha	Grey and brown soils of heavy texture
Limestones	Wonardo	Grey and brown soils of heavy texture
	Duchess	Rendzinas
	Tobermorey	Grey-brown and red calcareous desert soils
Slate	—	Skeletal soils
Phyllite	Forsayth, Sturgeon	Red and yellow earths
Schist	Wyandotte	Red and yellow podzolics
Gneiss	Forsayth, Nangum, Elliott, Sturgeon	Red and yellow earths
	Cargoon	Red and yellow podzolics
Quartzite	—	Skeletal soils
Amphibolite	Forsayth	Red and yellow earths
	Wonardo	Grey and brown soils of heavy texture
	Moonah	Red-brown earths
Diorite	Forsayth	Red and yellow earths
	Rosella	Black earths
Gabbro and dolerite	Forsayth	Red and yellow earths
Basalt	Lang	Krasnozems
	Rosella	Black earths
	Glendhu	—

TABLE 13 (*Continued*)

Parent Rock	Soil Family	Great Soil Group
Granite	Cockatoo, Cullen	Brown soils of light texture
	Sturgeon	Red and yellow earths
	Cargoon, Wallabadah	Red and yellow podzolics
	Vanrook, Boorama	Solodized solonetz
	Moonah	Red-brown earths
Felsite	Cockatoo, Cullen, Norman	Brown soils of light texture

*Skeletal soils are associated with all consolidated rock types.

Grey and brown soils of heavy texture (Wonardo), rendzina (Duchess), and grey-brown and red calcareous desert soils (Tobermorey) are developed on limestone. Grey and brown soils of heavy texture are also developed on calcareous shales and alluvium derived from these rocks in the central plains area. Red and yellow earths (Wonorah, Clarina, Nangum, Sturgeon) are developed in shale areas of the Normanton, Burketown, Canobie triangle and to a lesser extent in the Einasleigh uplands. On the fine-textured alluvia derived from these latter areas, as well as postulated comparable alluvia along the margin of the Isa highlands, red and yellow earths (Zingari, Nangum, Wonorah, Forsayth) are developed. On more recent fine-textured sediments derived largely from metamorphic rocks of the Einasleigh uplands, solodized solonetz soils (Miranda, Vanrook) have developed. The solonchaks (Carpentaria) are confined to the littoral saline muds fringing the Gulf of Carpentaria.

On sandstones, weakly lateritized sandstones, or derived alluvia the following soils are developed—brown soils of light texture (Cockatoo, Cullen, Currajong, Norman), red and yellow earths (Sturgeon, Elliott), and red and yellow podzolics (Wyandotte, Wallabadah, Stawell, Mayvale). These soils are for the greater part confined to the Einasleigh uplands and their western margins. On the more recent coarse-textured alluvia derived largely from metamorphic rocks, brown soils of light texture (Manbulloo), red and yellow podzolics (Wyandotte), or alluvial soils are developed. These are restricted to the levees of major streams. The aeolian sands are confined to dunes associated with the littoral zone.

(*b*) *Climate*

Within the above framework the effects of climate are rather difficult to assess because of lack of repetition of similar lithologies in different climatic regions. However, the general impression is that the effect of climate is subsidiary to that of lithology, e.g. extensive areas of grey and brown soils of heavy texture (dominantly Barkly) occur on calcareous shales or derived alluvium in the Carpentaria and inland plains with average annual rainfalls ranging from 16 to 34 in. Other soils associated with particular parent materials throughout the climatic range of the area include Cockatoo, Manbulloo, Sturgeon, Elliott, Forsayth, and Tobermorey.

On the other hand, some climatic control appears evident in the soils formed on the igneous and metamorphic complexes of the Einasleigh uplands with average

annual rainfalls of 20 to 30 in. compared with those on similar rocks in the Isa highlands with average annual rainfalls of less than 20 in. On granite in the higher-rainfall area, apart from skeletal soils, brown soils of light texture (Cockatoo and Cullen) are dominant with some solodized solonetz (Vanrook, Miranda) whereas in the lower-rainfall area brown soils of light texture are absent and red and yellow earths (Sturgeon) are dominant with some solodized solonetz (Vanrook and Boorama) and red-brown earths (Moonah). Likewise on metamorphic rocks in the higher-rainfall area, red and yellow podzolics (Wyandotte, Cargoon) are dominant with some red and yellow earths (Forsayth) whereas in the lower-rainfall area the former are absent and the latter are dominant. In effect the profiles in the lower-rainfall areas are mainly red to brown and less leached than those of the higher-rainfall areas. This latter effect is somewhat exaggerated because of the fact that the metamorphic rocks in the Isa highlands are generally more basic than those in the Einasleigh uplands.

(*c*) *Geomorphology*

There appears to be little correlation between soils and the geomorphic surface on which they occur (Tables 10–12). Most soil families occur on two or more surfaces, the only exceptions being the krasnozems and wiesenbodens confined to the Pliocene and Pleistocene basalt plains and plateaux, solonchaks and aeolian sands confined to the late Pliocene and Pleistocene marine plains, and rendzinas confined to the late Tertiary to Quaternary plains of erosion. All these soils are formed on particular parent materials which do not occur on other surfaces and the relationship is with lithology rather than geomorphology.

Neglecting the volcanic plateaux and plains and the marine plains, which include rather specific parent materials, and also the pre-mid Mesozoic plateau which is of limited extent and carries only skeletal soils, the widest range of soils is to be found on the late Tertiary to Quaternary plains of erosion. This range includes brown soils of light texture, red and yellow earths, red and yellow podzolics, red-brown earths, solodized solonetz, grey and brown soils of heavy texture, black earths, rendzinas, and grey-brown and red calcareous desert soils. The early to mid Tertiary plateaux and plains of erosion and the Pliocene outwash plains carry a similar range but lack red-brown earths, black earths, rendzinas, and grey-brown and red calcareous desert soils. By contrast a more restricted range of soils is developed on the Quaternary alluvial plains probably owing to admixture during transportation, reducing the range of parent materials. The Pleistocene riverine paludal plains and the early Recent covered plains carry brown soils of light texture, red and yellow earths, red-brown earths, grey and brown soils of heavy texture, solodized solonetz, and alluvial soils. The late Recent bar, lacine, and scroll plains have brown soils of light texture, grey and brown soils of heavy texture, and stratified alluvial soils.

Thus, soils with comparable morphologies occur on several different geomorphic surfaces, e.g. Cockatoo soils (brown soils of light texture) or Balootha soils (grey and brown soils of heavy texture) occur on early to mid Tertiary or late Tertiary to Quaternary erosional plains and plateaux or on Pliocene, Pleistocene, or Recent alluvial plains.

Whilst the soils on the early to mid Tertiary erosional surfaces are not characteristic, the underlying materials are characteristic and indicate deep weathering. On the coarser-grained materials such as the Blythesdale sandstone and to a less extent granite these materials are mottled rock (mottled zone) and on the finer-grained sediments such as the Rolling Downs group they consist of pale-coloured silicified material (pallid zone).

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PART IX. VEGETATION OF THE LEICHHARDT–GILBERT AREA

By R. A. PERRY* and M. LAZARIDES*

I. VEGETATION IN RELATION TO THE ENVIRONMENT

(*a*) *Range of Environments*

The environment of the area is diverse. Mean annual rainfall ranges from less than 15 in. in the south-western corner to nearly 50 in. in the north-eastern corner. Most of the rain falls in 4 or 5 summer months and an annual drought of 6 months or more is characteristic. A wide range of sedimentary, metamorphic, and igneous rocks are present. Topographically the country ranges from rugged mountains to broad flat featureless plains, altitude ranges from sea-level to about 3000 ft, and local relief amplitude from less than 10 ft to about 500 ft. Rainfall run-off from the rugged country is high but some of the plains receive run-on and are flooded for several months each year. The soils range from fine-textured to coarse-textured, deep to shallow, and alkaline to moderately acid.

(*b*) *Community Types in Relation to Environment*

With such a wide range of habitats it is not surprising that the vegetation is diverse and comprises several hundred associations in the sense of Beadle and Costin (1952). However, a common feature of the whole area, and one which probably exerts a selective effect on the physiognomy of the vegetation, is the long annual drought. This is probably responsible for the vegetation's being mostly restricted to grasslands or woodlands with grassy understoreys.

Grasslands occupy about one-third of the area, comprising most of the cracking clay soil plains, at least where rainfall is less than about 25 in. per year. The reason for the absence of trees on these plains is not known but the presence of trees under higher rainfalls seems to indicate that their absence is associated in some way with water relations. Woodlands occur on most other soils and occupy most of the rest of the area. The height and density of the trees vary from about 15 ft high and 50 yd apart in the sparse low woodlands of the south-western corner to 60–80 ft high with canopies almost touching on deep soils above the 30-in. rainfall isohyet. The series continues without a recognizable floristic or structural discontinuity to forests with trees 80–100 ft high with canopies touching. These forests occur on only limited areas, on plains (or plateaux) with deep, coarse-textured soils above about 30-in. rainfall. In parts of some lower communities trees are close enough for canopies to touch. The best example is the lancewood community, which occupies large areas of dissected sandstone country; this is normally a woodland but in some areas is dense enough to be called forest. Trees are also densely spaced in small areas under high rainfall, fringing streams, and on dunes.

* Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T.

(c) *Plant Types in Relation to Environment*

In the Northern Territory, Perry (1960) and Perry and Lazarides (1962) have classified the plants according to their method of survival through the long annual droughts. The same three groups occur in this area.

(i) *Perennial Drought-resisting Species.*—These are the plants which remain green through the dry period and include most of the trees and shrubs and also spinifexes (*Triodia* spp.), which are evergreen perennial grasses.

(ii) *Perennial Drought-evading Species.*—This group includes most of the mid-height and some of the short grasses. They are green during the wet season but the above-ground parts are dry and dead during the dry season. The few deciduous trees and shrubs also fall in this group.

(iii) *Annual Drought-evading Species.*—Many of the short grasses and most of the forbs are in this group. Each year they germinate from seed, grow, mature and set seeds, and die.

(d) *Plant Distribution in Relation to Environment*

On a narrower basis the environmental control of the distribution of individual species and plant communities can be explained largely in terms of the availability of water—either the amount available or the period over which adequate water is available. This is a complex factor involving climate (rainfall and evaporation), topography (run-on and run-off), and the depth and physical nature of the soil (permeability, field capacity, wilting point). The various influences may compensate for one another, for example a plant which grows in depressions (receiving run-on) in the dry part of the area may grow on plains under moderate rainfall and on hill slopes (run-off) under high rainfall.

II. Plant Geography

(a) *Prominent Trees*

As in most of non-arid Australia, eucalypts are the most prominent trees. They characterize most of the woodlands and more than 50 species occur in the area. Of the woodland areas not characterized by eucalypts the largest (about 15,000 sq miles) is the broad outwash plain on the eastern side of the Carpentaria plains where paperbarks (about seven species of *Melaleuca*) are the most prominent trees. In the southern parts of these outwash plains various other trees (*Bauhinia, Acacia, Albizia, Erythrophleum, Terminalia, Atalaya, Grevillea, Owenia*) are also prominent in the Bylong low woodland. Another large (about 7000 sq miles) mostly non-eucalypt woodland area is the broken dissected sandstone country where lancewood (*Acacia shirleyi*) is the characteristic tree. The south-western corner of the area is arid and, as in other arid parts of Australia, *Acacia* spp. rather than *Eucalyptus* spp. are the prominent trees. *Atalaya, Ventilago, Grevillea, Hakea, Owenia,* and others are also important in this part of the area.

(b) *Prominent Grasses*

The prominent grasses over most of the area are mid-height (1½–4 ft) perennials. On the vast cracking clay plains the genus *Astrebla* is by far the most important and

all four species occur within the area. The largest and most widespread grass genus is *Aristida* (three-awn), which is represented in the area by about 40 species. With two or three exceptions (notably *A. latifolia*) these do not occur on the cracking clay plains. They include some short annual species. The most prominent grasses in the moderate- to high-rainfall areas are blue grasses (*Dichanthium* spp. and *Bothriochloa* spp.), kangaroo grass (*Themeda australis*), spear grass (*Heteropogon contortus*), and ribbon grass (*Chrysopogon fallax*). Of these only some of the blue grasses grow on cracking clays under moderate rainfall but most extend to cracking clays under high rainfall.

In the Isa highlands the characteristic grasses are spinifexes (*Triodia* spp.), which are perennial evergreen grasses. About six species are represented.

(*c*) *The Great Artesian Basin as a Migration Barrier*

The Great Artesian Basin occupies all the central part of the area from the Gulf of Carpentaria to the southern boundary. Since early Mesozoic times it has been either submerged or an area of cracking clay soils and has been a barrier to species interchange between the Einasleigh uplands and the Isa highlands. The barrier is less efficient in the north, where low lateritic tablelands in the basin provide habitats somewhat similar to those of the flanking uplands.

Although many species occur on both sides of the basin many other individual species or groups of species are restricted to one or the other. For example, in the genus *Eucalyptus* the ironbark group (*E. crebra*, *E. drepanophylla*, *E. whitei*, *E. melanophloia*, *E. shirleyi*) and yellowjack group (*E. similis*, *E. peltata*) do not occur west of the Great Artesian Basin although apparently suitable habitats occur. In other groups such as the boxes, *E. brownii*, *E. microneura*, and *E. leptophleba* are restricted to the east but *E. pruinosa*, *E. argillacea*, and *E. tectifica* do not occur in the east. *E. brevifolia* does not occur in the east. Other species such as *E. camaldulensis*, *E. microtheca*, *E. dichromophloia*, *E. terminalis*, *E. polycarpa*, *E. confertiflora*, *E. papuana*, and *E. grandifolia* occur on both sides of the basin.

III. Classification of the Vegetation

(*a*) *Relevant Features of the Vegetation*

(i) *Stratification.*—The vegetation over most of the area is characterized by two well-developed layers, a tree layer and a grass layer. Both layers are present in more than half the area, the grass layer alone on about one-third, and the tree layer alone on about one-tenth. Both layers are absent on about 1000 sq miles of coastal mud flats. Shrubs are present in most of the woodlands but are rarely prominent, and generally their presence or absence makes little noticeable difference to the community.

(ii) *Species Distribution.*—Each individual plant species appears to have its own area of distribution and its own environmental range. No two species were noticed which had identical or even closely similar distributions—this is true for the common species at least. Similar habitats tend to have similar assemblages of plants but no two stands were floristically identical. As well as changes occurring

through chance, slight changes in any direction of any habitat factor cause slight changes in floristic composition and, in general, the greater the difference between two habitats the greater the difference between their flora.

Abrupt changes in floristic composition occur with abrupt changes in environment, e.g. the vegetation on either side of a sharp boundary between cracking clay soils and deep sandy soils has few species in common. The bigger and sharper the environmental change, the more species distributions are likely to be conterminous at the break. Such sharp environmental discontinuities give the appearance of sharply defined discontinuous vegetation communities. However, if intermediate habitats occur in other localities their vegetation is commonly intermediate. Abrupt environmental changes are associated mostly with topography, geology, or soils. Climatic changes tend to be gradual.

(iii) *Prominent Species.*—The bulk of the vegetation, in either the tree or the grass layer, is made up of relatively few prominent species. By restricting attention to these a number of reasonably discontinuous regional plant communities can be recognized in both layers. Even among the prominent species it is rare to find one which is 100% constant to a community and none showed 100% fidelity to any community. Associated species exhibited much lower constancy but it is possible that some minor ones may be faithful to particular communities.

(iv) *Temporal Variability.*—The floristic composition of at least the grass layer may vary with time. For example, at Katherine in the Northern Territory the composition of a perennial mid-height grass community is known to vary over relatively short periods (3 years) from *Sorghum plumosum* dominant to *Themeda australis* dominant and vice versa in response to wet or dry seasons. Where vegetation is as dynamic as this, detailed floristic classification seems pointless and it is more logical to define broad groups and to describe their spatial and temporal (where known) variability.

(v) *Dominance.*—The individual distributions of species and of tree and grass communities and the temporal variability in grass communities appear to belie the dominance of any species over others in the sense of any particular species or group of species conditioning the environment and so determining its associates. In this respect Arndt and Norman (1959) at Katherine in the Northern Territory found that clearing the trees from a grassy woodland made little difference to the floristic composition and dry matter yield of the grass layer over a period of 2 years. Similarly destruction of the grass layer did not appear to affect the tree layer over 8 years.

(vi) *Physiognomy.*—The height and density of the vegetation vary fairly continuously with increasing wetness from sparse and low to tall and dense. Communities defined by floristic discontinuities are not always restricted to one structural form. For example, although most stands of the ironbark community of the Einasleigh uplands are woodlands, some are forests.

(*b*) *System of Classification*

(i) *Floristic.*—By considering only the prominent species, a number of reasonably discontinuous communities have been defined in both the tree and grass layers. Such communities are dominance-types (Whittaker 1962) and are in reality vegetation

TABLE 14

RELATION BETWEEN TREE LAYER AND GRASS LAYER COMMUNITIES

	Grass layer absent (or nearly so)			Grass layer characterized by water plants	Grasses short (< 12-18in.), annuals or short-lived perennials			Grasses short (< 12 in.), perennial	Grass layer mid height (1½–4 ft), moderately dense, perennial drought-evading grasses								Grass layer mid-height (1½–4 ft), sparse–moderately dense, perennial evergreen grasses		Grass layer tall (> 4 ft)
	Bare ground	Samphire flats	Lagoon vegetation		Arid short grass	Solodic soil short grass	Saline soil short grass	Couch grass	Mitchell grass downs	Blue grass–browntop downs	Eastern mid-height grass	Western mid-height grass	Three-awn	Three-awn–ribbon grass	Frontage mid-height grass	Western spinifex	Eastern spinifex	Fringing grass
Trees absent (or nearly so)	×	×	×		×	×	×	×	×	×		×		×		×		
Tree layer low (< 20 ft) and sparse																		
Arid sparse low woodland	×				×				×	×		×						
Isa highlands sparse low woodland					×							×						
Tree layer low (< 20 ft) and moderately dense																		
Bylong low woodland														×				
Paperbark low woodland						×						×		×		×		
Deciduous low woodland	×				×						×			×				
Mulga low woodland					×							×				×		
Gidgee low woodland and forest	×				×				×	×		×				×		
Silverleaf box low woodland					×					×								
Tree layer medium height (20–30 ft) and sparse																		
Downs sparse woodland			×			×	×		×	×								

Tree layer medium height (20–80 ft) and moderately dense													
Western box woodland					×		×		×				
Georgetown box woodland	×		×			×		×	×		×		
Downs woodland					×								
Stringybark woodland								×	×		×		
Ironbark woodland and forest	×					×		×	×		×	×	
Poplar gum–grey bloodwood woodland						×							
Reid River box woodland	×				×	×		×	×			×	
Frontage woodland									×	×			
Tree layer moderate height (20–80 ft) and dense													
Lancewood woodland and forest	×										×	×	
Fringing woodland and forest	×	×											×
Microphyll vine woodland	×												

continua in which the component species are distributed along environmental gradients and within which it is not possible to select internally homogeneous but externally discontinuous "associations" of species. As with individual species the grass and tree layer continua (synusiae) are independently distributed in space according to environment. They tend to be conterminous at large, abrupt, environmental discontinuities but otherwise form a mosaic pattern.

The relation between the various tree and grass layer communities is presented in Table 14. The crosses in the table indicate the various combinations of tree and grass layers which were observed in the field. These combinations of synusiae are the whole plant communities (or phyto-coenoses) of various areas. The tree and grass layer communities are described separately in the text not only to save space (22 tree communities and 17 grass communities instead of nearly 80 phyto-coenoses) but because:

(1) They are independently distributed and separate treatment presents a more realistic picture of the vegetation.

(2) The phyto-coenoses can then be classified according to either tree or grass layer affinities. Normal Australian practice is to classify phyto-coenoses on the basis of tree layer affinities but in some cases in northern Australia (e.g. where a grassland community continues under a tree layer) such practice separates floristically closely related communities and it is more logical to group on the basis of grass layer affinities. Practically, grouping according to tree layer affinities is useful for forestry or clearing purposes and grouping on the basis of grass layer affinities is more useful in considering the vegetation for grazing.

The tree layer continua are broadly similar in circumscription to the alliances of Beadle and Costin (1952) but the grass layer continua have no place in their system.

(ii) *Physiognomic.*—Both tree and grass layer communities have been arranged in Table 14 and in the text in order of increasing height and density. The terms grassland, woodland, and forest have been used in a descriptive sense rather than as a system of classifying the tree layer communities—in fact such a classification system seems illogical where the floristically defined communities transgress the divisions between structural units. The terms are defined as follows:

Grassland.—Vegetation in which woody plants are absent or nearly so.

Woodland.—Vegetation with sparse to moderately dense trees (canopies not touching).

Forest.—Vegetation with dense trees (canopies at least touching).

Epithets indicating relative height or density are applied in some cases.

Woody plants such as mulga, gidgee, vine tree, whitewood, silverleaf box, snappy gum, and paperbarks, all of which commonly grow to 10–15 ft high, are considered to be trees. This means that some vegetation locally or colloquially called scrub (e.g. mulga scrub) is here termed woodland.

(iii) *Mapping Units.*—The tree and grass layer continua are not necessarily mapping units. In a few instances they occupy areas large enough to be mapped

individually but in most instances, because landscapes are complexes of several well-defined habitats, two or more continua occur in intricate patterns. This means that the mapping unit has to be a complex of continua.

The land systems described in Part III are, among other things, complexes of vegetation continua. The use of the land system map as a vegetation map is facilitated by Tables 15–20, in which the relative importance of the various tree and grass layer communities in each land system is indicated. Also the vegetation inset map on the land system map shows groups of land systems classified according to their dominant tree layer community (colour) and dominant grass layer community (screen).

It should be stressed that this map shows land systems classified according to their dominant vegetation only, associated and minor communities are entirely neglected. It is therefore a greatly simplified presentation of the vegetation. The detailed mosaic can only be obtained from the land system descriptions and map.

IV. Description of the Vegetation

(*a*) *Nomenclature*

Plant names are used to name communities where the communities can be reasonably typified by one or two plants but communities involving many species, none with a very high constancy, have been given geographic or descriptive names. This obviates the use of long community names formed by combining more than two plant names and the use of a plant name to typify a community in which the plant is present in, for example, only half the stands.

In Table 21 the names of communities described below are compared with those of comparable communities described from nearby areas.

(*b*) *Tree Layer Continua*

(i) *Trees Absent (or Nearly So).*—About one-third of the area is virtually treeless. The largest component is the country with cracking clay soils in the Carpentaria and inland plains (Julia, Donors, Donaldson, Wonardo, Balbirini, Monstraven, Gregory, and Georgina land systems), especially that part with a mean annual rainfall of less than about 25 in. This part of the area is mostly grassland, either Mitchell grass downs or blue grass–browntop downs. Some of the cracking clay soil areas on the basalt of the eastern uplands are also treeless with blue grass–browntop downs (Rosella land system). The coastal salt flats and meadows (Carpentaria land system) are the next largest treeless area. Of the other land systems in which treeless areas comprise a major part of their area Collis is largely shallow calcareous silty soils with a short grass cover on limestones in the low-rainfall part of the area, and Punchbowl is largely stripped, low, lateritic plateaux with shallow sandy soils over pallid zone with spinifex (*Triodia pungens*). In all, about two-thirds of the land systems contain at least small treeless areas. As well as those already mentioned, the habitats range from rocky areas near scarps in the Einasleigh uplands with *Melaleuca foliolosa*, stony and skeletal soil areas with spinifex (*Triodia* spp.) in the Isa highlands (e.g. Kuridala), plains with short grasses under low rainfall (e.g. Percol), solodized

TABLE 15

RELATION BETWEEN TREE LAYER COMMUNITIES* AND LAND SYSTEMS OF HILLY AND MOUNTAINOUS EROSIONAL SURFACES

Land form	Plateaux and High Plains						Immaturely Dissected Plateaux and High Plains									Maturely Dissected Hill Country		
Age of surface	Early to mid Tertiary						Pre-mid Mesozoic	Pre-mid Mesozoic and early to mid Tertiary		Early to mid Tertiary		Early to mid Tertiary with late Tertiary to Quaternary				Dissected pre-mid Mesozoic, some early to mid Tertiary and late Tertiary to Quaternary		
Land system	Normanton	Karoon	Eurunga	Boorooman	Hampstead	Warrigal	Mt. Elliott	Argylla	Wairuna	Ortona	Torwood	Punchbowl	Merlin	Cowan	Collis	Leichhardt	Belmore	Kuridala
Trees absent		m	m				m	m				*D*	S	S	*D*			S
Trees low and sparse																		
Arid sparse low woodland													m					m
Isa highland sparse low woodland	m						*D*	*D*			m	S	*D*	*D*	S			*D*
Trees low and moderately dense																		
Bylong low woodland																		
Paperbark low woodland	m											m		m				
Deciduous low woodland										m						m	m	
Mulga low woodland													m					
Gidgee low woodland												m	m	m	m			
Silverleaf box low woodland	m											m		m				
Trees medium height and sparse																		
Downs sparse woodland	m	m										m		m				

Trees medium height and moderately dense																			
Western box woodland	m																		
Georgetown box woodland					*D*					m	m					m	*D*		
Downs woodland																			
Stringybark woodland	*D*				m							m							
Ironbark woodland and forest		*D*	*D*	*D*	S	*D*			*D*	*D*	m					*D*	m		
Poplar gum–grey bloodwood woodland				m															
Reid River box woodland		m		m					m							m			
Frontage woodland										m						m	m	m	
Trees medium height and dense																			
Dune woodland and forest																			
Lancewood woodland and forest		m	m	m	m	m			m	S	*D*								
Fringing woodland and forest		m	m			m		m		m	m	m	m	m	m	m	m	m	
Microphyll vine woodland																			

* *D*, dominant; S, subdominant; m, minor.

TABLE 16

RELATION BETWEEN TREE LAYER COMMUNITIES* AND LAND SYSTEMS OF PLAINS OF EROSION

Age of surface	Early to Mid Tertiary								Late Tertiary to Quaternary							Late Tertiary to Quaternary with Some Pre-mid Mesozoic							
Land system	Strathpark	Manrika	Dandry	Esmeralda	Strathmore	Murgulla	Yanman	Glenharding	Julia	Donors	Donaldson	Wonardo	Wonomo	Lyall	McKinnon	Quamby	Heidelberg	Stanhill	Niall	Georgetown	Reedy Springs	Kilbogie	Townley
Trees absent		m	m	m	m	m			*D*	*D*	*D*	*D*	m		S	S		m		m			
Trees low and sparse																							
Arid sparse low woodland		m							m	m	m	m				S							
Isa highland sparse low woodland		m								m	m	m				*D*							
Trees low and moderately dense																							
Bylong low woodland					m	*D*																	
Paperbark low woodland		m	m	m	*D*					m							m	m		m			
Deciduous low woodland								m										m		S			
Mulga low woodland													*D*										
Gidgee low woodland						m				m	S					m							
Silverleaf box low woodland		*D*				S				S	m												
Trees medium height and sparse																							
Downs sparse woodland		m								m													

Trees medium height and moderately dense																							
Western box woodland																							
Georgetown box woodland	*D*		m	*D*	m		m									m	*D*		*D*		m	*D*	
Downs woodland							m						m										
Stringybark woodland			*D*	m	m																		
Ironbark woodland and forest			m				*D*	*D*					*D*	*D*		*D*		S	m	*D*	*D*	m	
Poplar gum–grey bloodwood woodland							m	S								S		m		m			
Reid River box woodland							m						m	m				*D*		m	m		
Frontage woodland			m	m			m							m	m			m	m	m	m	m	
Trees medium height and dense																							
Dune woodland and forest																							
Lancewood woodland and forest	m		m																				
Fringing woodland and forest							m	m		m	m	m		m	m	m			m	m	m	m	m
Microphyll vine woodland																							

* *D*, dominant; S, subdominant; m, minor.

TABLE 17

RELATION BETWEEN TREE LAYER COMMUNITIES* AND LAND SYSTEMS OF CONSTRUCTIONAL SURFACES

Land form	Outwash Plains						Riverine Paludal Plains				Covered Plains			Bar Plains	Lacine and Scroll Plains		Marine Plains	Basalt Plains and Plateaux		Little-weathered Lava Flows
Age of surface	Pliocene						Pleistocene				Early Recent			Late Recent	Late Recent		Late Pliocene and Quaternary	Pliocene and Pleistocene		Early Recent
Land system	Mayvale	Claraville	Bylong	Abingdon	Korong	Percol	Balbirini	Monstraven	Glenore	Miranda	Gregory	Cloncurry	Gilbert	Georgina	Armraynald	Prospect	Carpentaria	Rosella	Boonderoo	Toomba
Trees absent			m		m	S	*D*	*D*		S	*D*	m	m	*D*			*D*	m	m	
Trees low and sparse																				
Arid sparse low woodland					m	*D*	m	m			m	m		m						
Isa highland sparse low woodland					m															
Trees low and moderately dense																				
Bylong low woodland	m	m	*D*		m															
Paperbark low woodland	*D*	*D*	m	m												*D*				
Deciduous low woodland																				
Mulga low woodland																				
Gidgee low woodland			m		m	m		m			m			m						
Silverleaf box low woodland					*D*															
Trees medium height and sparse																				
Downs sparse woodland			m	m			m		S	*D*	m		m	S	*D*		m			

Trees medium height and moderately dense																					
Western box woodland									D												
Georgetown box woodland			m	m																	
Downs woodland																		D	m		
Stringybark woodland				D														m	D		
Ironbark woodland and forest																					
Poplar gum–grey bloodwood woodland																					
Reid River box woodland																					
Frontage woodland		m		m		m	m			m	S	D	D	m	S	S					
Trees medium height and dense																					
Dune woodland and forest																	m				
Lancewood woodland and forest																					
Fringing woodland and forest	m	m				m	m	m	m	m	m	m	m	m	m	m					
Microphyll vine woodland																					D

* *D*, dominant; S, subdominant; m, minor.

TABLE 18

RELATION BETWEEN GRASS LAYER COMMUNITIES* AND LAND SYSTEMS OF HILLY AND MOUNTAINOUS EROSIONAL SURFACES

Land form	Plateaux and High Plains						Immaturely Dissected Plateaux and High Plains									Maturely Dissected Hill Country		
Age of surface	Early to mid Tertiary						Pre-mid Mesozoic	Pre-mid Mesozoic and early to mid Tertiary		Early to mid Tertiary		Early to mid Tertiary with late Tertiary to Quaternary				Dissected pre-mid Mesozoic, some early to mid Tertiary, and late Tertiary to Quaternary		
Land system	Normanton	Karoon	Eurunga	Boorooman	Hampstead	Warrigal	Mt. Elliott	Argylla	Wairuna	Ortona	Torwood	Punchbowl	Merlin	Cowan	Collis	Leichhardt	Belmore	Kuridala
Grass layer absent Bare ground Samphire flats			m	m	m	m			m	*D*	*D*		m	m		m	m	
Water plants Lagoon vegetation			m	m	m													
Grasses short, annual or short-lived perennials Arid short grass Solodic soil short grass Saline soil short grass	m											m	m	m	*D*		m	m
Grasses short, perennials Couch grass																		

Grasses mid height, drought-evading perennials																			
Mitchell grass downs															m	m			
Bluegrass–browntop downs	m	m										m			m				
Eastern mid-height grass		*D*	m	*D*		m			*D*	m							*D*	m	
Western mid-height grass	m							m				m	m						m
Three-awn		m			*D*							m						*D*	
Three-awn–ribbon grass	*D*				m						m				m		m	m	
Frontage grass										m							m	m	m
Grasses mid height, evergreen perennials																			
Western spinifex	m						*D*	*D*		m	m	*D*	*D*	*D*	m			m	*D*
Eastern spinifex		m	*D*		m	*D*			m		m								
Grasses tall																			
Fringing grass		m	m			m		m		m			m		m	m	m	m	

* *D*, dominant; S, subdominant; m, minor.

TABLE 19

RELATION BETWEEN GRASS LAYER COMMUNITIES* AND LAND SYSTEMS OF PLAINS OF EROSION

Age of surface	Early to Mid Tertiary								Late Tertiary to Quaternary							Late Tertiary to Quaternary with Some Pre-mid Mesozoic							
Land system	Strathpark	Manrika	Dandry	Esmeralda	Strathmore	Murgulla	Yanman	Glenharding	Julia	Donors	Donaldson	Wonardo	Wonomo	Lyall	McKinnon	Quamby	Heidelberg	Stanhill	Niall	Georgetown	Reedy Springs	Kilbogie	Townley
Grass layer absent																							
Bare ground	m		m			m					m							m					
Samphire flats																							
Water plants																							
Lagoon vegetation	m						m												m				
Grasses short, annual or short-lived perennials																							
Arid short grass									m	m	m	m	*D*			*D*							
Solodic soil short grass		m	m	m	m	m												m		m			
Saline soil short grass																							
Grasses short, perennials																							
Couch grass																			m				

Grasses mid height, drought-evading perennials																							
Mitchell grass downs									*D*	m	m	*D*	m			m							
Bluegrass–browntop downs		m					m			*D*	*D*			m	m				m				m
Eastern mid-height grass							*D*	*D*		m				*D*	*D*		*D*		*D*		*D*	*D*	
Western mid-height grass		*D*									m		m			m							
Three-awn																				*D*			*D*
Three-awn–ribbon grass	*D*	m	*D*	*D*	*D*	*D*	m			m							m	*D*		m			m
Frontage grass			m	m			m								m	m			m	m	m	m	m
Grasses mid height, evergreen perennials																							
Western spinifex		m	m		m	m				m	m	m				m							
Eastern spinifex																							
Grasses tall																							
Fringing grass							m	m		m	m	m		m	m	m				m	m	m	m

* *D*, dominant; S, subdominant; m, minor.

TABLE 20

RELATION BETWEEN GRASS LAYER COMMUNITIES* AND LAND SYSTEMS OF CONSTRUCTIONAL SURFACES

Land form	Outwash Plains						Riverine Paludal Plains				Covered Plains			Bar Plains	Lacine and Scroll Plains		Marine Plains	Basalt Plains and Plateaux		Little-weathered Lava Flows
Age of surface	Pliocene						Pleistocene				Early Recent			Late Recent	Late Recent		Late Pliocene and Quaternary	Pliocene and Pleistocene		Early Recent
Land system	Mayvale	Claraville	Bylong	Abingdon	Korong	Percol	Balbirini	Monstraven	Glenore	Miranda	Gregory	Cloncurry	Gilbert	Georgina	Armraynald	Prospect	Carpentaria	Rosella	Boonderoo	Toomba
Grass layer absent																				
Bare ground						m		m									*D*			*D*
Samphire flats																	m			
Water plants																				
Lagoon vegetation	m		m										m					m	m	
Grasses short, annual or short-lived perennials																				
Arid short grass					m	*D*	m	m			m	m		m						
Solodic soil short grass			m	m					S	S			m							
Saline soil short grass																	m			
Grasses short, perennials																				
Couch grass																		m	m	

Grasses mid height, drought-evading perennials																					
Mitchell grass downs			m			m	m	*D*			*D*	m		S							
Bluegrass–browntop downs					m		*D*	m	*D*	*D*	m			*D*	*D*		m		*D*	m	
Eastern mid-height grass																			m	*D*	
Western mid-height grass					*D*			m													
Three-awn																					
Three-awn–ribbon grass	*D*	*D*	*D*	*D*	m											*D*					
Frontage grass		m				m	m			m	S	*D*	*D*	m	m	S					
Grasses mid height, evergreen perennials																					
Western spinifex					m																
Eastern spinifex																					
Grasses tall																					
Fringing grass	m	m				m	m	m	m	m	m	m	m	m	m						

* *D*, dominant; S, subdominant; m, minor.

TABLE 21

COMPARISON BETWEEN COMMUNITIES DESCRIBED IN THIS REPORT WITH THOSE DESCRIBED FROM NEARBY AREAS

This Publication (Perry)	Alice Springs Area (Perry and Lazarides 1962)	Barkly Region (Christian and Perry 1954)	Townsville–Bowen Region (Perry 1953)
Trees absent	Absent	—	—
Arid sparse low woodland	Sparse low trees	*Ventilago viminalis*	—
Isa highlands sparse low woodland	*E. brevifolia*	*E. brevifolia* *E. argillacea–E. terminalis* *E. terminalis–Cassia* spp.	—
Bylong low woodland	—	*Bauhinia cunninghamii–Gyrocarpus americanus*	—
Paperbark low woodland	—	*Melaleuca acacioides* *M. leucadendron*	—
Deciduous low woodland	—	*Terminalia* spp.–*Bauhinia cunninghamii–Cochlospermum* sp.	—
Mulga low woodland	*Acacia aneura*	*Acacia aneura*	—
Gidgee low woodland and forest	*Acacia georginae*	*Acacia georginae* *Acacia cambagei* *A. georginae–Cassia* spp.	—
Silverleaf box low woodland	—	*E. pruinosa–E. microtheca* *E. pruinosa*	—
Downs sparse woodland	—	*E. microtheca* *Bauhinia cunninghamii*	—
Western box woodland	—	*E. argillacea–E. terminalis–E. tectifica*	—
Georgetown box woodland	—	—	—
Downs woodland	—	—	—
Stringybark woodland	—	*E. dichromophloia* *E. tetrodonta–E. miniata*	—
Ironbark woodland and forest	—	—	Narrow-leaved ironbark–red-barked bloodwood Silver-leaved ironbark
Poplar gum–grey bloodwood woodland	—	—	Poplar gum–grey bloodwood Grey bloodwood
Reid River box woodland	—	—	Reid River box
Frontage woodland	*Eucalyptus papuana*	*E. papuana–E. tectifica*	Poplar gum–grey bloodwood
Dune woodland and forest	—	—	—

TABLE 21 (*Continued*)

This Publication (Perry)	Alice Springs Area (Perry and Lazarides 1962)	Barkly Region (Christian and Perry 1954)	Townsville–Bowen Region (Perry 1953)
Lancewood woodland and forest	—	*Acacia shirleyi*	Lancewood
Fringing woodland and forest	*E. camaldulensis–Acacia estrophiolata*	Fringing communities	Fringing forests Mangrove communities
Microphyll vine woodland	—	—	Softwood communities
Bare ground	Absent	—	—
Samphire flats	*Arthrocnemum* spp.	Salt marsh	Salt marsh
Lagoon vegetation	—	Communities of lagoons etc.	Lagoons
Arid short grass	Short grasses and forbs	*Sporobolus australasicus–Enneapogon* spp.	—
Solodic soil short grass	—	—	—
Saline soil short grass	—	*Xerochloa barbata*	Sand couch
Couch grass	—	—	—
Mitchell grass downs	*Astrebla pectinata* *A. lappacea*	*Astrebla pectinata* *A. elymoides*	—
Blue grass–browntop downs	—	*Eulalia fulva–Dichanthium fecundum*	*Ophiuros*–blue grass
Eastern mid-height grass	—	—	—
Western mid-height grass	*Chrysopogon fallax* *Aristida pruinosa* *Themeda australis* *T. avenacea* *Bothriochloa ewartiana–Eulalia fulva*	—	—
Three-awn	—	—	—
Three-awn–ribbon grass	—	—	—
Frontage mid-height grass	*Chloris acicularis*	—	—
Western spinifex	*Triodia pungens* *T. longiceps*	—	—
Eastern spinifex	—	—	—
Fringing grass	—	—	—

solonetz soils with short grass in linear, flat-floored depressions in many land systems (e.g. Esmeralda) between the 20 and 30 in. mean annual rainfall isohyets, to swampy areas and lagoons.

(ii) *Tree Layer Low (<20 ft) and Sparse*

(1) *Arid Sparse Low Woodland.*—This is a community which is widespread in arid northern Australia. In the Leichhardt–Gilbert area it is mostly restricted to plains receiving a mean annual rainfall of less than about 17 in. but extends nearly to the 25-in. isohyet on clay soil. It occurs on Boorama (solodized solonetz), Forsayth, Wonorah, and Zingari (red and yellow earths), Barkly, Wonardo, and Balootha

(grey and brown soils of heavy texture), Moonah (red-brown earths), Duchess (rendzina), Tobermorey (grey-brown and red calcareous desert soils), and shallow skeletal soils.

The tree layer is low (10–15 ft) and very open. The commonest and most widespread species are *Atalaya hemiglauca* (whitewood), *Ventilago viminalis* (vine tree), *Acacia estrophiolata* (ironwood), *A. cambagei* (gidgee), and *Grevillea striata* (beefwood). *Hakea lorea* (corkwood), *Owenia acidula* (emu apple), *Ehretia saligna* (soapbox), *Acacia aneura* (mulga), and *A. coriacea* are represented in the drier parts, *Eremophila mitchellii* (budda) on solodic soils, and several eucalypts, especially *E. terminalis* (bloodwood), toward the wetter margins. On fine-textured soils *Atalaya hemiglauca*, *Grevillea striata*, and *Acacia cana* (boree) are the commonest trees and some of the other species do not occur. Many other species occur sporadically in various parts of the continuum.

Shrubs, approximately 3 ft high, are a fairly regular feature but are generally even less frequent than the trees. The common species are *Carissa lanceolata* (konkerberry), *Capparis* spp., *Cassia* spp. (turkey bush), and *Acacia* spp. In some areas on shallow soils on limestone shrubs (*Cassia* spp.) form a moderately dense layer whereas on cracking clay soils they rarely occur.

The normal grass layer is the arid short grass community but some stands occur with western mid-height grass, Mitchell grass downs, blue grass–browntop downs, and bare ground.

(2) *Isa Highlands Sparse Low Woodland.*—This community extends across northern Australia from the Kimberleys in Western Australia to western Queensland, generally on shallow or stony soils or on laterite and between the 15 and 27 in. mean annual rainfall isohyets. In the Leichhardt–Gilbert area it is typical of the Isa highlands but extends eastwards onto the low lateritic plateaux in the Carpentaria and inland plains. It does not occur in the Einasleigh uplands. As well as on skeletal soils and rock outcrops of the Cloncurry complex and on ferruginous, mottled, and pallid zones of lateritic profiles, it was recorded on small areas of red and yellow earths.

The community is very open with widely spaced low (10–20 ft) trees, mostly eucalypts. *Eucalyptus brevifolia* (snappy gum) is the commonest, particularly on acid rocks and laterites, but it is frequently absent from stands on basic rocks where *E. terminalis* (bloodwood) and *E. argillacea* (western box) are more typical. *E. dichromophloia* (bloodwood) is represented in the higher-rainfall parts and *E. pruinosa* (silverleaf box) is common particularly in somewhat better-watered areas. *E. papuana* (ghost gum), *E. setosa* (bloodwood), and *E. normantonensis* (mallee) occur sporadically. Non-eucalypt trees are uncommon but *Terminalia canescens* can be expected on stony areas on acid rocks and on laterite, *Petalostigma banksii* (quinine bush) in higher-rainfall parts, and *Grevillea striata* (beefwood) and *Atalaya hemiglauca* (whitewood) in better-watered parts under low rainfall.

Shrubs occur in most stands, normally at a low density but in some places moderately dense. *Acacia* spp. (including *A. chisholmi*, *A. leursenii*, and *A. hilliana*) are most common on acid rocks and laterite and *Cassia* spp. (turkey bushes) on limestone.

Typically the grass layer is western spinifex, but on plains with shallow soils it is arid short grass and in better-watered areas—depressions under low rainfall and plains under high rainfall—it is western mid-height grass.

(iii) *Tree Layer Low (< 20 ft) and Moderately Dense*

(1) *Bylong Low Woodland.*—The main area of this community is the southern part of the wide outwash plains which occupy the eastern part of the Carpentaria and inland plains (Bylong land system). Several other smaller areas occur but all are within these lowlands, and in all instances the soils are deep sands (brown soils of light texture) and the mean annual rainfall is 20–25 in.

The tree layer is low (15–20 ft) and moderately dense, the trees being of the order of five crown widths apart. Many species, mostly non-eucalypt, occur in an apparently haphazard pattern. *Bauhinia cunninghamii* (bean tree) appears to occur in more stands than most, but *Atalaya hemiglauca* (whitewood), *Grevillea striata* (beefwood), *Owenia acidula* (emu apple), *Acacia excelsa* (ironwood), *Albizia basaltica*, *Erythrophleum chlorostachys* (ironwood), *Terminalia aridicola*, and *Melaleuca nervosa*, *M. viridiflora*, and *M. acacioides* (paperbarks) are fairly constant. Many other species, including several eucalypts, are less constant. In some stands *E. polycarpa* (grey bloodwood) is an emergent growing to about 40 ft high.

Scattered shrubs occur in most stands. *Carissa lanceolata* (konkerberry) is the most constant but *Capparis* spp., *Phyllanthus* sp., and *Acacia farnesiana* (mimosa) are fairly common.

A feature of the community is that most of the trees and shrubs are grazed by stock.

The associated grass layer is three-awn–ribbon grass.

(2) *Paperbark Low Woodland.*—Most of this community occurs in a large block (Claraville, Mayvale, Prospect, and Strathmore land systems) which constitutes the central part of the outwash plains on the eastern side of the Carpentaria and inland plains. In this area it blankets almost all the country. Small areas occur in many other land systems in the same general area and extend somewhat onto the Einasleigh uplands but not onto the Isa highlands. It mostly occurs between the 20 and 30 in. mean annual rainfall isohyets and on red and yellow earths, brown soils of light texture, and red and yellow podzolics. Much of the country may be flooded with shallow water for short periods each wet season.

The tree layer consists very predominantly of *Melaleuca* spp. (paperbarks) including *M. nervosa*, *M. viridiflora*, *M. acacioides*, *M. symphyocarpa*, and others. The trees are fairly closely spaced (visibility is limited to 100 yd or so) and uniformly 15–20 ft high, giving the appearance of a dwarf forest in some stands. Other species form only a small proportion of any stand although a number occur in the community as a whole. They include *Terminalia platyptera*, *Bauhinia cunninghamii* (bean tree), *Grevillea parallela*, *Excoecaria parvifolia* (gutta percha), *E. pruinosa* (silverleaf box), *E. microneura* (Georgetown box), *Dolichandrone heterophylla*, *Celastrus cunninghamii*, *Petalostigma banksii* (quinine bush), *Gardenia vilhelmii*, and many others. *E. polycarpa* (grey bloodwood) is a sporadic emergent, 30–40 ft high, in some stands. Shrubs

about 3 ft high, especially *Carissa lanceolata* (konkerberry), *Phyllanthus* spp., and *Capparis* spp., are sparse but constant.

By far the most common grass layer is three-awn–ribbon grass, and the only other which occurs at all commonly is the solodic soil short grass. Western mid-height grass and western spinifex were recorded in occasional stands.

(3) *Deciduous Low Woodland.*—On rocky outcrop areas, particularly on granitic rocks but also on metamorphics, volcanics, and sedimentaries the vegetation is a low (20 ft) woodland in which many of the species are deciduous. Density varies considerably but is generally moderate. Floristic composition varies from place to place but some of the most constant species are *Terminalia platyptera, T. aridicola, Cochlospermum* sp., *Ficus* spp. (fig), *Gyrocarpus americanus*, and *Petalostigma banksii* (quinine bush). Less constant species are *Dolichandrone heterophylla, Bauhinia cunninghamii, Gardenia* spp., *Maba humilis* (ebony), *Erythrophleum chlorostachys* (ironwood), *Erythrina vespertilio* (coral tree), and *Brachychiton* spp. (bottle tree). *Brassaia actinophylla* and *Tristania suaveolens* occur in some stands where the mean annual rainfall is greater than about 40 in. Several shrubs are fairly constantly represented.

Mostly the ground is bare rock with a few scattered grasses. In some places eastern upland mid-height grass or three-awn–ribbon grass occur, but generally sparser than normal.

(4) *Mulga Low Woodland.*—This is one of the most widespread communities in arid Australia but in the Leichhardt–Gilbert area it occupies only several small areas in the far south-west where mean annual rainfall is less than 15 in. It is the major unit in Wonomo land system, where it occurs on Forsayth soils (medium-textured red earths) and is associated with arid short grass and western mid-height grass. Small areas also occur in Merlin land system on gravelly Sturgeon soils (coarse-textured red earths) and associated with western spinifex grass layer (*Triodia longiceps*).

The tree layer is low (< 20 ft). *Acacia aneura* (mulga) is by far the most common tree and occurs in all stands. It is very strongly over-dispersed with dense groves separated by intergroves in which the tree cover is sparse or absent. Other trees occur only sporadically. They include *A. estrophiolata* (ironwood), *Grevillea striata* (beefwood), *Atalaya hemiglauca* (whitewood), *Owenia acidula* (emu apple), *E. terminalis* (bloodwood), and *E. papuana* (ghost gum). Shrubs, *Cassia* spp. (turkey bushes) and *Eremophila* spp. (fuchsias), occur sporadically.

(5) *Gidgee Low Woodland and Forest.*—This community occurs mostly in the south-western corner of the area, generally on fine-textured soils under a mean annual rainfall of less than about 20 in. To a lesser extent it occurs on red earths and calcareous desert soils. It characteristically occurs in patches in country which is seemingly uniform except that some is occupied by gidgee and some by another community (grassland, silverleaf box low woodland, or arid sparse low woodland). The tree layer is low (< 20 ft) and moderately dense but in some areas is so dense that it forms a low forest. Gidgee (*Acacia cambagei*) is commonly the only species in the tree layer but *E. terminalis* (bloodwood), *Atalaya hemiglauca* (whitewood), and *Ventilago viminalis* (vine tree) occur sporadically.

Shrubs, *Carissa lanceolata* (konkerberry), *Eremophila* spp. (fuchsias), *Cassia* spp. (turkey bushes), and *Ehretia saligna* (soapbox), occur sparsely in some stands.

The community is commonly associated with bare ground or arid short grass. Small areas on grey and brown soils of heavy texture are associated with Mitchell grass downs and blue grass–browntop downs.

It is not a major component in any land system.

(6) *Silverleaf Box Low Woodland.*—This community extends across northern Australia from the Kimberleys in Western Australia to the Great Artesian Basin in Queensland. It mostly occurs on red and yellow earth soils between the 17 and 25 in. mean annual rainfall isohyets. Smaller areas occur on deep sandy soils and shallow skeletal soils and under slightly higher and lower rainfall. The tree layer is open to moderately dense and 15–20 ft high. *E. pruinosa* (silverleaf box) is by far the most common tree and occurs in all stands. A number of other low tree species occur sporadically. Of these *Atalaya hemiglauca* (whitewood), *Grevillea striata* (beefwood), and *E. terminalis* (bloodwood) are the most constant, *Melaleuca viridiflora* (paperbark), *Terminalia canescens*, and *Excoecaria parvifolia* (gutta percha) occur in some stands toward the higher-rainfall margin, and *Bauhinia cunninghamii* (bean tree), *Hakea arborescens*, *Celastrus cunninghamii*, *E. confertiflora*, and *E. polycarpa* (grey bloodwood) occur rarely. The shrub cover is sparse but *Carissa lanceolata* (konkerberry) has a high constancy and *Acacia* spp., *Phyllanthus* sp., and *Capparis* sp. occur in some stands.

The most common associated grass layer is western mid-height grass (particularly *Aristida* spp. and *Sehima nervosum*). On shallow, gravelly soils and deep sands western spinifex grass layer (*Triodia pungens*) is associated, on fine-textured soils particularly toward the higher-rainfall margin blue grass–browntop downs or three-awn–ribbon grass is the grass layer, and in the more arid areas some stands occur over arid short grass.

(iv) *Tree Layer Medium Height* (20–30 *ft*) *and Sparse*

(1) *Downs Sparse Woodland.*—This is a community which occurs across northern Australia on fine-textured soils where the mean annual rainfall is greater than 20–25 in. or under lower rainfall in areas with run-on. The tree layer is normally sparse, particularly towards the lower-rainfall margins, but is denser under higher rainfall and in some stands subject to flooding. Several species occur but *E. microtheca* (coolibah) is the only one with high constancy. *Excoecaria parvifolia* (gutta percha) is fairly constant in seasonally flooded areas and occurs on plains where the mean annual rainfall exceeds about 30 in. In the Leichhardt–Gilbert area no other species is at all important on cracking clays but on fine-textured yellow earths (Nangum) and fine-textured solodized solonetz (Miranda) *E. confertiflora*, *E. grandifolia*, *Bauhinia cunninghamii* (bean tree), and *Grevillea striata* (beefwood) occur also. Shrubs are normally absent but *Acacia farnesiana* (mimosa) is present in some stands.

The most common grass layer is blue grass–browntop downs. In the Gilbert "delta" and nearby, fairly large areas occur with solodic soil short grass. Smaller areas (low-rainfall margin) are associated with Mitchell grass downs. It occurs over saline

soil short grass on some salt meadow country near the Gulf of Carpentaria and where it occurs in shallow seasonal lagoons it is associated with lagoon vegetation.

(v) *Tree Layer Medium Height* (20–80 *ft*) *and Moderately Dense*

(1) *Western Box Woodland.*—This community is widely distributed across northern Australia but does not occupy large areas. It is most common on, but not limited to, fine-textured yellow earths under a mean annual rainfall of about 20–30 in.

The tree layer is moderately dense, with trees several crown widths apart, and most commonly about 30 ft high. In some stands it attains 50 ft. *E. argillacea* (western box) is by far the most common tree; it is present in all stands and in some is the only tree species. *Bauhinia cunninghamii* (bean tree), *Grevillea striata* (beefwood), and *E. microtheca* (coolibah) occur sparsely in a small proportion of stands. *Carissa lanceolata* (konkerberry) and *Capparis* spp., shrubs about 3 ft high, are fairly constant but sparse.

In the Leichhardt–Gilbert area the community occurs only near Normanton, where it is a major unit in Glenore land system on Nangum soils (fine-textured yellow earths) with blue grass–browntop downs. It also occurs on Vanrook soils (solodized solonetz). Similar habitats form only a minor proportion of Normanton land system, where some stands are associated with western mid-height grass or three-awn–ribbon grass.

(2) *Georgetown Box Woodland.*—This community is restricted to north Queensland, and mostly to the western slopes of the Einasleigh uplands (viz. the Einasleigh–Croydon–Mt. Norman area). Although its geographic distribution is limited it has a wide habitat range and, within its geographic range, it occupies a large proportion of the area. It is a major constituent of Georgetown, Belmore, Stanhill, Esmeralda, Strathpark, Hampstead, and Townley land systems. It occurs on brown soils of light texture, red and yellow earths, red and yellow podzolics, solodized solonetz, and shallow and skeletal soils and on igneous, metamorphic, and sedimentary rocks and alluvium.

The tree layer varies in height and density from about 20 ft high and very open on stony slopes to about 40 ft high and moderately dense (trees several crown widths apart) on better-watered areas. Most commonly it is about 30 ft high and moderately dense. *E. microneura* (Georgetown box) is by far the most common tree and is present in all stands. The only other trees of comparable height are *Erythrophleum chlorostachys* (ironwood), which is fairly constant but sparse, and several eucalypts which occur sparsely in some stands. A low tree layer 10 to 15 ft high is fairly common. *Petalostigma banksii* (quinine bush) is common on shallow soils and *Melaleuca* spp. (paperbarks) on flatter areas. *Bauhinia cunninghamii* (bean tree), *Alphitonia excelsa*, *Ventilago viminalis* (vine tree), *Dolichandrone heterophylla*, *Terminalia ferdinandiana*, *T. aridicola*, and several others occur sparsely in some stands. *Carissa lanceolata* (konkerberry), a shrub about 3 ft high, is fairly constant but sparse. Several other shrubs, *Dodonaea filifolia*, *Acacia* sp., and *Distichostemon* sp., are less constant.

Most commonly the associated grass layer is either three-awn–ribbon grass or eastern mid-height grass. Small areas on solodic soils occur with solodic soil short grass and rugged stony areas have bare ground or western spinifex.

(3) *Downs Woodland.*—The fine-textured soils (mainly black earths, Rosella family) of the Einasleigh uplands, particularly where mean annual rainfall exceeds 25–30 in., commonly carry a woodland in which the tree layer varies from about 30 to 60 ft high and from open to moderately dense as mean annual rainfall increases.

Towards the lower-rainfall margin *E. orgadophila* is the most common tree and lower trees, *E. terminalis* (bloodwood) and *Atalaya hemiglauca* (whitewood), are present in some stands. With increasing rainfall *E. leptophleba* (box) and *E. orgadophila* are the common trees and under high rainfall (35–50 in.) *E. crebra* (ironbark) and *E. howittiana* occur in some stands.

The community is small in area and is invariably associated with the blue grass–browntop downs grass community.

(4) *Stringybark Woodland.*—Across northern Australia from the Kimberleys in Western Australia to Cape York Peninsula in Queensland where mean annual rainfall exceeds about 27 in. the stringybark woodland continuum is the common vegetation on coarse-textured and lateritic soils. In the Leichhardt–Gilbert area it is the main unit in Dandry, Abingdon, and Normanton land systems and is a small constituent of several others. It occurs on brown soils of light texture (Cockatoo family), red and yellow earths (Sturgeon, Clarina, and Wonorah families), and skeletal and stony soils on scarps.

The tree layer is normally 40–60 ft high and moderately dense. It is lower and more open toward the low-rainfall margin and higher and denser under high rainfall. The common species are *E. tetrodonta* (stringybark), *E. miniata* (woollybutt), and *E. dichromophloia* (bloodwood), but none is present in all stands. *E. tetrodonta* and *E. miniata* are most common under high rainfall and are generally absent from areas where mean annual rainfall is less than about 30 in. Stands in such areas or on steep stony slopes are commonly characterized by *E. dichromophloia* alone. Other tree species which occur sparsely and less constantly are *E. polycarpa* (grey bloodwood), particularly on deep sandy soils, *E. microneura* (Georgetown box), particularly adjacent to western slopes of the Einasleigh uplands, and *E. leptophleba* (box) on deep sandy soils. A low tree layer, 10–25 ft high, normally sparse but in some stands approaching moderate density, is commonly present. *Erythrophleum chlorostachys* (ironwood), *Planchonia careya* (cockatoo apple), and *Petalostigma banksii* (quinine bush) are the most constant species. *P. banksii* is particularly prominent on shallow and stony soils. Less constant low tree species include *Acacia* spp., *Melaleuca* spp., *Grevillea* spp., *Gardenia* spp., *Bauhinia cunninghamii*, *E. setosa* (bloodwood), and *E. confertiflora*. Shrubs are present but sparse in most stands.

In the Leichhardt–Gilbert area the common grass layer is three-awn–ribbon grass but small areas occur with three-awn grass and near the lower-rainfall margins and on shallow and stony soils the grass layer is western spinifex.

(5) *Ironbark Woodland and Forest.*—Except for a few small areas on the eastern margin of the Carpentaria and inland plains this continuum is confined to the Einasleigh uplands. Nowhere in northern Australia does it occur west of the Great Artesian Basin but it extends north and south of the Leichhardt–Gilbert area along most of the length of Queensland. In the Leichhardt–Gilbert area it occurs under

a mean annual rainfall exceeding 20 in., on red and yellow earths, red and yellow podzolics, krasnozems, brown soils of light texture, and shallow stony soils on igneous, metamorphic, and sedimentary rocks.

In most stands the tree layer is 30–50 ft high and moderately dense (trees several crown widths apart) but toward the low-rainfall margin and on rocky areas with excessive run-off some stands are only 20 ft high and very open. On the other hand, in some stands on plains with deep sandy soils under moderate rainfall or medium-textured soils under high rainfall the tree layer is higher (80–100 ft, and in a few stands up to 120 ft) and denser (canopies touching). The most common and constant tree species is *E. crebra* (ironbark). It is present in most stands except those near the lower-rainfall margins, on rocky areas with high run-off, and some special habitats. Of the other ironbarks *E. drepanophylla* (narrow-leaf ironbark) was not satisfactorily separated from *E. crebra* in the field but is thought to occur in association with *E. crebra* in better-watered habitats. *E. melanophloia* (silverleaf ironbark) grows under lower rainfall and commonly on shallow soils. *E. shirleyi* (silverleaf ironbark) occupies the most arid habitats in the continuum. It normally occurs on rock outcrops and extends to the low-rainfall margin. It rarely exceeds 20 ft in height and stands are very open. *E. whitei* (ironbark) is common on basalt in the lower part of the rainfall range. It was not always distinguished from *E. crebra* and may occur more widely.

As well as ironbarks, many other eucalypts occur in the tree layer. Of these *E. dichromophloia* has a high constancy, particularly in stands on shallow soils. *E. papuana* (ghost gum) is less constant but is prominent on krasnozems and in stands in better-watered habitats. *E. polycarpa* (grey bloodwood) and *E. leptophleba* (box) are common on deeper soils. On sandy soils where the mean annual rainfall is less than 30 in., *E. miniata* (woollybutt) and *E. similis* (yellowjack) are present in some stands. *E. citriodora* (lemon-scented gum), *E. cloeziana* (stringybark), *E. tessellaris* (Moreton Bay ash), and *E. howittiana* occur only in the tallest and densest stands, probably the best-watered habitats. *Tristania suaveolens* and *Casuarina inophloia* are also limited to these stands. *E. peltata* (yellowjack), *E. trachyphloia*, and *E. exserta* occur in rocky or shallow soil areas and are therefore commonly associated with *E. shirleyi* (silverleaf ironbark). *E. terminalis* is restricted to lower-rainfall parts, *E. microneura* (Georgetown box) to some stands near the western margin of the continuum, and *E. cambageana* to higher-rainfall parts.

A sparse low tree layer (10–20 ft high) is present in most stands. It includes *Bursaria incana*, *Planchonia careya* (cockatoo apple), *Hakea arborescens*, *Erythrophleum chlorostachys* (ironwood), *Petalostigma* spp. (quinine bush), *Acacia* spp., *Dolichandrone heterophylla*, *Alphitonia excelsa*, *Persoonia falcata*, *Grevillea* spp., *E. setosa*, *E. confertiflora*, and many others. Shrubs are very sparse but fairly constant.

The most constantly associated grass layer is eastern mid-height grass. Small areas occur with eastern spinifex on sandy soils in the south-eastern corner of the area (near Pentland), with three-awn or three-awn–ribbon grass on flatter parts of the topography towards the western margin (near Einasleigh and Forsayth), and with bare rock or western spinifex on steep or stony habitats.

(6) *Poplar Gum–Grey Bloodwood Woodland.*—This community is restricted to the higher-rainfall parts (> 30 in.) of the Einasleigh uplands. It mostly occurs on deep

sandy soils but also on finer-textured soils (even solodized solonetz) under high rainfall (>40 in.) and in areas of restricted drainage. It is more common on granite than other rocks.

The tree layer is 50–60 ft high and moderately dense. *E. alba* (poplar gum) and *E. polycarpa* (grey bloodwood) are the most constant species but neither is present in all stands. *E. tessellaris* (Moreton Bay ash) and *E. leptophleba* (box) occur under higher-rainfall conditions. In some poorly drained areas dense stands of *Melaleuca* spp. (paperbarks) about 15–20 ft high occur. About the same height, *Grevillea pteridifolia*, *Alphitonia excelsa*, *Melaleuca* spp., and other species are sparsely represented in many stands.

Eastern mid-height grass was the only associated grass layer recorded in the Leichhardt–Gilbert area.

(7) *Reid River Box Woodland.*—This community has a virtually monospecific tree layer and is restricted to the Einasleigh uplands. It occurs in eastern Queensland north and south of the Leichhardt–Gilbert area but does not extend west across the Great Artesian Basin. Although widespread it typically occurs in small areas on lower slopes, where soils are shallow, fine-textured solodized solonetz.. It is represented in many land systems as a small unit but it occupies major areas in only one, viz. Niall land system, which is an undulating plain developed on sediments of the Broken River group.

The tree layer is 30–50 ft high and fairly dense (trees 1–3 crown widths apart). *E. brownii* (Reid River box) is normally the only species and it occurs in all stands. *E. crebra* (ironbark) has a low constancy. Low trees, 10–20 ft high, are present in most stands but only sparsely. *Eremophila mitchellii* (budda), *Petalostigma* sp. (quinine bush), and *Erythroxylum australe* are the most constant but *Alphitonia excelsa*, *Dolichandrone heterophylla*, *Grevillea parallela* (narrow-leaf beefwood), and several others occur in some stands. *Carissa lanceolata* (konkerberry), a shrub about 3 ft high, is constant but sparse.

The most common ground layer is eastern mid-height grass, generally sparser than normal. The habitat is highly erodable and many stands have patches of bare ground. On small areas blue grass–browntop downs, three-awn, and three-awn–ribbon grass and eastern spinifex were recorded.

(8) *Frontage Woodland.*—Levees, with coarse-textured soils, are a common feature adjacent to watercourses in northern Australia. They are commonly known as frontage country and for this reason the distinctive vegetation associated with them is called frontage woodland. The density, height, and floristic composition of the main tree layer vary with rainfall. Under low rainfall (<20 in.) it is open and 20–30 ft high and *E. papuana* (ghost gum), *E. terminalis* (bloodwood), and *Bauhinia cunninghamii* are the most common and constant species. Up to about the 25-in. mean annual rainfall isohyet the same species occur but generally denser and 30–40 ft high, and *E. pruinosa* (silverleaf box) occurs in some stands. From about 25 to 30 in. the trees are 40–60 ft high and *E. polycarpa* (grey bloodwood) is more common than *E. terminalis* but *E. papuana* remains common. *E. confertiflora* also occurs. Above about 30 in. the tree layer is about 60 ft high and moderately dense. *E. leptophleba* (box) occurs in some stands with *E. papuana* and *E. polycarpa* and in some it occurs

alone. *E. crebra* (ironwood) also occurs in some stands. Under high rainfall (> 40 in.) stands are characterized by one or more of *E. papuana*, *E. polycarpa*, *E. leptophleba*, *E. crebra*, *E. tessellaris* (Moreton Bay ash), *E. alba* (poplar gum), and *E. camaldulensis* (river red gum). *E. tectifica* (box) is represented in small areas in the north-west (25–30 in.), and *E. foelscheana* (bloodwood), *E. grandifolia* (cabbage gum), and *E. tetrodonta* (stringybark) occur along some parts of the lower Gilbert River.

A sparse, low (10 to 30 ft depending on rainfall) tree layer is present in most parts. Many species were recorded but *Bauhinia cunninghamii* (bean tree) and *Erythrophleum chlorostachys* (ironwood) are the most constant and *Planchonia careya* (cockatoo apple) and *Melaleuca* spp. (paperbarks) are fairly constant in the higher-rainfall parts.

Shrubs, 3–5 ft high, occur sparsely in most stands. *Acacia farnesiana* (mimosa) and *Carissa lanceolata* (konkerberry) are the most constant. The associated grass layer is frontage grass.

(vi) *Tree Layer Moderate Height (20–80 ft) and Dense*

(1) *Dune Woodland and Forest.*—The vegetation of the coastal sand dunes is distinctive. The upper tree layer, about 40 ft high and moderately dense, includes *E. papuana* (ghost gum), *E. polycarpa* (grey bloodwood), and *Erythrina vespertilio* (coral tree). The lower tree layer about 20 ft high and dense includes *Pandanus* sp., *Ficus* sp. (fig), *Erythrina vespertilio* (coral tree), *Grevillea striata* (beefwood), *Myoporum* sp. (boobialla), *Maba humilis* (ebony), *Erythrophleum chlorostachys* (ironwood), and many other species. A number of shrubby species also occur. The grass layer includes *Sporobolus virginicus* (salt couch grass), *Aristida browniana* (kerosene grass), *Vetiveria pauciflora*, *Panicum delicatum*, and *Chrysopogon fallax*.

(2) *Lancewood Woodland and Forest.*—This community is widespread in northern Australia, extending from the western part of the Northern Territory across to the east coast of Queensland. Where the mean annual rainfall is between about 20 and 30 in. it is characteristic of steep scarps of lateritic mesas and plateaux, and although widespread mostly occupies only a small proportion of the area. Its largest development is in the Leichhardt–Gilbert area where it occurs on dissected sandstones of the Blythesdale and Rolling Downs groups. It occupies the major part of Torwood, a moderate part of Ortona, and small areas in several other land systems.

Acacia shirleyi (lancewood), a tree 20–30 ft high, characterizes the tree layer and is present in all stands. The tree layer is normally dense (crowns touching) but some stands, particularly on very rocky areas and under low rainfall, are more open. In only a few stands are any other tall tree species present, and then only sparsely. *E. trachyphloia*, *E.* sp. aff. *normantonensis*, and *E. howittiana* were the only ones recorded. Low trees (10–15 ft high) are also infrequent but *Petalostigma banksii* (quinine bush), *Canthium* sp., *Terminalia ferdinandiana*, *Bursaria incana*, and *Alphitonia excelsa* were recorded in some stands toward the higher-rainfall margin.

Shrubs are absent, or at best occasional. The ground is normally virtually bare although quite a lot of species occur sporadically. Small areas are associated with western spinifex or eastern spinifex.

(3) *Fringing Woodland and Forest.*—In most parts of the area the tallest and densest vegetation is along the banks of the watercourses. It varies considerably in height and floristic composition but except for small channels under low rainfall

the density is such that the crowns of the trees at least touch. Height varies from about 20 ft in the driest situations to about 80 ft along large, permanent watercourses. The most constant species, along all but the smallest channels, is *E. camaldulensis* (river red gum). Along larger channels one or more of *Melaleuca leucadendron* (paperbark), *Cathormion umbellatum*, *Terminalia* spp., *Tristania suaveolens*, *Nauclea orientalis* (Leichhardt pine), and *Ficus* sp. (fig), associated with *E. camaldulensis* and *Pandanus* sp., is common. On heavy soil all but the larger channels are fringed by *E. microtheca* (coolibah) or *Excoecaria parvifolia* (gutta percha). Small channels in the driest parts of the area are fringed by *Acacia cambagei* (gidgee) or *E. argillacea* (western box). In the high-rainfall parts of the Einasleigh uplands *Casuarina cunninghamiana* is a fairly constant companion of *E. camaldulensis* (river red gum), and *Melaleuca* spp. (paperbark), *E. tereticornis* (red gum), and *E. tessellaris* (Moreton Bay ash) are less constant. *Melaleuca bracteata* (black tea-tree) fringes smaller streams in the basalt country. Muddy foreshores and salt-water channels are fringed with mangroves.

Low trees and shrubs occur in some stands and a distinctive grass layer, commonly including tall grasses, is generally present. Small areas occur with lagoon vegetation.

(4) *Microphyll Vine Woodland.*—On the rough stony lava flows of Recent age the vegetation is a dense low (20–30 ft) community characterized by a mixture of non-eucalypt species. A similar community 30–40 ft high occurs in small areas of restricted drainage with above about 35 in. rainfall and on favourable aspects of hills where the mean annual rainfall exceeds about 45 in.

(*c*) *Grass Layer Continua*

(i) *Grass Layer Absent (or Nearly So)*

(1) *Bare Ground.*—Some areas, such as the coastal mud flats, eroded and scalded areas, and rock faces are entirely bare of ground vegetation. As well as these, very large areas of dissected sandstone country which have extremely sparse ground vegetation have been classified here. Fairly constant plants include *Cleistochloa subjuncea*, *Lomandra leucocephala* (iron grass), *Schizachyrium obliqueberbe*, *Rottboellia formosa*, and *Eriachne ciliata*.

Bare ground is the major unit on the saline mud flats of Carpentaria land system, on the steep rocky slopes of Torwood and Ortona land systems, and on the rocky lava flows of Toomba land system. It is a small part of many other land systems.

(2) *Samphire Flats.*—These occur only in Carpentaria land system and are those parts of the coastal saline mud flats on which occasional bushes of samphire occur. They are useless for grazing.

(ii) *Grass Layer Characterized by Water Plants*

(1) *Lagoon Vegetation.*—Shallow lagoons occur in many land systems. Their vegetation is variable and depends on the depth, frequency, and length of flooding. Where shallow water lies more or less permanently, various waterlilies constitute the vegetation. Annual flooding for much of the year tends to produce *Eleocharis* spp. Shallow flooding for shorter periods on heavy soils produces *Oryza australiensis* (native rice), *Sesbania* spp. (Sesbania pea), and *Aeschynomene indica* and in other

high-rainfall areas produces *Leersia hexandra*, *Ischaemum arundinaceum*, and *Imperata cylindrica* (blady grass). Characteristic plants of short-term flooding are *Pseudoraphis spinescens* (water couch), *Marsilea* sp. (nardoo), and *Eragrostis* spp. All these occur as concentric zones around deeper lagoons and lakes.

The lagoons are normally treeless but shallow lagoons and the outer zone of larger ones are commonly associated with a fringing woodland and some with downs sparse woodland.

The areas provide nutritious but limited grazing.

(iii) *Grasses Short* (< 12–18 *in.*), *Annuals or Short-lived Perennials*

(1) *Arid Short Grass.*—This is a community which is widespread throughout arid Australia. In the Leichhardt–Gilbert area it is best developed in the south-western corner, where it occurs on grey-brown and red calcareous desert soils, rendzinas, red-brown earths, red and yellow earths, solodized solonetz, and shallow skeletal soils and is the common understorey of the arid sparse low woodland. As with the arid sparse low woodland it extends into higher-rainfall areas (up to about 25 in.) on gravelly areas of grey and brown soils of heavy texture, calcareous desert soils, and shallow skeletal soils on limestone. It is also the most common grass community associated with mulga and gidgee low woodlands and in some areas is associated with trees absent, Isa highland sparse low woodland, and silverleaf box woodland.

The grass layer is short, normally only about 6 in. high, and ground cover is low. The most common and constant species are *Aristida arenaria* (kerosene grass) and *Enneapogon* spp. (*E. polyphyllus* and *E. avenaceus*). *Brachyachne convergens* (native couch grass) and *Dactyloctenium radulans* (button grass) tend to be more common on finer-textured soils. Other common species are *Aristida hirta*, *A. hygrometrica* (kerosene grasses), *Sporobolus australasicus*, *Tragus australianus* (burr grass), *Tripogon loliiformis*, *Chloris scariosa* (star grass), *Sida fibulifera*, *Portulaca oleracea*, *Bassia* spp., *Salsola kali*, and *Cleome viscosa*. Occasional tussocks of taller grass occur, *Aristida jerichoensis* on coarse to medium-textured soils and *A. latifolia* and *A. anthoxanthoides* on finer-textured soils. Gilgais have blue grass–browntop downs community.

The community provides good-quality forage but yield is low.

(2) *Solodic Soil Short Grass.*—The largest areas of solodized solonetz soils carrying short grass occur in the Gilbert "delta", particularly in the upper parts. Similar country occurs in the linear, flat-floored depressions which are a small but characteristic feature of many of the land systems on the western slopes of the Einasleigh uplands. Small areas are present in the broad outwash plains in the eastern part of the Carpentaria and inland plains and on the low lateritic plateaux in the plains. The areas are most commonly treeless but downs sparse woodland is associated with moderate areas. Paperbark low woodland is frequently associated with it around the margins of the depressions and it was recorded occasionally under Georgetown box woodland.

The grass layer is only about 6 in. high. The most common and constant species are *Aristida hirta*, *A. superpendens* (kerosene grasses), *Chloris scariosa* (star grass), and *C. pumilio*. *Eriachne armittii*, a taller grass, is also common and *Chrysopogon fallax* (ribbon grass) occurs in small, almost monospecific patches. Less common species are *Aristida hygrometrica* (kerosene grass), *Polycarpaea* spp., *Gomphrena* sp., *Schizachyrium obliqueberbe*, *Eragrostis speciosa*, *Eriachne melicacea*,

E. obtusa, *E. stipacea*, *Panicum majusculum*, *Perotis rara* (comet grass), *Pseudopogonatherum contortum*, *Heterachne gulliveri*, *Ectrosia leporina*, *Bulbostylis barbata*, *Sacciolepis indica*, *S. myosuroides*, and *Sorghum* sp.

Pastorally the community provides good-quality forage but the yield is relatively low.

(3) *Saline Soil Short Grass.*—In the Leichhardt–Gilbert area this community is confined to the salt meadows of Carpentaria land system. It occurs in similar situations around the whole northern coast of Australia. It is normally treeless, but in some areas is associated with downs sparse woodland. The grass layer is 6 to 12 in. high and fairly dense. On the lower, more saline areas, the characteristic plant is *Sporobolus virginicus* (salt couch grass) and on slightly higher areas it is *Xerochloa imberbis* (rice grass). Less common species are *Chloris divaricata*, *C. pumilio*, *Salsola kali*, *Bassia* spp., and *Fimbristylis* spp.

The community produces a moderate yield of fairly good-quality forage but the areas are limited.

(iv) *Grasses Short* (< 12 *in.*), *Perennial*

(1) *Couch Grass.*—Small areas of swampy country with wiesenboden (Spring family) or black earth (Rosella family) soils occur in the Einasleigh uplands. They are treeless with a dense, short grass layer characterized by *Cynodon dactylon* (couch grass). Other short species include *Triraphis mollis*, *Eriochloa procera*, *Chloris virgata*, *Eragrostis* sp., and *Iseilema macratherum* (Flinders grass). Taller grasses, including *Bothriochloa intermedia* (blue grass), *Dichanthium sericeum* (blue grass), and *Chloris divaricata*, occur in patches.

The small areas are confined to Rosella, Boonderoo, and Niall land systems. Although very limited in extent the community produces a high yield of good-quality forage and has a high stocking rate.

(v) *Grass Layer Mid-height* (1½–4 *ft*), *Moderately Dense, Perennial Drought-evading Grasses*

(1) *Mitchell Grass Downs.*—This community occupies very large areas of treeless rolling plains with calcareous cracking clay soils developed on sediments of the Rolling Downs group. It is prominent in the southern part of the Carpentaria and inland plains. Mean annual rainfall is less than 25 in. The community is widespread on heavy clay soils across northern Australia, extending westwards to the Kimberleys and southwards to northern New South Wales.

The community is normally treeless. In the Leichhardt–Gilbert area small areas are associated with downs sparse woodland, particularly toward the higher-rainfall margin or in depressions, with arid sparse low woodland particularly where the soils are gravelly, and with gidgee low woodland on country which in many places appears no different from adjacent treeless areas.

The most common and constant grasses in the mid-height grass layer are *Astrebla* spp. (Mitchell grasses). *Astrebla squarrosa* (bull Mitchell grass) and *Astrebla lappacea* (curly Mitchell grass) are characteristic of the rolling downs on Mesozoic sediments. *Astrebla pectinata* (barley Mitchell grass) is characteristic of the downs on Cambrian sediments (south-western corner of the area) and also occurs on the rolling downs near the southern margin of the area. *Astrebla elymoides* (weeping

Mitchell grass) occurs only in small depressions within the barley Mitchell grass plains. Typically the Mitchell grass tussocks are 1½ to 3 ft high with a basal diameter of 6 to 9 in. and are spaced at 2 to 4 ft centres.

Many other mid-height grasses occur in the community, but only infrequently. The commonest of these, *Aristida latifolia* (feathertop), appears to increase under heavy grazing or in seasons with winter rainfall. Others include *Panicum whitei, P. decompositum* (panics), *Eulalia fulva* (browntop), *Eriochloa crebra, E. pseudoacrotricha, Leptochloa digitata, Bothriochloa ewartiana* (blue grass), *Dichanthium superciliatum* and *D. fecundum* (blue grasses), and *Pennisetum basedowii.* In better-watered habitats these grasses are more common and the community grades into the blue grass–browntop community. Forbs of similar height, or somewhat taller, include *Hibiscus ficulneus, Cassia sophera,* and *Sesbania* sp. They are not common.

Except in drought years the interspaces between the perennial grass tussocks have a dense cover of short grasses and forbs 6–12 in. high. By far the commonest and most constant of these are *Iseilema* spp. (Flinders grasses). Other grasses include *Chionachne hubbardiana, Eragrostis japonica, Sporobolus australasicus,* and *Digitaria ctenantha.* Small legumes include *Alysicarpus rugosus, Psoralea cinerea* (virbene), *Crotalaria medicaginea* (rattlepod), and *Neptunia* spp. Among the other forbs are *Flaveria australasica, Sida* spp., *Portulaca oleracea, Gomphrena brownii, Corchorus* spp., *Boerhavia diffusa* (tar-vine), *Pterigeron odorus* (stinkweed), and *Malvastrum spicatum.*

The community provides a moderate yield of forage of good quality during and shortly after the wet season and of poor quality during the dry season. It has a fairly high stocking rate and is the mainstay of the sheep industry in the area.

(2) *Blue Grass–Browntop Downs.*—This is virtually the higher-rainfall, or better-watered, equivalent of Mitchell grass downs and grades into that community. It is widely distributed in northern Australia on heavy clay soils where rainfall exceeds about 25 in. or in depressions or temporarily flooded areas under lower rainfall. It is the common community of gilgais over a very large part of northern Australia.

Typically it is treeless or, particularly in better-watered parts, associated with downs sparse woodland. In some parts in the Einasleigh uplands it is associated with downs woodland and in Glenore and Normanton land systems it occurs on Nangum soils with western box woodland. Small areas occur with arid sparse low woodland, gidgee low woodland, silverleaf box low woodland, and Reid River box woodland.

The mid-height grass layer is composed of perennial drought-evading tussock grasses. The layer is taller (3–4 ft) and denser than in Mitchell grass downs and the individual tussocks tend to have a smaller basal diameter. The community is also floristically more variable and none of the species is more than moderately constant. The most common and constant of the mid-height grasses are *Dichanthium fecundum, D. superciliatum* (blue grasses), and *Eulalia fulva* (browntop). Slightly less constant are *Astrebla squarrosa* (bull Mitchell grass), *Aristida latifolia* (feathertop), *Bothriochloa intermedia, B. ewartiana* (blue grasses), and *Chrysopogon fallax* (ribbon grass). *Ophiuros exaltatus* (cane grass), a taller grass, is common in patches under somewhat wetter conditions than normal. In seasonally flooded depressions *Oryza australiensis* (native rice), *Leptochloa brownii,* and the tall forbs *Sesbania* sp., *Aeschynomene indica,* and *Eleocharis* spp. form a tall layer and *Pennisetum basedowii* and *Eriachne squarrosa*

occur with other mid-height grasses. The shrub *Chenopodium auricomum* (bluebush) occurs sparsely in these areas. On Miranda soils in the Gilbert "delta" some of the species (particularly *Eriachne* spp. and *Chrysopogon fallax*) of the solodic soil short grass are prominent. In the Einasleigh uplands where the rainfall exceeds about 35 in. *Themeda australis* (kangaroo grass) and *Heteropogon contortus* (black spear grass) occur in the downs continuum, although they are more normally characteristic of the eastern mid-height grass continuum.

Possibly because of the greater density of the mid-height grass layer, the short grass layer does not contribute as much bulk as it does in the Mitchell grass downs. However, many species are represented in it. The most common grasses are *Iseilema* spp. (Flinders grasses), *Echinochloa colonum* (awnless barnyard grass), *Eragrostis japonica* (love grass), *Eriochloa procera*, *Elytrophorus spicatus* (spike grass), and *Brachyachne convergens* (native couch grass). *Cynodon dactylon* (couch grass) grows in some stands in the Einasleigh uplands. Legumes include *Rhynchosia minima*, *Alysicarpus rugosus*, *Neptunia* spp., and *Psoralea* spp. Among the other forbs are *Borreria* spp., *Polymeria* sp., *Sida* spp., *Hibiscus* spp., *Corchorus* spp., *Ipomoea* spp., and *Convolvulus* spp.

The community provides a greater bulk of somewhat poorer-quality forage than Mitchell grass downs, with the possible exception of areas on basalt where forage quality is good. It has a relatively high carrying capacity.

(3) *Eastern Mid-height Grass.*—This community occurs over most of the Einasleigh uplands. Similar communities extend throughout eastern Queensland and in other parts of northern Australia where mean annual rainfall exceeds about 25 in. In the Leichhardt–Gilbert area it occurs on krasnozems, red and yellow earths, red and yellow podzolics, brown soils of light texture, and shallow, stony soils. It is most commonly associated with ironbark woodland and forest but also occurs with poplar gum–grey bloodwood woodland, Reid River box woodland, Georgetown box woodland, and deciduous low woodland. It is somewhat similar to the native pasture described by Arndt and Norman (1959) on Tippera clay loam.

The mid-height grass layer is dense and is composed of perennial drought-evading tussock grasses, 3–4 ft high and with small (mostly < 3 in.) basal diameters. The most common and constant species are *Themeda australis* (kangaroo grass), *Bothriochloa ewartiana* (blue grass), *Heteropogon contortus* (black spear grass), and *Aristida* spp. (three-awns) including *A. armata*, *A. inaequiglumis*, *A. biglandulosa*, *A. ingrata*, *A. jerichoensis*, *A. ramosa*, *A. queenslandica*, *A. glumaris*, *A. perniciosa*, *A. pruinosa*, and *A. praealta*. Of these *Themeda* and *Bothriochloa* tend to be the most common on deeper soils and the various *Aristida* spp. are particularly represented on steeper slopes and towards the lower-rainfall margins. Moderately constant grasses of similar height include *Dichanthium fecundum*, *D. sericeum* (blue grasses), *Rhynchelytrum repens* (red Natal grass), *Panicum simile*, *P. decompositum*, *Cymbopogon bombycinus* (citronella grass), *Alloteropsis semialata*, *Bothriochloa decipiens* var. *cloncurrensis* (pitted blue grass), *Eulalia fulva* (browntop), *Sorghum plumosum*, and *Sehima nervosum*. *Heteropogon triticeus* (giant spear grass) is fairly constant on stony areas. Forbs of similar height are not common but include *Notoxylinon australe*, *Achyranthes aspera*, *Trichodesma zeylanicum*, *Waltheria indica*, *Grewia retusifolia*, and *Hibiscus radiatus*.

Shorter grasses and forbs are relatively unimportant as far as yield is concerned but very many species are represented. The more constant grasses include *Enneapogon pallidus, E. polyphyllus, Aristida hygrometrica* (kerosene grass), *Sporobolus australasicus, Perotis rara, Eragrostis japonica* (love grass), *E. pubescens, Digitaria parviflora, D. brownii, Setaria brownii, Schizachyrium obliqueberbe, Brachiaria holosericea, B. piligera,* and *B. miliiformis.* Legumes include *Indigofera linnaei, I. hirsuta, I. linifolia, Desmodium biarticulatum, D. filiforme, Glycine falcata, Zornia albiflora, Galactia* sp., and *Tephrosia* spp. Among the other forbs are *Borreria* spp., *Sida* spp., *Evolvulus alsinoides, Bonamia media, Polycarpaea* spp., *Goodenia* sp., *Gomphrena* spp., *Pterocaulon glandulosum,* and *Boerhavia diffusa* (tar-vine).

The community provides a moderate yield of fair-quality forage and has a relatively high stocking rate. Its stocking rate is higher where it occurs on basalt, possibly owing to better-quality forage.

(4) *Western Mid-height Grass.*—In the western part of the area, particularly on plains adjacent to the Isa highlands and the low plateaux in the Carpentaria and inland plains, a community similar to eastern mid-height grass has developed. It is shorter (2–3 ft), more open, and has a somewhat different floristic composition. It occurs on red and yellow earths and shallow skeletal soils, generally where rainfall exceeds about 17–20 in. but with run-on it extends into more arid areas.

The most constant mid-height grasses are *Aristida* spp. (particularly *A. pruinosa* and *A. inaequiglumis*), *Sehima nervosum,* and *Themeda australis* (kangaroo grass). Less constant and less common are *Chrysopogon fallax* (ribbon grass), *Aristida anthoxanthoides* (three-awn), *Heteropogon contortus* (black spear grass), *Eulalia fulva* (browntop), *Dichanthium fecundum* (blue grass), *Bothriochloa ewartiana* (blue grass), and *Cymbopogon bombycinus* (citronella grass). *Triodia pungens* (soft spinifex) occurs sparsely but moderately constantly. Forbs of similar height are rare.

Shorter grasses and forbs form a larger proportion of the community than in the eastern mid-height grass community. Common short grasses are *Aristida hygrometrica, A. arenaria* (kerosene grasses), *Sporobolus australasicus, Brachyachne convergens* (native couch grass), *Eriachne armittii, E. ciliata, Enneapogon polyphyllus, Paspalidium rarum, Digitaria brownii, Rottboellia formosa, Panicum australiense, P. majusculum,* and *Dactyloctenium radulans* (button grass). Small legumes are rare but include *Indigofera* spp., *Crotalaria medicaginea,* and *Tephrosia* spp. Other forbs include *Ptilotus* spp., *Bonamia media, Evolvulus alsinoides,* and *Cleome viscosa.*

The community is the most common understorey associated with the silverleaf box woodland. It is less common under arid sparse low woodland and Isa highland sparse low woodland and in small areas it occurs with mulga low woodland, western box woodland, paperbark woodland, or trees absent.

Yield is lower than for eastern mid-height grass but quality seems to be fairly good. Its stocking rate is only moderate.

(5) *Three-awn.*—This community is restricted to undulating plains, mainly on granite and felsite, in the Croydon–Georgetown part of the area. The soils are mostly shallow and the rainfall about 25 in. It occurs under Georgetown box woodland, ironbark woodland, stringybark woodland, and Reid River box woodland.

The mid-height grass layer varies from sparse to moderately dense and is patchy. The common species are *Aristida armata*, *A. pruinosa*, *A. inaequiglumis*, and *A. praealta* (three-awns). Less constant are *Chrysopogon fallax* (ribbon grass), *Bothriochloa ewartiana* (blue grass), *Dichanthium fecundum* (blue grass), *Themeda australis* (kangaroo grass), *Heteropogon contortus* (black spear grass), and *Rhynchelytrum repens* (red Natal grass). A moderately dense short grass layer in which *A. hygrometrica* (kerosene grass) is the most constant species is present. Others include *Schizachyrium obliqueberbe*, *Rottboellia formosa*, *Digitaria brownii*, *Eragrostis japonica* (love grass), *Perotis rara* (comet grass), *Setaria brownii*, *Evolvulus alsinoides*, *Borreria* spp., *Polycarpaea* spp., and *Cleome viscosa*.

The community may be only the extreme western form of the eastern mid-height grass community. It also grades into the three-awn–ribbon grass community.

Forage yield is only moderate and quality is poor. It has a moderate stocking rate.

(6) *Three-awn–Ribbon Grass.*—This is the characteristic understorey community of the broad outwash plain of the east of the Carpentaria and inland plains. To the west of this, small areas are associated with the low lateritic plateaux of the plains, and to the east, small areas occur on the western slopes of the Einasleigh uplands. It occurs on brown soils of light texture, red and yellow earths, and red and yellow podzolics. It is the most common understorey associated with the paperbark low woodland, Bylong low woodland, Georgetown box woodland, and stringybark woodland and occurs under small areas of the silverleaf box low woodland, western box woodland, ironbark woodland, frontage woodland, Reid River box woodland, and deciduous low woodland. Very small areas are treeless.

Mid-height grasses are a moderately constant feature of the community but rarely form a well-defined layer. *Aristida ingrata* (three-awn) is one of the most constant but is never more than sparse. *Chrysopogon fallax* (ribbon grass) is also moderately constant but tends to occur in patches and unless the inflorescence is present it appears as a short rather than a mid-height grass. Other somewhat less constant grasses are *Aristida pruinosa* (three-awn), *A. browniana* (kerosene grass), *A. inaequiglumis*, *A. sciuroides*, *A. armata* (three-awns), *Sorghum plumosum*, *Panicum seminudum*, and *Alloteropsis cimicina*. Many others occur with only a low constancy. These include many of those, such as *Bothriochloa ewartiana* (blue grass), *Heteropogon contortus* (black spear grass), *Dichanthium fecundum* (blue grass), and *Themeda australis* (kangaroo grass), which are more typical of the eastern mid-height grass community. They are more common in the eastern part of the three-awn–ribbon grass community and are rare in most other stands.

The well-defined short grass layer, 6–18 in. high, is a characteristic feature of the community. It is only moderately dense but is floristically rich. Probably the most constant species is *Aristida hygrometrica* (kerosene grass), which is present in most stands. Many others including *Perotis rara* (comet grass), *Aristida browniana* (kerosene grass), *Digitaria ctenantha*, *D. brownii*, *Schizachyrium obliqueberbe*, *Setaria apiculata*, *Paspalidium rarum*, *Eriachne armittii*, *E. obtusa*, *Eragrostis japonica*, and *Rottboellia formosa* are moderately constant and many more have a low constancy. A number of small forbs also occur.

Both yield and quality are low. The pasture has a low stocking rate and is characterized by a mineral deficiency which causes cattle after prolonged grazing to develop a disease locally termed "hooky-hooky".

(7) *Frontage Mid-height Grass.*—This community occurs on levees along all the frontages of watercourses throughout the area. It is associated with frontage woodland.

It is structurally and floristically diverse but a mid-height grass layer is present in most stands. One of the most constant species, particularly where rainfall exceeds about 20 in., is *Bothriochloa decipiens* var. *cloncurrensis* (pitted blue grass). In similar rainfall conditions other common and fairly constant species are *Panicum delicatum*, *Aristida* spp. (three-awn), *Chrysopogon* spp. (ribbon grass), and *Sorghum plumosum*. In the Einasleigh uplands *Bothriochloa ewartiana* (blue grass), *Dichanthium fecundum* (blue grass), and *Heteropogon contortus* (black spear grass) occur in many stands. *Hyptis suaveolens* is a common herb in the higher-rainfall parts.

Under low rainfall *Chloris divaricata* is the most constant species but *Aristida pruinosa* (three-awn), *A. browniana* (kerosene grass), *Bothriochloa decipiens* var. *cloncurrensis* (pitted blue grass), *B. ewartiana* (blue grass), *Themeda australis* (kangaroo grass), and *Chrysopogon fallax* are all prominent in some stands.

Near Cloncurry *Cenchrus ciliaris* (buffel grass) has replaced the native community.

Short grasses and forbs are a relatively minor feature under high rainfall but are prominent under low rainfall. The most constant is *Aristida hygrometrica* (kerosene grass). Slightly less constant are *Perotis rara* (comet grass), *Brachiaria piligera*, *Enneapogon pallidus*, *Crotalaria medicaginea* (rattle pod), *Sida* spp., and *Cleome viscosa*. Many others occur.

Pastorally forage quality appears to be fairly good but yield varies with rainfall, being moderate under low rainfall and high under high rainfall. Stocking rate is high. Because of their proximity to natural waters these pastures were the first stocked and have suffered the heaviest stocking rates. In some places they have been badly damaged by heavy grazing.

(vi) *Grass Layer Mid-height* (1½–4 *ft*), *Sparse–Moderately Dense, Perennial Evergreen Grasses*

(1) *Western Spinifex.*—This is a community which is widespread across northern Australia from the Kimberleys in Western Australia to the Isa highlands in Queensland. It occurs under a mean annual rainfall less than about 25 in. on rocky slopes, shallow skeletal soils, deep sandy soils, and lateritic soils. In the Leichhardt–Gilbert area it is the common community on the Isa highlands and on the low lateritic plateaux in the Carpentaria and inland plains. Small areas occur on the western slopes of the Einasleigh uplands.

It is the most common understorey associated with the Isa highland sparse low woodland and in the same area commonly occurs without a tree cover. It is fairly common with silverleaf box low woodland and in small areas is associated with Georgetown box woodland, ironbark woodland, stringybark woodland, lancewood woodland and forest, mulga low woodland, and paperbark low woodland.

The mid-height grass layer is characterized by *Triodia* spp. (spinifex), which are perennial evergreen tussock grasses. The most common and widespread of

these is *Triodia pungens* (soft spinifex), which occurs on acid rocks and laterite. *T. burkensis*, *T. molesta*, and *T. longiceps* (hard spinifex) are common in the southern end of the Isa highlands, *T. longiceps* occurring particularly on limestones. *T. molesta* also occurs in the Croydon area.

Typically the interspaces between the perennial tussocks are virtually bare although a number of short species, e.g. *Eriachne ciliata*, occur sparsely.

The sclerophyllous foliage of the spinifex is only poor-quality forage and is mostly not grazed. Apart from areas of soft spinifex (*Triodia pungens*) which have a low stocking rate, the community is useless for grazing.

(2) *Eastern Spinifex.*—The small areas of this community are restricted to the plateaux and dissected plateaux in the south-eastern corner of the area. Mostly it occurs on sandy soils with smaller areas on shallow soils and on broken sandstone country. Most stands are associated with ironbark woodland but some occur under lancewood woodland and small areas under Reid River box woodland.

Triodia mitchellii and *T. hostilis* (spinifex) are the characteristic plants. On the sandy soils of the plateaux the community is associated with a prominent shrub layer 3–5 ft high, and tends to be patchy with areas dominated by spinifex alternating with patches of *Aristida* spp. (three-awns) and *Bothriochloa* spp. (blue grasses). On shallow soils and on scarps the stands are mostly spinifex and the interspaces are mostly bare.

The community has a low pastoral value. Its stocking rate is low and in some areas *Gastrolobium grandiflorum* (heart-leaf poison) is a danger to stock.

(vii) *Grass Layer Tall* (> 4 *ft*)

(1) *Fringing Grass.*—Under the fringing woodland or forest on the banks of the watercourses the grass layer is generally tall. *Chionachne cyathopoda*, *Vetiveria* spp., and *Arundinella nepalensis* are characteristic species on all but small channels. *Xanthium chinense* (Noogoora burr) is common. Small channels are fringed by mid-height grasses. *Chloris acicularis* (windmill grass) is the most constant under low rainfall but *Themeda avenacea* (tall oat grass) is common and many others occur in some stands. The short grasses *Pseudoraphis spinescens* (water couch grass) and *Cynodon dactylon* (couch grass) occur in some stands under medium to high rainfall.

The community occupies only a small area but the forage remains green for longer than that of adjacent country.

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PART X. LAND USE IN THE LEICHHARDT–GILBERT AREA

By R. A. PERRY*

I. INTRODUCTION

Parts I–IX were concerned with the scientific description and classification of the land of the area. They are factual accounts based on field observations and interpretations from aerial photographs. In this Part an attempt is made to interpret these facts in terms of land use. It is inevitable that this interpretation will be modified as more information becomes available, and by changes in the economic situation and available markets in other parts of Australia and of the world.

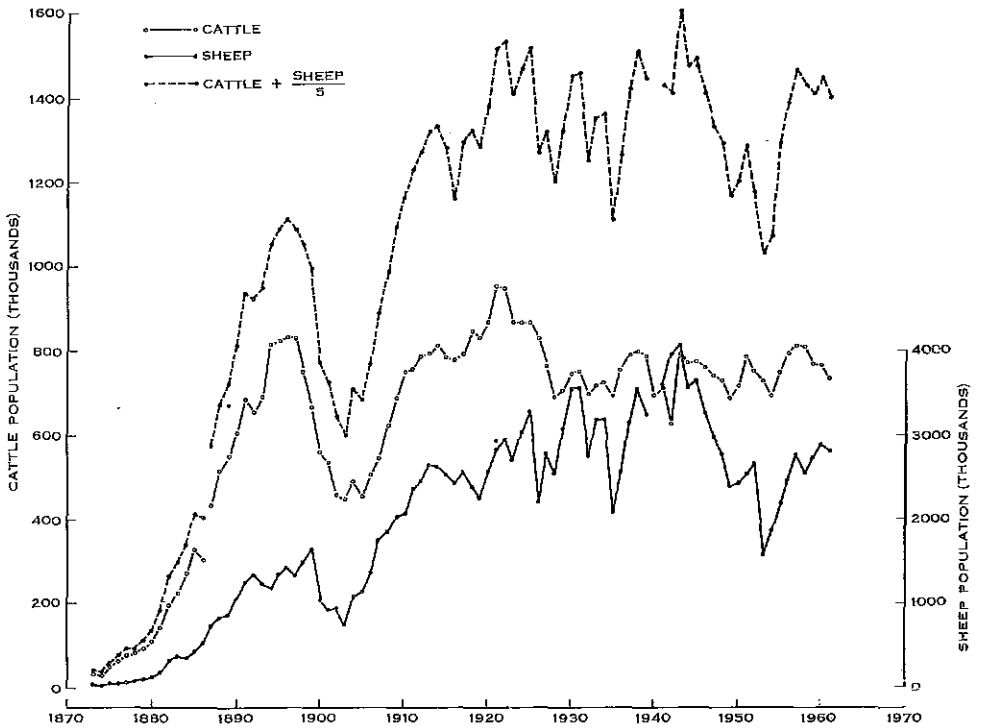

Fig. 14.—Stock population of Leichhardt–Gilbert area, 1879–1961.

II. HISTORY OF LAND USE

The history of the Leichhardt–Gilbert area has been treated in Part I. The main points of interest to land use are:

(1) Pastoral settlement started with sheep in 1864 and by 1865 Floraville, Canobie, Iffley, Donors Hills, Millungera, and Dalgonally stations had been founded as well as those such as Hughenden and Richmond in the upper Flinders.

* Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T.

(2) Because of isolation, drought, and floods, the pastoral industry had virtually failed by 1870.

(3) The discovery of the Etheridge, Palmer, and Croydon gold-fields in 1870, 1873, and 1885 respectively, created a demand for meat and the gulf area was gradually resettled but with cattle. Railways from Normanton to Croydon and from the east to Forsayth were built to serve the fields.

(4) Both these early occupations were dependent on surface water and the areas grazed were mostly frontage country.

(5) Artesian water was discovered in Queensland in 1884 and by the early 1890s several artesian bores had been drilled in the southern part of the Leichhardt–Gilbert area.

(6) The cattle tick reached the area in 1894 and remains a serious pest of the cattle industry to the present day.

(7) The Cloncurry mineral field was connected by rail through the southern part of the area to Townsville in 1910. About 20 years later the railway was extended to Mt. Isa. These lines, constructed to serve the mining industry, also provided outlets for the animal industries.

The advent of artesian water enabled pastoralists to use country other than the frontages and stock numbers rose steadily to a peak of 830,000* cattle in 1896 and 1,666,000 sheep in 1899 (Fig. 14). During the late 1890s and in the early part of the present century the influence of droughts and ticks caused stock numbers to fall to a minimum value in 1903. Between 1903 and 1913-14 stock numbers rose rapidly, the cattle population nearly doubling and the sheep population more than trebling. The cattle population continued to rise and reached an all-time peak in 1921. During the 1920s cattle numbers decreased but sheep numbers increased, and the total grazing pressure (calculated as cattle population plus one-fifth of the sheep population) was only slightly higher in 1930 compared with 1920. From Figure 14 it appears that since 1914 total grazing pressure has fluctuated about a mean roughly equal to the 1914 population (1,330,000 cattle equivalents), reaching peaks of 1,530,000 and 1,600,000 cattle equivalents in 1922 and 1943 respectively and lows of 1,100,000 and 1,030,000 cattle equivalents in 1935 and 1953 respectively.

The history of mineral production† is illustrated in Figures 15 and 16. The Palmer field, which produced large quantities of gold during the 1870s, is not in the

* Stock populations for the Leichhardt–Gilbert area were calculated from figures supplied by the Commonwealth Bureau of Census and Statistics, Canberra, and the Deputy Commonwealth Statistician, Brisbane, for local government areas (petty sessions districts). For 1887–1960 the stock population for the area was calculated on the sum of populations for Cloncurry, Croydon, Etheridge, 0·6 Flinders, 0·5 Carpentaria, 0·2 Winton, 0·3 Dalrymple, McKinlay, and Richmond petty sessions districts. Before 1887 Cloncurry, Croydon, Norman (Carpentaria), and Hughenden (Flinders) were not separately recorded. For the years 1873–87 the sum of populations for areas equivalent to the Cloncurry, Croydon, Norman, Hughenden, Etheridge, Charters Towers, and Winton petty sessions districts was obtained. The proportion of stock numbers in the Leichhardt–Gilbert area to sum of stock numbers for the petty sessions districts was calculated for 1887 and was used to estimate populations for the Leichhardt–Gilbert area for 1873–86.

† Figures for mineral production were obtained from unpublished records of the Bureau of Mineral Resources and from Carter, Brooks, and Walker (1961).

Leichhardt–Gilbert area but influenced its development. By comparison the Etheridge and Croydon gold-fields were not as rich but maintained a moderate production for a longer period (about 1880 to 1913). The main period of production from the Cloncurry field was between 1910 and 1920. The Mt. Isa field, a few miles beyond the western margin of the area, began producing in the early 1930s and by 1960 had produced metals worth about £200,000,000.

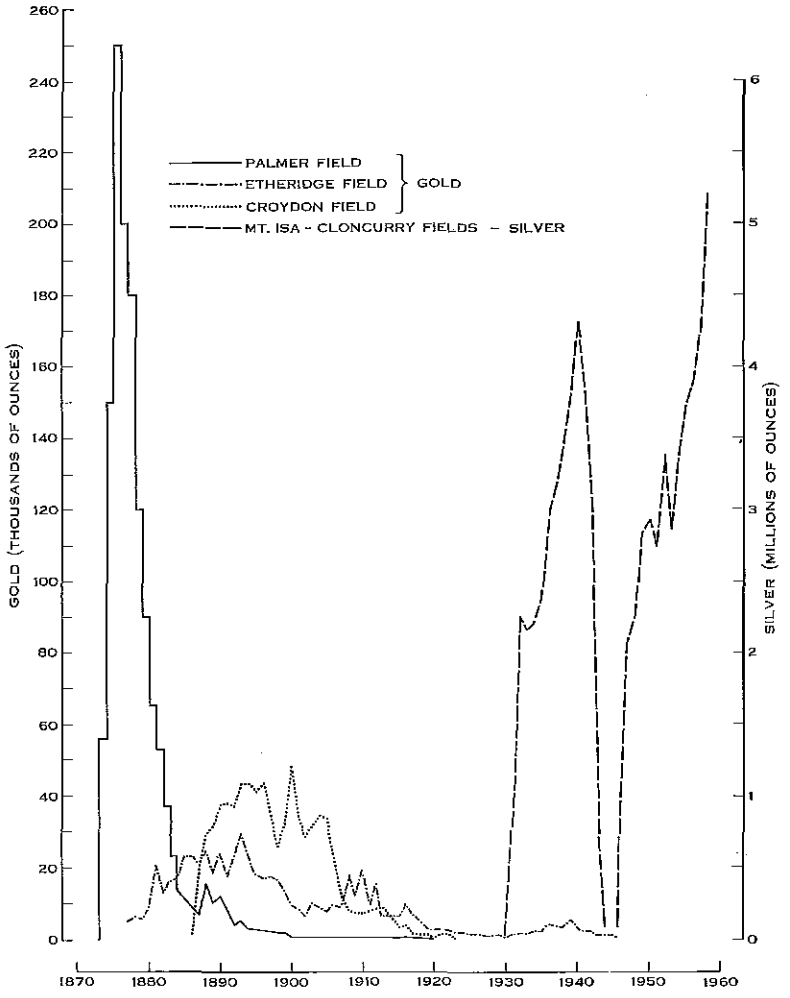

Fig. 15.—Gold and silver production, 1873–1960.

III. Present Land Use

(*a*) *Grazing*

Currently the main land use is the grazing of natural pastures. In 1960 the area carried 834,000 cattle mostly in the northern and eastern three-quarters and 2,825,000 sheep mostly in the southern quarter, or a total grazing pressure equivalent to 1,399,000 cattle.

The cattle industry, particularly in the Carpentaria and inland plains, is run on an extensive system with little or no animal management and no pasture management. Properties are large, with few fences, breeding is largely uncontrolled, branding percentage is low, mortality rate is high, few females are turned off, and the male turn-off is mainly as 4- or 5-year-old bullocks. Few properties are able to dip their cattle frequently enough to achieve tick control, although most practise dipping.

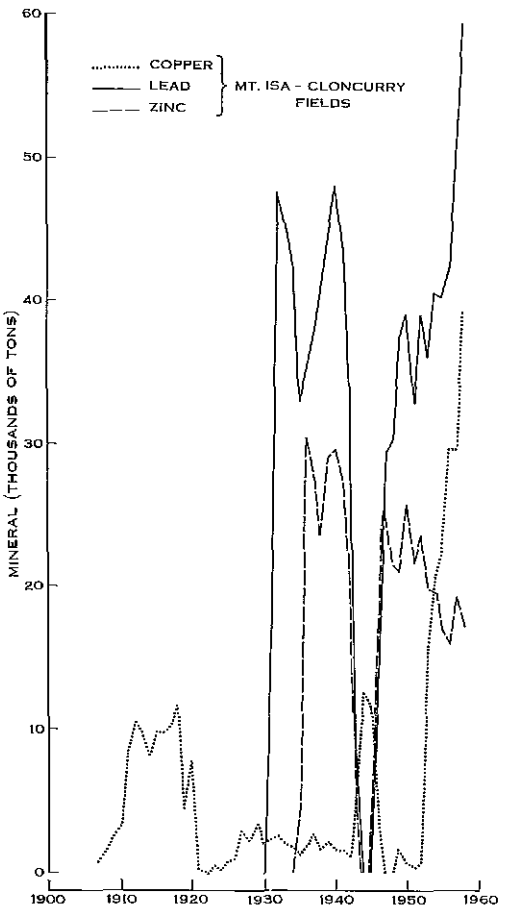

Fig. 16.—Copper, lead, and zinc production, 1907–60.

By comparison the sheep industry is on a more intensive scale. Properties are small, fenced, and mostly well watered and subdivided.

Both the cattle and sheep industries suffer from the extreme seasonal fluctuation in pasture quality and quantity. In general the pastures are good in summer and poor in the late dry season with the result that animals gain weight during, and for a few months after, the wet season and then lose weight until the beginning of the next wet season. The most critical period for animals, and the period which determines

animal productivity, is the late dry season. In this respect the sheep areas are a little better than the cattle areas, possibly because of the reasonably regular low winter rains which produce herbage growth in many years.

(*b*) *Mining*

By 1960 the only mine of any size operating within the area was the Mary Kathleen uranium mine, near Cloncurry. Even this mine closed in 1963 and mineral production from the area is currently negligible. The Mt. Isa mine just outside the area is producing large amounts of copper, lead, and silver.

IV. Climate and Land Use

The climate of the area varies from arid tropical (mean annual rainfall about 15 in.) in the south-west to humid tropical (rainfall more than 40 in.) in the north-

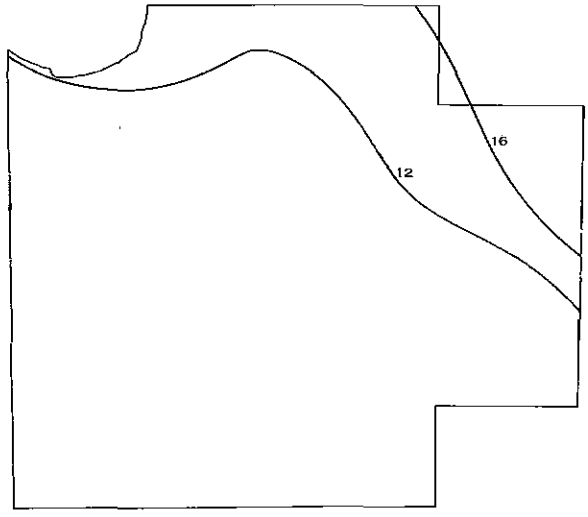

Fig. 17.—Length of agricultural growing season (in weeks expected in four years out of five).

east. The strongly seasonal nature of the rainfall limits the period during which soil moisture is adequate for plant growth and is the most important factor influencing land use.

The growing period for agricultural plants varies from less than 5 weeks in the south-west to more than 25 weeks in the north-east (Fig. 6). A reasonable condition for safe dry-land agriculture or perennial improved pastures is that in 4 years out of 5 the growing period should be 16 weeks or longer. On this basis only the north-eastern corner of the area is suitable for safe dry-land agriculture (Table 5, Fig. 17). For short-season fodder crops or annual pastures a growing season of 12 weeks in 4 years out of 5 should be suitable. This corresponds broadly to that part of the Einasleigh uplands where mean annual rainfall exceeds about 25 in. and that part of the Carpentaria plains where rainfall exceeds about 30 in. Dry-land use in the remainder of the area is virtually limited, by climate, to the grazing of natural pastures.

The growing period for natural pastures in any area is longer than the agricultural growing period and varies from somewhat less than 10 weeks in the south-west to more than 35 weeks in the north-east (Fig. 6). The period of rapid growth is shorter and varies over the area from 4 to 12 weeks. In the Einasleigh uplands, where cooler and more humid atmospheric conditions prevail, the occurrence of light winter rains is frequently adequate to maintain pasture growth well into the dry season, when frosts may be as important as lack of moisture in retarding growth. In the southern part of the area winter rains average about 2 in. and produce herbage growth in many years.

The critical period for animals is the later part of the dry season, when forage is scarce or its quality low. During and shortly after the wet season the native pastures provide more than adequate forage for the animal population, which is limited by the critical period late in the dry season. Since growth of introduced plants will be limited by the dry season, it is likely that improved pastures will also show very marked seasonal production. In this respect it is important to remember that no matter how much better improved pastures are than native pastures during the wet season they will not affect the biological productivity of the area unless they alleviate the nutritionally critical period in the late dry. The same applies to fodder crops.

Frosts are unknown over most of the area but occur infrequently in winter in the southern inland parts and in the eastern high country where they reduce considerably the value of standing native pasture. Frost resistance is a necessary character in any perennial pasture species for this part of the area.

For irrigated agriculture the net annual water requirement (not allowing for transmission losses) varies from about 20 in. at Cashmere to 84 in. at Cloncurry. The requirements for supplementary irrigation in the period from the last week in November to the third week in March, even assuming pre-irrigation, are much lower and range from about 4 in. at Cashmere to about 25 in. at Cloncurry.

V. Possibilities of Water Storage

Most properties in the area have suitable locations for water storages which would hold enough water to irrigate a few acres.

The availability of quantities of water adequate for larger irrigation projects would be limited to the major rivers. Of these the Leichhardt River and Morning Inlet have only small discharges (Table 9), the Flinders–Cloncurry–Saxby and Norman–Clara–Yappar systems flow through flat country with no suitable dam sites, and only the Gilbert–Einasleigh system has both a large flow and apparently suitable dam sites.

VI. Agricultural Potential

Slopes and soils are such that more than half the area is arable. However, generally the soils have only a low to moderate nutrient status and fertilizer dressings would be necessary for agriculture. The basalt soils of the Einasleigh uplands and some of the alluvial soils near Cloncurry are more fertile but some of the basalt soils are too stony for agriculture.

From a consideration of climate, topography, soils, and the possibility of storing water for irrigation the following assessment of the agricultural potential has been made.

(*a*) *Dry-land Agriculture*

Climatically the north-eastern corner is the only part of the area where dry-land agriculture based on either cash crops or perennial pastures (e.g. siratro and *Glycine javanica*) appears to be a safe proposition. This part of the area is high and has infrequent winter frosts. Although some parts are rugged, much of it consists of a basalt tableland with relatively fertile soils, some of which are too stony for agriculture.

The basalt soils are either black earths (Rosella family) or krasnozems (Lang family). The black earths have the higher net fertility level and water-holding capacity but a higher proportion is stony and because of their physical properties they present more cultivation problems. They commonly occur in locally low parts of the topography and frosts are more severe. Besides a somewhat lower fertility level, the krasnozems may present a problem in phosphate fixation.

The area climatically suitable is about 5000 sq miles and of this more than 2000 sq miles is too rugged. Even if half of the remainder is too stony the area suitable for dry-land agriculture is of the order of 1000 to 1500 sq miles.

A larger area comprising the northern two-thirds of the eastern plateau country, the country north of the Gilbert River, the Gilbert delta country, and a coastal strip from south of Normanton to Burketown is suitable climatically for annual pasture or fodder crop production. On the extra portion of the eastern plateau a higher proportion of the country is rugged and a higher proportion of the basalt soils is too stony. Most of the country in, and north of, the headwaters of the Gilbert River is too rugged. That part north of the middle reaches of the Gilbert consists of a gently sloping plain (Dandry and Mayvale land systems) which is topographically suitable but which has infertile soils. The levees of the Gilbert and Einasleigh Rivers appear to be well suited to agriculture.

In the Gilbert delta the sandy soils appear suitable but may not store enough moisture to last through dry periods within the wet season. The heavier soils have dense intractable subsoils but those with deeper topsoils (say >6 in.) may be suitable for cropping. The strip from Normanton to Burketown is mostly saline coastal country unsuited to agriculture. Thus of the area climatically suited for annual pastures or fodder crops the only parts suitable on other criteria are the flatter and less stony parts of the eastern plateau country, the levees of the Gilbert and Einasleigh Rivers, and parts of the Gilbert delta. Townsville lucerne (*Stylosanthes sundaica*) may persist on the sandier soils. On the heavy soils crops like sorghum, cowpeas, and mung beans would be worth investigating. They would need fertilizing with phosphate on most soils but may grow satisfactorily without fertilizer on the basalt country. Such crops could be grazed in the field during the dry season but harvesting the grain would probably be more efficient.

Buffel grass is well established on some parts of the Cloncurry River frontage which have high soil phosphate levels. Properties in this area would have a good chance of establishing buffel grass if they selected sites with high phosphate.

(*b*) *Irrigated Agriculture*

Most properties could select sites where they could store enough water, adjacent to suitable soils, to irrigate several acres of fodder crops. Probably the most efficient use of water in small storages would be as a supplement to wet-season crops.

The frontages of the Gilbert system (Gilbert, Einasleigh, Etheridge Rivers) comprise a considerable area of country which would be suitable for irrigated agriculture (cash crops or pastures) using water from the rivers or river beds. Natural rainfall would be adequate during the wet season for grasses such as *Urochloa mosambicensis*, *Setaria sphacelata*, Ronpha grass (*Phalaris arundinacea*), *Panicum antidotale*, and buffel grass (*Cenchrus ciliaris*). Ronpha grass and the Nandi strain of *Setaria sphacelata* would grow well during winter under irrigation. The frontages of the Leichhardt River are less attractive because of the lower rainfall and the river is more deeply entrenched, necessitating a greater lift for water.

On the basis of discharge and availability of dam sites the Gilbert–Einasleigh system appears to be the only large-scale irrigation prospect. Of the commandable areas probably Abingdon land system would be the most attractive on the basis of soils but it is relatively small. The river levees and sandier soils of the delta would be nearly as good. For more extensive areas the Wallabadah soils of Mayvale land system appear to be fair for irrigation, although infertile. The heavier delta soils (Miranda and Vanrook families) are intractable and salting and surface crusting may be problems. They are similar to some of the soils of the Burdekin flood-plain and an idea of their potential could be gained from the performance of related soils in the Burdekin valley.

VII. Nutritive Value of the Pastures

Little accurate information is available on the nutritive value of the pastures and its seasonal fluctuations. However, from observations it is clear that animals grazing any of the pastures lose weight for some part of each year.

Norman and Arndt (1959) have shown that cattle grazing on native pasture at Katherine, N.T., lose approximately 20% of their body weight between May and November. During this period the crude protein content of the pasture falls from 3% in May to 1·5% in October–November (Arndt and Norman 1959).

Norman (1963*a*) followed the seasonal fluctuations in pasture yield and showed that after effective rainfall (2 in. or more in a fortnight) dry matter production was very rapid but ceased within 4 wk of the cessation of rain and then yield decreased. He also showed (Norman 1963*b*) that during the dry season, the dry standing native pasture is an adequate source of energy, which can be utilized effectively if cattle are given small amounts of high-protein supplement.

The Katherine results could be expected to apply generally to structurally similar pastures (predominantly mid-height perennial drought-evading grasses) under similar climatic conditions. Katherine has a strongly seasonal rainfall, 85% of the average annual rainfall of 35–36 in. falling in the 4 months December–March, and is thus climatically comparable to the north-western part of the Leichhardt–Gilbert area. In this area blue grass–browntop downs, western mid-height grass, three-awn,

three-awn–ribbon grass, and frontage mid-height grass pastures are structurally similar. Of the other pastures in the Leichhardt–Gilbert area the Mitchell grass downs are likely to be somewhat better, at least during the early part of the dry season, because of the abundance of nutritious short annual grasses in the interspaces between the bunch grasses. In the southern parts the herbage produced from winter rains probably maintains a higher nutritive level for a longer period. The eastern mid-height pastures are structurally similar to the Katherine pastures but under the longer rainy season probably maintain a fair nutritive level for a longer period, probably until frosts occur in July or August.

The arid short grass pastures probably maintain a fair nutritive level during the dry season but their dry matter production is low and they may not be an adequate energy source. Little is known of the value of top feed, present in many parts of the arid short grass country and in the southern sandy forest country, but it is probably a useful source of energy and protein.

The spinifex pastures are composed predominantly of evergreen perennial grasses which are unpalatable and probably indigestible. However, they probably maintain a fairly stable low level of nutrition throughout the year and in periods of stress may provide better forage than pastures composed of drought-evading grasses.

VIII. Pasture Lands

From purely climatic considerations it is clear that the agricultural potential is limited and that, for most of the area, grazing of natural pastures is likely to remain the major land use. For this reason the land systems have been classified, on the basis of pastoral affinities, into groups called pasture lands. Including a group called non-range which is too rugged, stony, or barren for grazing, 15 pasture lands have been defined. The Isa highlands contain only non-range country. As well as non-range country the Carpentaria and inland plains comprise 10, and the Einasleigh uplands 4 pasture lands. The most important characteristics of the pasture lands are summarized in Table 22. Their boundaries and constituent land systems are shown on the accompanying map.

(*a*) *Non-range Country*

This country is unsuited for grazing, or virtually so, because it is rugged, stony, or barren.

Of the nine land systems three (Mt. Elliott, Argylla, and Kuridala) are restricted to and comprise most of the Isa highlands. They consist of rugged, stony hills and mountains on rocks of the Cloncurry complex and carry scattered low trees, commonly snappy gum, box, or bloodwood, over spinifex. Although evergreen, the spinifex pastures are of little or no use for grazing except for short periods after burning. Small areas of valleys and frontages carry better pastures, mostly western mid-height grass or arid short grass, and where large enough are stocked at a low rate. However, in the predominantly useless country stock tend to concentrate on and overgraze the small usable areas. The proportion of country flat enough for agriculture is negligible but areas large enough for small gardens can be found near small mining communities.

Torwood land system occupies the remaining small part of the Isa highlands and also occurs in both the Carpentaria and inland plains and the Einasleigh uplands. It consists of broken sandstone country and mostly carries dense lancewood over bare ground or sparse grasses. Some of the wider valleys contain unmapped areas of better country.

The other five land systems (Wairuna, Ortona, Leichhardt, Belmore, and Toomba) are limited to the Einasleigh uplands. Toomba land system consists of rocky lava almost bare of grass but the others are hilly to mountainous country with eucalypt woodland mostly over eastern mid-height grass. In these, narrow valleys and gentler slopes are used for grazing, especially near country with lower relief, but the overall carrying capacity is low. Pastorally the usable areas are similar to the eastern mid-height grass country.

(*b*) *Spinifex Plains and Low Plateaux*

Most (Normanton, Punchbowl, and Cowan land systems) of this pasture land occurs in the northern part of the Carpentaria plains, where it consists of low, somewhat dissected plateaux developed from lateritized greywacke, sandstone, and siltstone of the Rolling Downs group. Where soils occur they are mostly gravelly or sandy. Trees are commonly absent or consist of sparse snappy gum or silverleaf box, but where rainfall is greater than about 30 in. bloodwood and stringybark are more common. The common grass is soft spinifex with three-awn and ribbon grass becoming more common under higher rainfall.

A smaller area (Merlin land system) occurs south of the Isa highlands on lateritized Cambrian siltstone and sandstone. The common soils are stony or gravelly. Trees are absent or consist of sparse snappy gum or bloodwood and the common grass is hard spinifex.

The pasture land is poor grazing country but is used for light grazing in conjunction with better country. Spinifex is more palatable when young and for this reason is burnt as often as it will carry a fire (every 5–10 years). At any time spinifex has a low pastoral value but it is useful at the end of the dry season when adjacent normally better-quality pastures are very poor.

In some parts surface waters are available in rocky water-holes in shallow streamlines and in most places artesian water can be obtained from deep bores.

The country has no agricultural potential.

Of the four land systems Normanton has the highest rainfall and is the only one with stringybark woodland. It has more three-awn and ribbon grass than the others. Punchbowl land system has large treeless areas with soft spinifex and minor areas of heavy soil with blue grass and browntop. Cowan land system is similar but has moderate areas of silverleaf box with three-awn and ribbon grass. Merlin land system has a much lower rainfall than the other three and also differs in that it has hard spinifex. It contains small areas with sparse trees and mid-height grasses.

(*c*) *Northern Sandy Forest Country*

This country mainly consists of the northern three-quarters of the broad sandy outwash plains in the east of the Carpentaria and inland plains, but smaller areas occur

TABLE 22
SOME CHARACTERISTICS OF THE PASTURE LANDS

Pasture Land	Land Systems	Main Pastures	Mean Annual Rainfall* (in.)	Agricultural Growing Season* (wk)	Pastoral Growing Season* (wk)	Elevation† (ft)	Area (sq miles)	Stocking Rate (cattle/ sq mile)
Non-range country	Mt. Elliott, Kuridala, Argylla, Torwood, Wairuna, Ortona, Leichhardt, Belmore, Toomba	—	15–40	<5–25	<10–35	300–2500	21,700	0–4
Spinifex plains and low plateaux	Normanton, Punchbowl, Merlin, Cowan	Western spinifex	<15–30	<5–15	<10–20	Mostly <300 some 700–1000	2300	5
Northern sandy forest country	Strathpark, Dandry, Esmeralda, Strathmore, Stanhill, Mayvale, Claraville, Abingdon, Prospect	Three-awn–ribbon grass	20–33	7–20	12–23	50–1000	16,900	5
Southern sandy forest country	Bylong, Murgulla	Three-awn–ribbon grass	18–25	7–10	12–15	100–1000	5800	10
Coastal country	Carpentaria	Bare ground	27–35	13–17	18–22	<100	2000	5
Western mid-height grass country	Manrika, Korong	Western mid-height grass	15–30	<5–15	<10–20	<500	1800	12
Arid short grass country	Collis, Wonomo, Quamby, Percol	Arid short grass	<15–20	<5–8	<10–13	250–1300	5000	12

Delta country	Miranda	Solodic soil short grass	30–33	14–16	19–21	< 250	1900	16
Frontage country	Cloncurry, Gilbert, Armraynald	Frontage mid-height grass	< 15–35	< 5–17	< 10–22	< 20–700	1700	50
Blue grass–browntop plains	Donors, Donaldson, Balbirini, Glenore, Georgina	Blue grass–browntop downs	15–33	< 5–16	< 10–21	20–750	15,400	15
Mitchell grass plains	Julia, Wonardo, Monstraven, Gregory	Mitchell grass downs	< 15–28	< 5–14	< 10–20	250–1000	22,700	20
Eastern spinifex country	Eurunga, Warrigal	Eastern spinifex	20–22	10–12	16–17	1000–2000	600	5
Three-awn country	Townley, Georgetown, Hampstead	Three-awn	20–30	10–16	15–20	300–1500	2000	12
Eastern mid-height grass country	Karoon, Boorooman, Yanman, Glenharding, Lyall, McKinnon, Heidelberg, Niall, Reedy Springs, Kilbogie	Eastern mid-height grass	20–35	10–> 25	15–> 35	Mostly 1500–2500, some as low as 500	10,300	17
Basalt country	Rosella, Boonderoo	Eastern mid-height grass and blue grass–browntop downs	20–30	9–25	14–35	1400–3050	7000	18

* Range quoted is from driest to wettest localities.

† Range quoted is from lowest to highest localities.

over older rocks in the same general area. The soils are mostly deep sands with associated red and yellow earths and podzolics. The common vegetation is paperbark low woodland about 15 ft high or Georgetown box woodland about 30 ft high but these give way, with increasing rainfall, to a woodland 40–50 ft high of stringybark and bloodwood. Top feed is not common. Over the whole area the grass layer is of the three-awn–ribbon grass type, which has a relatively sparse cover and a low forage production.

Minor areas include treeless shallow flat-floored valleys carrying short grasses, small frontages and lagoons and depressions, and occasional rock outcrop areas with lancewood or deciduous low trees.

Where used, this country has a low stocking rate (about 5 cattle/sq mile). On some properties grazing on it is seasonally alternated with grazing on heavy soil areas. With prolonged grazing cattle develop a deficiency disease locally known as "hooky-hooky" and probably due to low phosphate and/or calcium.

Artesian water is available from deep bores.

Agriculturally some of the higher-rainfall areas, with fertilizer dressings, may be suitable for Townsville lucerne or other annual fodder crops. If dams are ever built on the Gilbert–Einasleigh river system the best areas to irrigate would be Abingdon or Mayvale land systems.

(*d*) *Southern Sandy Forest Country*

The largest area (Bylong land system) of this country is the southern quarter of the broad sandy outwash plains in the east of the Carpentaria and inland plains. Murgulla land system is a sandy erosional plain. The soils are mostly deep sands and the common vegetation is Bylong low woodland which contains many top-feed species such as bean tree (*Bauhinia*), whitewood, and vine tree. The common grass vegetation is of the three-awn–ribbon grass type which has a sparse ground cover and a low forage production.

Artesian water can be obtained from deep bores.

Pastorally this country has a much higher stocking rate than the northern sandy forest country, possibly because of the top feed. It is commonly seasonally grazed in conjunction with heavy soil areas but because of predators and grass seeds (three-awn) is used for cattle rather than sheep grazing.

Although the soils are physically suitable for agriculture they are poor and the growing season is too short for even short-season fodder crops.

(*e*) *Coastal Country*

This is a belt of plains 10–25 miles wide adjacent to the Gulf of Carpentaria. The soils are mostly saline clays, commonly bare of vegetation but with appreciable areas of salt couch and rice grasses.

Most surface water is saline and for this reason the country can be grazed only for short periods during the wet season when fresh water is available.

The soils are too saline for agriculture.

(*f*) *Western Mid-height Grass Country*

Of the two land systems Korong consists of outwash plains with red earth soils and Manrika is an erosional plain with yellow earth soils on lateritized rocks of Rolling Downs group. Silverleaf box woodland over western mid-height grass (three-awn and kangaroo grass) is the common vegetation on both. Areas of western spinifex occur in both.

The grasses on this country respond to lighter falls of rain than those of the adjacent heavy soil plains, but are never of more than moderate quality and stocking rates are only moderate. Artesian water is available from deep bores and some areas are accessible from natural surface waters in streams and man-made surface waters on adjacent heavy soils.

The soils are suitable for agriculture but the growing season is not long enough for even short-season fodder crops except possibly in the extreme northern parts.

(*g*) *Arid Short Grass Country*

This is all sparsely timbered plains or undulating plains with occasional hills and small plateaux. The soils are mostly shallow and either skeletal or red earths. It occurs on the western margin of the Carpentaria and inland plains, adjacent to the Isa highlands.

The pastures are mostly short (6–12 in.) and characterized by annual (or short-lived perennial) grasses of which kerosene grass and niggerheads are common. In wetter situations, i.e. most of the higher-rainfall parts and depressions in the lower-rainfall parts, the western mid-height grass community occurs. Common plants are three-awn and kangaroo grass. Areas of shallow stony soil carry spinifex and small areas of heavy soil with Mitchell grass occur. Many of the trees and shrubs, particularly in the more arid areas, provide top feed.

The short pastures respond rapidly to light falls of rain and provide palatable and nutritious forage, but yield is low. The country has a moderate stocking rate but is used for the production of fat cattle as well as for breeding. Supplies of ground water are variable and difficult to locate but some surface waters are available in water-holes in stream-lines and the topography is suitable for dams and surface catchment tanks.

Agriculturally the growing season is too short for even short-season fodder crops. Near Cloncurry buffel grass has established on many areas and there may be a potential for further spread, particularly on soils with high phosphate content.

(*h*) *Delta Country*

The only land system (Miranda) of this pasture land comprises the heavier soil parts of the Gilbert River "delta". It has mostly heavy soils, is sparsely timbered, and carries solodic soil short grass or blue grass–browntop pastures. Minor areas include frontage country, heavy soil depressions, and channels.

The pastures grow rapidly and are reasonably nutritious during the wet season but their quality rapidly deteriorates in the dry season. They are used for cattle grazing and have a fairly high stocking rate. Large water-holes are available in and near the major streams and ground water is available at shallow depth.

The growing season for agricultural plants is too short for the growing of cash crops or perennial pastures to be a safe proposition but it should be long enough for short-season fodder crops. For dry-land agriculture the heavier soils are physically unattractive and the water-holding capacity of the sandy soils may be so low that plants would be adversely affected during dry periods within the wet season. The sandy soils appear suitable for irrigation but salting problems may develop with the heavy soils. These heavy soils are similar to some of the soils of the Burdekin floodplains.

(*i*) *Frontage Country*

The three land systems of this pasture land occur as narrow strips adjacent to streams. They consist of coarse-textured alluvia and mostly have sandy soils. The soils are mostly Sturgeon family in Cloncurry, mostly Manbulloo family in Gilbert, and alluvial in Armraynald land system. The vegetation is a eucalypt woodland varying from about 20 ft high under low rainfall to 60–80 ft high under high rainfall. Stream channels are an important minor element.

In the higher-rainfall areas the pastures are composed of mid-height perennial tussock grasses, commonly pitted blue grass, ribbon grass, black spear grass, and three-awns. Many shorter grasses and forbs also occur. In the lower-rainfall areas the pastures are shorter (<2 ft) and perennials, generally mainly three-awns, are more widely spaced. Shorter grasses and forbs are common. Buffel grass is prominent on the frontage of the Cloncurry River. The pastures shoot after even small falls of rain and grow rapidly during the wet season.

Because of the availability of stock water in the streams the frontage country was among the first stocked and it has been heavily stocked since. Many areas show evidence of over-grazing.

The soils, although generally low in nutrients, are physically suitable for agriculture. Under irrigation they could be used for a wide range of crops. The frontages of the Gilbert and rivers to the north of it have a growing season probably long enough for growing short-season fodder crops but too short for safe dry-land cash cropping. Townsville lucerne grows well on the frontages within the Gilbert delta and buffel grass grows well on frontages of the Cloncurry River.

(*j*) *Blue Grass–Browntop Plains*

This pasture land comprises most of the lower part of the Carpentaria and inland plains but extends along stream-lines to the southern boundary of the area. It consists mostly of nearly flat to undulating plains with heavy cracking clay soils, generally without trees, and with a grass vegetation composed of mid-height (2–4 ft) grasses among which blue grasses, browntop, bull Mitchell grass, feathertop, ribbon grass, and sorghums are prominent. Shorter grasses, especially Flinders grasses, occur in the spaces between the taller grasses. The pastures grade into those of Mitchell grass downs, particularly in some parts of Georgina land system. Glenore land system is atypical in that its soils are fine-textured yellow earths rather than grey and brown soils of heavy texture, it is wooded, and the pastures are somewhat different.

With adequate rain the pastures grow rapidly and are soon coarse and rank. Yield is fairly high but during the dry season forage quality is poor and stock lose weight. Except for the relatively small southern extensions this country is used for cattle grazing. It has a moderately high stocking rate, somewhat below that of Mitchell grass downs. As far as possible the pastures are protected from fire.

Natural surface water is available in larger stream-lines and in occasional lagoons between stream-lines. The country is suitable for surface catchment tanks, and artesian or subartesian water is available from deep bores.

Agriculturally the soils would be difficult to work and some areas are subject to flooding. The growing season is too short for agriculture except possibly in the highest-rainfall parts where it may be long enough for short-season fodder crops such as *Sorghum almum* and pulses. Dressings of phosphate fertilizer would be needed. On the credit side, most of the plains are treeless and therefore require no clearing, the impermeable clay is very suitable for catchment tanks, and usually water requirement for supplementary irrigation during the wet season is moderately low.

(*k*) *Mitchell Grass Plains*

The vast areas of this pasture land occupy most of the southern part of the Carpentaria and inland plains and extend almost to the Gulf of Carpentaria. It consists very largely of gently undulating treeless plains with heavy cracking clay soils carrying Mitchell grass pastures. In general it is slightly drier than the blue grass–browntop downs but the pastures grade into one another, particularly in the intermediate-rainfall areas.

The Mitchell grasses are perennial tussock grasses about 2 ft high and 6–12 in. in diameter and are normally fairly regularly spaced at about 2–4-ft centres. A few other perennial tussock grasses occur and many short grasses and forbs occupy the interspaces. The most common of these are Flinders grasses. A sparse cover of short grasses and forbs occurs on minor gravelly or stony areas and coarse mid-height perennial grasses (blue grass–browntop downs) occur in gilgais and minor wetter situations.

After adequate rain both the perennials and the ephemerals grow rapidly. This growth is palatable and nutritious. By the end of the wet season the perennial grasses have matured to dry, coarse, unpalatable, and nutritionally poor pasturage and the ephemerals, which although dry are more palatable and nutritious, are selectively grazed. This continues until the ephemerals are consumed, after which stock are forced to graze the perennial pasturage which provides only a maintenance or sub-maintenance diet. Small falls of winter rain cause considerable damage because the standing dry pasture "blackens" and becomes virtually useless, but in the southern part of the area winter rain is high enough in many years to produce valuable herbage growth.

The country has a fairly high stocking rate and withstands grazing well, although under heavy grazing the perennial grasses are replaced by annuals. Most of it is subdivided into areas of 20,000 to 50,000 acres which are used for sheep grazing for wool production, but the northern parts are used for cattle grazing.

Water-holes in stream channels provide surface waters for variable periods after rain. They are widely spaced but the topography and soils are admirably suited for the construction of surface catchment tanks and much more use could be made of

them. The country is part of the Great Artesian Basin and artesian water can be obtained from deep bores (1000–2000 ft). The common method of providing stock water is to direct the flow from the bores into furrows which radiate from the bore to a distance of several miles.

The agricultural growing season is too short for regular production of even short-season fodder crops. However, small areas could be irrigated from surface catchment tanks. Some graziers have attempted to alleviate the critical period in the latter part of the dry season by making bush hay from part of their holdings. The low quality and yield and the damage to machinery from the irregular microtopography make this uneconomic.

(*l*) *Eastern Spinifex Country*

The two land systems (Eurunga and Warrigal) are both timbered plateaux in the south-eastern corner of the area. In Warrigal land system the plateaux are somewhat dissected. The soils are sandy and the vegetation is ironbark woodland, 20–40 ft high, commonly containing yellowjack and woollybutt. Shrubs and low trees are common.

The common grass vegetation is a mosaic of patches of eastern spinifex and patches of eastern mid-height grass (three-awn, bunch spear grass, blue grass, kangaroo grass). The pastures respond rapidly to light rains but are of only poor quality, and the country has a low stocking rate. Heart-leaf poison is a problem in some parts. Small areas of lancewood with bare ground or very sparse grasses occur on scarps of both land systems. Seasonally flooded rounded depressions are a minor feature of Eurunga land system.

The growing season appears too short to expect much in the way of fodder production or pasture improvement. The sandy soils appear suitable for Townsville lucerne. Although water supplies from surface storage or from "spears" in sandy channels are adequate for watering stock, only very small areas could be irrigated.

(*m*) *Three-awn Country*

This is a group of three land systems in the western part of the Einasleigh uplands, consisting of irregular plains and low hills. The country adjoins the Carpentaria and inland plains and is lower than most other parts of the uplands. Its pastures are intermediate between those of the northern sandy forest country of the Carpentaria and inland plains and those of the eastern mid-height grass country of the Einasleigh uplands. In all three land systems the common vegetation is Georgetown box woodland over three-awn pastures. In addition Townley land system contains small areas of blue grass–browntop downs and ironbark woodland, Georgetown land system contains moderate rocky areas carrying deciduous low woodland and small areas of flat-floored valleys with short grass, and Hampstead land system contains small areas of stony scarps with lancewood.

The pastures shoot with light falls of rain but are of poor quality and yield is low. In small areas Townsville lucerne has established and its introduction over wider areas could be encouraged. The country has a moderate carrying capacity.

Surface water, in quantities adequate for stock, is fairly plentiful and where necessary can be augmented with surface catchment tanks and dams.

The soils of Georgetown land system are too shallow and stony for agriculture and the growing season is too short on Hampstead land system. The soils of Townley land system are arable but the growing season is marginal for dry-land production of even short-season crops. However, small areas of fodder crops could be grown with supplementary irrigation using water conserved in small storages.

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

This country comprises most of the flatter non-basalt parts of the Einasleigh uplands. It consists of irregular plains and low hills developed on metamorphic, igneous, and sedimentary rocks on which mostly red and yellow earths or red and yellow podzolic soils have developed. In general slopes are steeper and the soils are shallower and less fertile than those of the basalt country. The common vegetation is eucalypt woodland, 20–80 ft high, in which ironbark (*E. crebra*) and bloodwood (*E. dichromophloia*) are the most common trees although many other species occur over smaller areas. Ironbark forests, 80–120 ft high, occur on some of the plateau areas and Reid River box woodland is important in Niall and McKinnon land systems. The floristic composition of the pasture varies over even short distances, and probably with time, but it is fairly uniformly of medium height and is usually characterized by one or more of the blue grasses, spear grass, and kangaroo grass. Ribbon grass is common but more patchy and three-awns are common in drier localities. Many other grasses and forbs occur in association with these or are characteristic in small areas. Various types of country occur in association with this one in the different land systems, including small areas of blue grass–browntop downs, lakes and lagoons, scarps and rock outcrops, and frontage and fringing country.

The pastures grow rapidly during the wet season and in the wetter areas retain a green tinge until the first frosts, after which the nutritive value and palatability decline rapidly. They are regularly burnt to destroy excess dry grass, to promote a new green growth, and to reduce cattle ticks.

Small areas of the better parts of this country are as good, or nearly as good, as the basalt country. However, the general lower fertility and shallowness of the soils usually result in poorer-quality pastures. The present stocking rate is lower and varies more from place to place than that of the basalt country. The turn-off is mainly fats bred and raised on the property. Adequate tick control would increase productivity.

Over most of the area the agricultural growing season is long enough for growing short-season fodder crops and in the wetter parts it is long enough for dry-land cash cropping. Much of the land has slopes too steep or soils too shallow or rocky for agriculture, but many flatter areas could be utilized. Most properties have enough suitable land and water available to irrigate small areas. Perennial pasture plants need to be frost-resistant.

(*o*) *Basalt Country*

This country occurs in two main belts, the larger stretching from Hughenden north-eastwards to the edge of the area and the other from Conjuboy northwards. It mostly consists of irregular stony plains with a tendency for the stoniness to

decrease northwards. The most common soils are krasnozems which carry a eucalypt woodland, 20–60 ft high, in which ironbark, bloodwood, and ghost gum are common. Black earths occupy a lesser area. They tend to be associated with depressed, or at least poorly drained, situations and trees are sparser or completely absent. Of the two land systems Boonderoo has mostly krasnozems and Rosella mostly black earths.

The pastures consist of fairly dense stands of mid-height grasses with some tall grasses. The krasnozems carry the eastern mid-height grass community with kangaroo grass, bunch spear grass, and blue grasses. The black earths carry blue grass–browntop downs with blue grasses, browntop, cane grass, and, in the lower-rainfall areas, bull Mitchell grass. Many other grasses and forbs occur, particularly short and medium-height ones. On minor rocky areas giant spear grass is common and in the north small swampy areas carry dense vigorous stands of couch grass.

The pastures grow rapidly during the wet season. In the south the grasses mature by the end of the rainy season but in the north a green tinge remains until the first frosts. Frosts particularly affect areas of black earths which tend to be locally low and have less protection from trees. The pastures are moderately nutritious until frosted but their value rapidly declines subsequently. The krasnozem country, in particular, is fairly regularly burnt to destroy accumulations of dry forage and to encourage the growth of fresh green forage. Burning is also considered to reduce cattle ticks.

This pasture land is the best large expanse of cattle-grazing country in the area, the black earths probably having a slightly higher stocking rate than the krasnozems. Most properties turn off fats from their own breeders, but some also fatten stores obtained from further west. Effective control of cattle tick would increase productivity.

Natural surface waters in swamps, springs, and shallow streams are common in some parts, particularly in the north. However, large areas are waterless or water is only available in deeply incised creeks and rivers with steep rocky sides. Boring through the hard basalt is difficult and results are uncertain but surface catchment tanks can be constructed in most areas.

Over most of this pasture land the agricultural growing season is long enough for the production of short-season fodder crops and in the northern parts it is long enough for dry-land cash cropping or perennial improved pastures. The soils are relatively fertile, the black earths having a somewhat higher fertility than the krasnozems. The main agricultural problem is stoniness, which is particularly bad on black earth areas. The largest stone-free areas occur to the north and north-east of Conjuboy. Perennial pasture plants for the area need to be frost-resistant.

IX. Stocking Rates of the Pasture Lands

In Part XI the stocking rates of the pasture lands for that part of the Leichhardt–Gilbert area north of latitude 21°S. are analysed. In Table 23 the figures derived are applied to the areas of the pasture lands for the whole Leichhardt–Gilbert area. The discrepancies where the areas of some pasture lands for the Leichhardt–Gilbert area are slightly lower than those for the area surveyed by the Bureau of Agricultural Economics are due to the areas used for the Bureau of Agricultural

TABLE 23

AREAS AND STOCKING RATES OF PASTURE LANDS

Pasture Land	Area Surveyed by Bureau of Agricultural Economics			Leichhardt–Gilbert Area				
	Area* (sq miles)	Proportion of Area (%)	Estimated Average Stocking Rate (cattle/ sq mile)	Area† (sq miles)	Proportion of Area (%)	Assumed Stocking Rate (cattle/ sq mile)	Stock Population (cattle equiv.)	Proportion of Stock (%)
Non-range country	13,860	17·6	4·4	21,700	18·5	3	65,100	4·5
Spinifex plains and low plateaux	2360	3·0	4·9	2300	2·0	5	11,500	0·8
Northern sandy forest country	17,254	22·0	5·0	16,900	14·4	5	84,500	5·8
Southern sandy forest country	5264	6·7	9·8	5800	5·0	10	58,000	4·0
Coastal country	2075	2·6	4·6	2000	1·7	5	10,000	0·7
Western mid-height grass country	983	1·3	11·8	1800	1·5	12	21,600	1·5
Arid short grass country	1269	1·6	25·4	5000	4·3	12	60,000	4·1
Delta country	1989	2·5	16·1	1900	1·6	16	30,400	2·1
Frontage country	1172	1·5	48·0	1700	1·5	50	85,000	5·8
Blue grass–browntop plains	9892	12·6	15·8	15,400	13·2	16	246,400	16·9
Mitchell grass plains	2606	3·3	18·3	22,700	19·4	20	454,000	31·2
Eastern spinifex country	600	0·8	5·0	600	0·5	5	3000	0·2
Three-awn country	2000	2·5	12·0	2000	1·7	12	24,000	1·6
Eastern mid-height grass country	11,234	14·3	17·4	10,300	8·8	17	175,100	12·0
Basalt country	6006	7·7	17·7	7000	6·0	18	126,100	8·7
Total	78,564	100·0	11·4	117,100	100·1	12·4	1,454,700	99·9

* Calculated for preliminary pasture lands before 1954 field season.

† Calculated from final pasture land map after 1954 season.

Economics region being calculated for the preliminary pasture lands defined before the 1954 field season, whereas the areas used for the whole Leichhardt–Gilbert area are for the pasture lands as mapped after all the field work. Apart from these minor discrepancies the main differences in the distribution of the pasture lands in the whole area as compared with the B.A.E. area are in those pasture lands wholly contained in the B.A.E. area and therefore occupying a relatively smaller proportion of the whole area. These include the northern sandy forest country, coastal country, delta country, eastern spinifex country, three-awn country, and eastern mid-height grass country. On the other hand, two pasture lands occur mainly in the area south of latitude 21°S. and so are under-represented in the B.A.E. area. They are the arid short grass country and Mitchell grass plains, with 1·6 and 3·3% of the B.A.E. area and 4·3 and 19·6% of the Leichhardt–Gilbert area respectively.

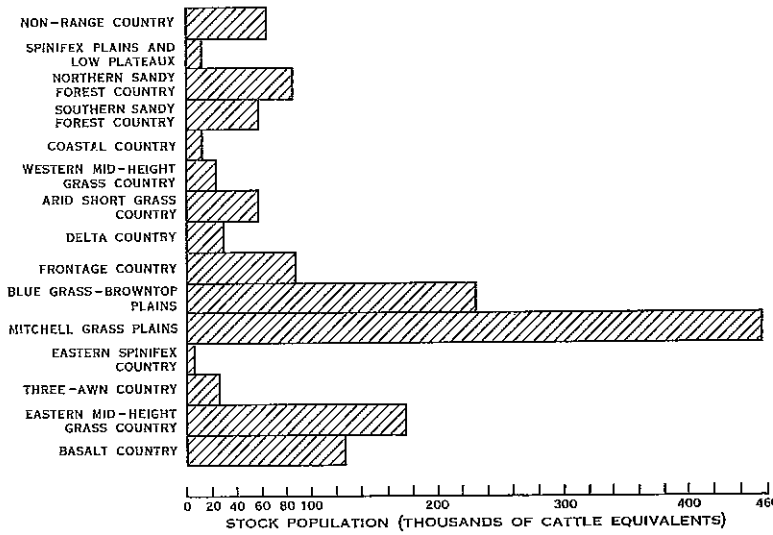

Fig. 18.—Stock populations of the pasture lands.

The stocking rates used in Table 23 for the pasture lands of the Leichhardt–Gilbert area are generally only rounded versions of the calculated average stocking rates for the B.A.E. area. Exceptions are non-range country where, because unoccupied and unstocked areas were excluded from the B.A.E. sample, the calculated stocking rate is likely to be high, and arid short grass country where, because that part of the pasture land south of latitude 21°S. has a lower stocking rate, the calculated stocking rate was halved.

The total stock population of the Leichhardt–Gilbert area calculated from the areas of the pasture lands and the assumed stocking rates was 1,454,700 cattle-equivalents, which is slightly lower than the 1957 and slightly higher than the 1956 and 1958–61 stock population (Fig. 14). On this basis the average stocking rate for the Leichhardt–Gilbert area is 12·4 cattle equivalents per sq mile compared with 11·4 for the B.A.E. area. This can be explained by the higher proportion of Mitchell grass country in that part of the area south of latitude 21°S.

The relative importance of the various pasture lands in the stock-carrying capacity of the area is illustrated in Figure 18. It clearly shows the importance of the blue grass–browntop and Mitchell grass plains of the Great Artesian Basin, which together carry almost half the stock.

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PART XI. BEEF CATTLE INDUSTRY IN THE GULF REGION OF QUEENSLAND

By F. H. COLLINS*

I. INTRODUCTION

During the winter months of 1954 and 1955 the Bureau of Agricultural Economics conducted a survey of the cattle industry of the gulf region of Queensland. The objects of the survey were to describe and assess the present land use of each pasture land defined by CSIRO and to measure the present and potential economic capacity of each pasture land.

The survey by the Bureau of Agricultural Economics was restricted to that part of the Leichhardt–Gilbert area north of latitude 21°S. In broad terms, the survey region was bounded by a line joining Mt. Isa, Pentland, Mt. Garnet, Mungana, and Burketown. All of the shire of Croydon and parts of Etheridge, Dalrymple, Herberton, Mareeba, Carpentaria, Burke, Barkly Tableland, Cloncurry, McKinlay, Wyangarie, and Flinders were included. The area of each constituent shire and the number of beef cattle in the region are shown in Table 24.

Most of the beef cattle industry in the Leichhardt–Gilbert area is located in the gulf region as defined above. Although the northern limit of the sheep industry in 1955 was about latitude 19°30'S., in general the area south of latitude 21°S. was mainly devoted to sheep, whereas the area north of 21°S. was used almost exclusively for cattle.

The Great Artesian Basin underlies all the central portion of the survey area, being limited in the east by the aquifer intake beds of the Einasleigh uplands and in the west by the Isa highlands. Because of the high cost of boring to artesian depth and the low additional return from beef cattle when compared with the capital outlay, there are few artesian bores within the beef cattle zone. Bores are, however, of particular importance in otherwise waterless tracts of land, where the marginal productivity of a bore may be comparatively high. In the analysis of carrying capacity, water availability was considered to be responsible for part of the variance within pasture lands.

The pastoral industry in the gulf region does not appear to have expanded greatly since the early part of this century. Since the gold rushes to the Croydon and Etheridge fields which boosted development of rail, road, and sea facilities, the population has continuously declined. In the post-war period considerable investment has resulted from profitable beef prices; this has affected not only property development but also the allied facilities of roads and stock routes. The remoteness of most of the area from relief country, inadequate local killing facilities, and the paucity of transport has led to heavy losses in the three post-war droughts. In spite of this, cattle numbers up to the onset of the most recent drought have shown almost the same overall proportionate increase in post-war years as for the remainder of Queensland.

* Bureau of Agricultural Economics, Canberra, A.C.T.

II. Analysis of Stocking Rates

(*a*) *General*

An analysis of stocking rates for the various pasture lands was performed on data from 172 properties, of which 53 were studied in more detail in relation to management and property development. The area of the 172 properties made up 60% of the total area under study. A weighted average stocking rate was calculated from a number of observations of each pasture land and the homogeneity of the pasture land was treated by measuring the standard error of the observations. Herd figures were used for cattle numbers, that is, the beef cattle unit of stocking was one herd animal. It was assumed that beef herds were reasonably uniform within each pasture land.

Table 24

CONSTITUENT CATTLE SHIRES AND CATTLE NUMBERS IN AREA SURVEYED BY BUREAU OF AGRICULTURAL ECONOMICS

Shire	Area (sq miles)	Gulf Region		
		Area (sq miles)	Beef Cattle Numbers	
			March 1957	March 1962
Burke	17,773	3255	71,541	66,922
Carpentaria	25,850	14,768	211,121	196,317
Barkly Tableland	15,160	854	8208	7182
Cloncurry	19,660	7856	100,986	72,107
Croydon	10,960	10,960	25,552	31,615
McKinlay	15,860	4802	72,469	67,416
Mareeba	20,430	4381	8400	8014
Etheridge	15,280	15,194	153,469	126,090
Richmond	9650	2993	39,472	41,066
Flinders	16,656	3466	65,331	53,642
Dalrymple	27,606	9402	113,056	107,461
Herberton	2481	633	7315	8952
Total	197,366	78,564	876,920	786,784

In general there were no more than three pasture lands on each of the properties surveyed. Consequently, with the assistance of property management a fairly accurate assessment of the stocking rate of the individual pasture lands on the surveyed properties could be obtained. In practically all cases a pasture land had to be considered in association with the type of country adjoining it.

(*b*) *Variation between Properties*

There appeared to be more variation in the rate of stocking between small properties than between large properties. Two reasons are advanced to explain this. Firstly that the small properties, where used as a commercial beef unit, carry more cattle per square mile than large properties because of better husbandry and management and a higher level of development. Secondly, where they are used as relief country

or as a "dealer's" block, the stocking rate over a year tends to be lower than that of large holdings owing to the intermittent nature of their use and the lack of attention given to stock and improvements.

(*c*) *Association of Pasture Lands*

There is an additive effect to the stocking rate of some pasture lands where they are in close conjunction with another pasture land on the same property. For example, blue grass–browntop plains and northern sandy forest country will carry, under certain conditions, 15 and 8 cattle/sq mile respectively if they are dissociated from each other. Under similar conditions, the rate can rise to 22 and 16 cattle/sq mile if both pasture lands are in conjunction on one property. The effect is the more pronounced the greater is the dissimilarity between the pasture lands concerned.

As the association of complementary pasture lands is the rule, the lower stocking rate when adjoining pasture lands are not complementary is most noticeable. Where the western mid-height grass country adjoins frontage country, the stocking rate of the latter appears to be reduced below the rate normally applying.

A similar effect is noticed from the interactions of non-range country with eastern mid-height grass country, three-awn country, and basalt country. In each case the association of the non-range country has lowered the stocking rate of better-class land below that applying when it appears in conjunction with a complementary pasture land. The non-range country is so steep and harsh as to preclude much grazing and even under favourable circumstances is of little assistance to the grazing of neighbouring country.

Northern sandy forest country is a pasture land whose stocking rate is not varied to any great extent by neighbouring pasture lands because only along a small proportion of its margin is there any markedly different class of land.

(*d*) *Homogeneity of Pasture Lands*

The most important factors, other than the physical resources of land and pastures, which affect the number of cattle carried on a given pasture land are the system of management, the distance from the market outlet and the available transport facilities, and the type of cattle enterprise.

The homogeneity of each pasture land is indicated by the size of the standard error associated with its average stocking rate. A large standard error indicates that there is considerable variability in the stocking rate of a pasture land from property to property. If the standard error of the stocking rate is small, that pasture land may be regarded as homogeneous. On the basis of the standard errors calculated for the stocking rates of the preliminary pasture lands, Mitchell grass plains have a high degree of homogeneity (S.E. about 6% of mean). Spinifex plains and plateaux, northern sandy forest country, delta country, arid short grass country, western mid-height grass country, frontage country, blue grass–browntop plains, southern sandy forest country, eastern mid-height grass country, and basalt country exhibit more variability but all have a standard error less than 20% of mean stocking rate. Non-range country and coastal country have the most variable stocking rate, only small areas being stocked.

TABLE 25

STOCKING RATES OF PASTURE LANDS IN AREA SURVEYED BY BUREAU OF AGRICULTURAL ECONOMICS

Pasture Land	Area in B.A.E. Survey (sq miles)	Proportion of Total Area (%)	Area in Sample Properties (sq miles)	Proportion of Total Sample (%)	Estimated Average Stocking Rate (cattle/ sq mile)	Estimated Cattle Population (Area × Stocking Rate)	Variation† in Stocking Rate
Non-range country	13,860	17·6	7553	15·9	4·4	60,984	High
Spinifex plains and low plateaux	2360	3·0	1730	3·7	4·9	11,564	Moderate
Northern sandy forest country	17,254	22·0	10,386	21·9	5·0	86,270	Moderate
Southern sandy forest country	5264	6·7	2933	6·2	9·8	51,587	Moderate
Coastal country	2075	2·6	1157	2·4	4·6	9545	High
Western mid-height grass country	983	1·3	509	1·1	11·8	11,599	Moderate
Arid short grass country	1269	1·6	898	1·9	25·4	32,233	Moderate
Delta country	1989	2·5	896	1·9	16·1	32,023	Moderate
Frontage country	1172	1·5	588	1·2	48·0	56,256	Moderate
Blue grass–browntop plains	9892	12·6	8592	18·1	15·8	156,294	Moderate
Mitchell grass plains	2606	3·3	2279	4·8	18·3	47,690	Low
Eastern spinifex country	600	0·8	379*	0·8	5·0	3000	—
Three-awn country	2000	2·5	1185*	2·5	12·0	24,000	—
Eastern mid-height grass country	11,234	14·3	5720	12·1	17·4	195,472	Moderate
Basalt country	6006	7·7	2584	5·5	17·7	106,306	Moderate
Total	78,564	100·0	47,389	100·0	11·4	884,823	

* Estimated from proportion in total area.

† Low = S.E. < 10% of mean; moderate = S.E. 10–20% of mean; high = S.E. 20–25% of mean.

The conclusion may be drawn that the pasture lands as defined in Part X are sufficiently uniform to use as a basis for calculations of present land use and production and the possible future potential.

III. Cattle Numbers

As a guide to the reliability of the assessed stocking rates of the pasture lands and the accuracy of the regional mapping, the average stocking rate of each preliminary pasture land was applied to its total area within the gulf region. The total number of cattle assessed in this way was compared with the cattle population of the area as recorded by the Commonwealth Statistician at March 31, 1957 (Table 24).

Table 26
TYPE OF ENTERPRISE ON CATTLE PROPERTIES IN AREA SURVEYED BY BUREAU OF AGRICULTURAL ECONOMICS

Type of Enterprise	Properties (%)
Breeding only, sale of male stores and surplus females	44
Breeding and restricted fattening of bullocks and cows	22
Breeding and fattening of entire turn-off	28
Fattening only	5

The estimated average stocking rates of the pasture lands are shown in Table 25 together with the areas and proportions of the pasture lands in the Bureau of Agricultural Economics survey area and B.A.E. sample properties. The estimated cattle population (sum of the products of areas of pasture lands by stocking rates) for the B.A.E. survey area was 884,823 or just less than 1% higher than the Commonwealth Statistician's figures for March 1957 (Table 24). The average stocking rate on properties surveyed and the whole gulf region was 11·4 and 11·3 cattle/sq mile respectively.

IV. Type of Enterprise

The way in which the cattle properties in the gulf region utilized their grazing resources is shown in Table 26.

V. Breeds of Cattle

It is estimated that about 60% of the cattle were predominantly pure Shorthorns, about 25% Shorthorn–Devon crosses, while the remainder were mainly Hereford crosses with a small number of Zebu crosses. The properties running Herefords were gradually changing over to Shorthorns. A strong interest was being taken in the performance of poll Shorthorns and some poll bulls were being introduced annually into the Shorthorn herds.

Encouraging results with Zebu cross cattle were recorded on the properties carrying Zebu cattle. On these properties, it was planned that in three generations all herd bulls would comprise three-eighths Zebu and preliminary results indicate that average age of turn-off can be reduced from 4½ years to 3½ years with carcasses dressing out at 550 lb chiller quality. Evidence from weighing trials indicated that Zebu cross cattle were making better weight gains in the gulf than British breeds, without deterioration in quality.

VI. Calving Rate

On seven properties, accurate detailed herd records were available over a period of years. The number of calves branded expressed as a percentage of breeders carried averaged 61%. Over a 4-year period branding percentage varied between properties from 47·4% to 81%. The lowest average branding on any property recorded in recent years was 25% in 1952. It was estimated from the records of the properties that an average of 10% of calves dropped died before branding.

VII. Weaning

Although arguments were advanced for and against regular weaning, breeder segregation, and bull removal, it is significant that the properties practising these methods had the highest branding percentages, the highest percentage turn-off, and the lowest mortality. The Royal Commission on abattoirs and meatworks (Queensland) in 1945 considered that more thorough control of cattle was one of the main requirements for increasing cattle production in the gulf country.

VIII. Turn-off

On the assumption that the number of calves branded consists of equal numbers of males and females, it is important to study the actual turn-off of males and females as compared with brandings. The average turn-off of male cattle from the records available on the seven breeding properties was calculated at 84% of male brandings. On the other hand, the average number of females marketed amounted to only 13% of the female brandings. In effect, this means that 16% of male cattle branded and 87% of females branded were not marketed. (The marketing of bulls did not exert any significant influence on the male turn-off.) Expressed as a percentage of total herd numbers, male cattle turn-off represented 10·4% and female turn-off 1·6%. On the properties engaged principally in fattening store cattle, turn-off averaged 41% of total cattle carried.

Over the 53 survey properties for which herd records were available, the average annual turn-off was 17% of average herd numbers or 146,832 head. Of these, 32·5% were fat males, 7·5% cast cows, and 60% store cattle.

Average age of turn-off of male store cattle was 2½–3 years. Male fat cattle turned off varied in age from 3 to 7 years, averaging approximately 5 years and dressing out at 600 to 650 lb. Female fats turned off varied considerably in age, averaging around 7 years and dressing out at 500 to 550 lb.

IX. Mortality

The above figures on male and female turn-off illustrate the heavy mortality rate prevalent on these properties.

The heavy wastage of cattle is due principally to the loss caused by the low numbers of cows marketed compared with the feasible maximum and the age of marketing male cattle. On the seven sample properties the turn-off figures indicate that 87% of females branded annually eventually die on the property. Average branding percentages varied from 47 to 81% and the overall average of 61% must be considered as very low. Also, with regard to male cattle the fact that 16% of male calves branded were not marketed suggested that there was considerable room for improvement in organization. Ample evidence was available that climatic conditions were not the only cause of the heavy mortality. Some properties on poor and rough country were securing average brandings of 75% while other properties comprising superior land types as far as stocking rates and ease of working stock are concerned could only secure average brandings of 60%. Similarly, some properties with poor fattening country were turning off fat cattle at 4 years old whilst other properties with better country were taking 6 years, or more, to market the turn-off.

Mortality rate on the seven survey properties averaged 12% of the total herd. Mortality rate ranged from 4% to 26% over a period of years. The high mortality of 26% on one property was due principally to a serious lack of water in the dry year of 1952.

In most instances heavy mortality and low turn-off were associated with the pattern of management employed on the individual properties. Until sufficient paddocks and watering facilities are available such heavy mortality will continue. It was significant that all the surveyed properties had plans for steady improvement programmes and considerable sums had been invested in property improvements, plant, and bulls over recent years.

The paucity of both population and transport facilities leads to diseconomies in property operation and hence must be considered in relation to the property development necessary for reducing the heavy mortality. However, with the present cattle price levels and the concessions available for developmental expenditure, the lack of transport and population, although retarding factors as regards development, cannot be advanced as a reason why improvements to counteract the heavy cattle mortality are not an economic proposition.

X. Land Use Development

Since 1955 (the B.A.E. survey year) herd numbers have declined in the gulf region (Table 24). This has been due to a run of dry years since 1957–58 and heavy marketings in 1959–60, when many drought-affected stock were slaughtered for the American trade. It is apparent that the industry is still very dependent on external factors such as rainfall for its prosperity. Development of the area will mitigate such effects on the cattle industry, especially where cropping allows fodder conservation. However, such a severe drought as Cloncurry shire has suffered over the last five years will always have a severe effect.

In both the short and long term, beef cattle will continue as the principal produce from the agricultural and pastoral resources of this region. Potential beef production has been assessed on the basis of information supplied by survey properties under two sets of assumptions:*

(1) Increase average annual turn-off to 24·3% of herd numbers by changing over to production of young store cattle (to 2 years) and sale of cast cows. Herd mortality assumed to be lowered to 5% overall and an average branding achieved of 70% of breeding cow numbers.

(2) Increase the stocking rate from an average of 11·4 to 14·4 per sq mile by investment in further station improvements and provision of adequate transport facilities, both road and sea. Type of turn-off as specified in (1) above.

TABLE 27

POTENTIAL STOCKING RATE OF PASTURE LANDS WITH PROPERTY DEVELOPMENT BUT WITHOUT PASTURE IMPROVEMENT IN BUREAU OF AGRICULTURAL ECONOMICS SURVEY

Pasture Land	Area (sq miles)	Potential Stocking Rate (cattle/ sq mile)	Potential Cattle Population
Non-range country	13,860	6·0	83,160
Spinifex plains and low plateaux	2360	8·0	18,880
Northern sandy forest country	17,254	8·0	138,032
Southern sandy forest country	5264	17·0	89,488
Coastal country	2075	10·0	20,750
Western mid-height grass country	983	12·0	11,796
Arid short grass country	1269	25·0	31,725
Delta country	1989	20·0	39,780
Frontage country	1172	50·0	58,600
Blue grass–browntop plains	9892	23·0	227,516
Mitchell grass plains	2606	23·0	59,938
Eastern spinifex country	600	5·0	3000
Three-awn country	2000	12·0	24,000
Eastern mid-height grass country	11,234	19·0	213,446
Basalt country	6006	19·0	114,114
Total	78,564	14·4	1,134,225

Although average mortality in the region is high, there are many instances of properties having an average mortality around the 5% assumed above, over fairly long periods of time. With further improvement of properties by fencing and waters, closer control could be exercised over beef herds.

* No account has been taken of possible agricultural developments such as fodder cropping or conservation. These developments would have a considerable effect on the productivity of grazing lands in this area.

Very few properties, if any, would be unable to increase carrying capacity by the addition of these improvements, together with improved methods of management. Consequently an upper estimate for potential stocking rate under these conditions was obtained from property management. These revised estimates could lead to an increase in total cattle from the present 885,000 to 1,134,000 head (Table 27).

The movement of cattle and the important role of transport in development of this area have been recorded elsewhere (Allen 1959; Kelly 1959; Thomas 1961). A new system of beef roads has been recently initiated and since 1960 new outlets by sea transport from Karumba and Burketown have been provided.

TABLE 28

POTENTIAL BEEF PRODUCTION OF GULF REGION WITH PROPERTY DEVELOPMENT BUT WITHOUT PASTURE IMPROVEMENT

Basis	Cattle Population ('000)	Cattle Turn-off				Meat Production (tons)
		Fat Males	Fat Females	Store Cattle	Total	
1955 cattle population	885	48,896	11,284	90,270	150,450	36,412
Store production from 1955 cattle population	885	—	58,065	156,990	215,055	37,315
Store production from increased stocking	1134	—	75,874	205,141	281,015	48,750

If adequate transport facilities were completed and cattle production changed to turn off young stores and cast cows, meat production could rise from 36,400 tons at present to 48,750 tons (34%). Actual numbers turned off would rise by as much as 87%, but the average weight per animal would fall in the change-over to store production (Table 28).

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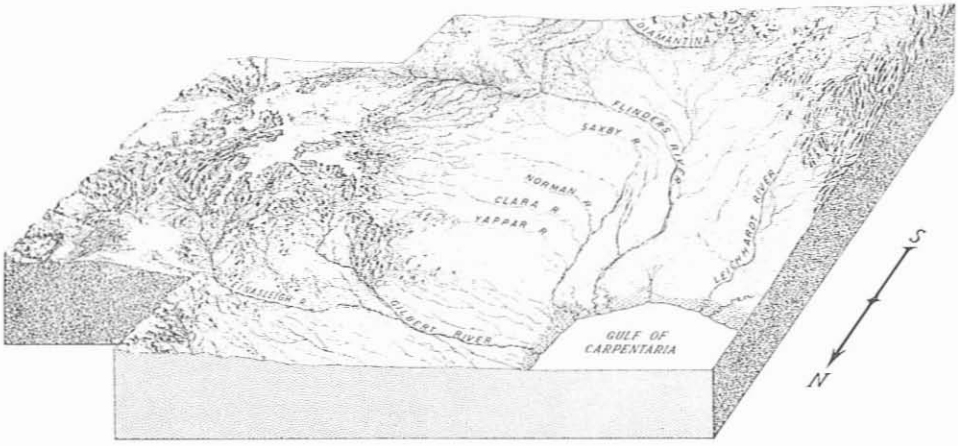

Fig. 1.—The Leichhardt–Gilbert area consists of three very distinct physiographic divisions. The Einasleigh uplands in the east rise to nearly 3000 ft and the Isa highlands in the west to 1650 ft. Between the two high areas are the vast Carpentaria and inland plains.

Fig. 2.—The Isa highlands occupy about one-twentieth of the area. They are hilly to mountainous country averaging about 1200 ft above sea-level. They coincide with the outcrop of the igneous and metamorphic rocks of the Cloncurry complex.

Fig. 1.—The Carpentaria and inland plains are a broad belt stretching from the Gulf of Carpentaria to beyond the southern margin of the area. The altitude at the divide between gulf and inland drainage is about 1000 ft.

Fig. 2.—The Einasleigh uplands are mostly about 2000 ft above sea-level. They are rugged in many parts but local relief rarely exceeds 500 ft and is normally much less.

Fig. 1.—The climate is strongly seasonal, most of the rain falling in four summer months. Because of the seasonal rainfall, river flow is intermittent; in the summer large volumes of water flow down the channels and flash floods are common, but during winter most rivers are dry.

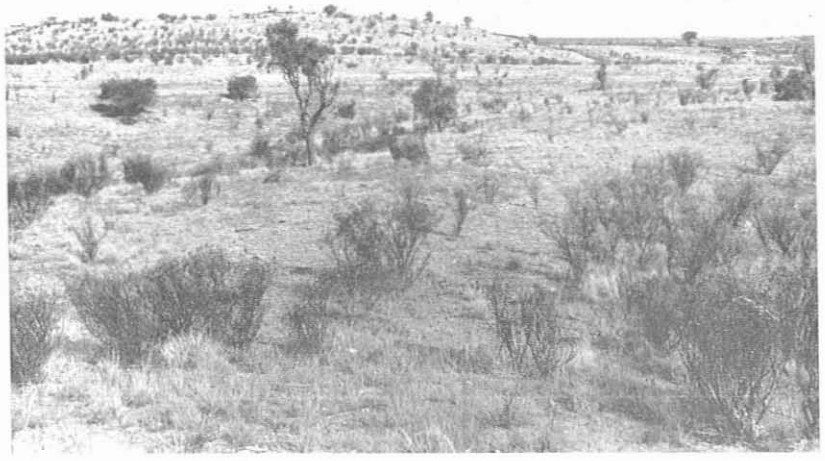

Fig. 2.—The climate of the south-western corner of the area is arid tropical, with mean annual rainfall and evaporation about 15 in. and 110 in. respectively. Under these conditions the vegetation consists of short grasses and sparse shrubs or low trees.

Fig. 1.—The climate of the north-eastern corner is humid tropical with mean annual rainfall and evaporation 30–40 in. and about 50 in. respectively. In this part the vegetation consists of eucalypt forest, 60–80 ft (up to 120 ft) high, over dense stands of perennial mid-height grass.

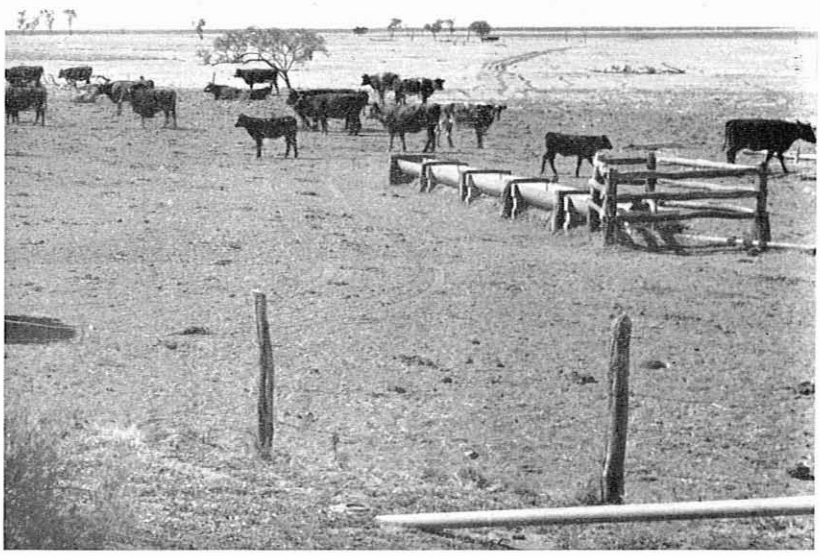

Fig. 2.—Climatically it appears that only in the north-eastern corner of the area is safe dry-land agriculture possible, although a larger area appears suitable for annual pastures or short-season fodder crops. Over most of the area dry-land land use is likely to remain limited to the grazing of natural pastures. Cattle are grazed in the northern three-quarters and sheep grazing is mostly concentrated on the Mitchell grass plains.

Fig. 1.—The mines which were productive between about 1870 and 1920 and were responsible for the development of the railway system are now abandoned. Currently mineral production in the area is very low. The rich Mt. Isa mines are only a few miles beyond the western margin.

Fig. 2.—Of the 15 pasture lands only one (non-range country) occurs in more than one physiographic division. Non-range country comprises rugged hills and mountains and stony or barren country of lower relief. This photograph is of lancewood forest country with very sparse grass, on shallow soil on sandstone.

Fig. 1.—Spinifex plains and low plateaux comprise a pasture land in the Carpentaria and inland plains. The country has gravelly or sandy soils, is treeless or carries only scattered trees, and has a low pastoral value. Some portions are useful in the latter part of the dry season when adjacent normally better-quality pastures are very poor.

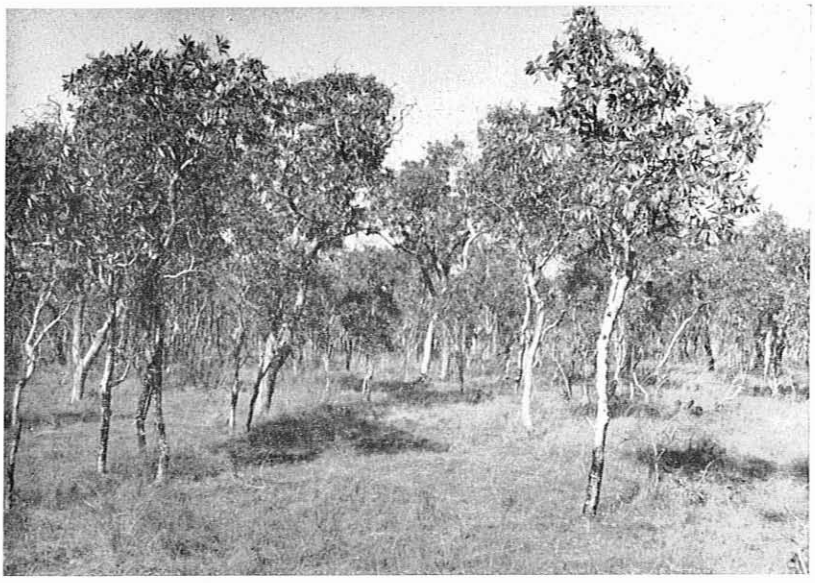

Fig. 2.—The northern sandy forest country is the northern part of the broad sandy outwash plains on the eastern side of the Carpentaria and inland plains. The soils are mostly infertile deep sands and the common vegetation is low paperbark woodland (stringybark–bloodwood woodland under higher rainfall). The relatively sparse grass cover is mainly three-awn and ribbon grass. The country has a low pastoral value.

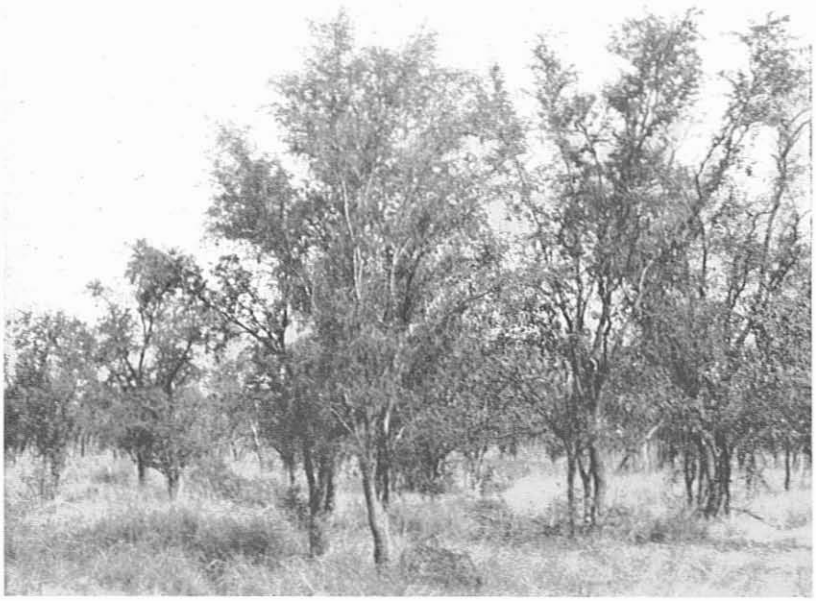

Fig. 1.—The southern sandy forest country is the southern part of the broad sandy outwash plains on the eastern side of the Carpentaria and inland plains. It has infertile deep sandy soils with a sparse grass cover of three-awn and ribbon grass but the tree cover contains many top-feed species such as bean tree (*Bauhinia*), whitewood, and vine tree, which may explain its somewhat higher stocking rate compared with the northern sandy forest country.

Fig. 2.—The 2000 sq miles of coastal country consists mostly of bare saline mud flats. Areas of salt couch and rice grass pastures occur particularly along the inland margins but lack of fresh water limits grazing to short periods after rain.

Fig. 1.—The western mid-height grass country consists of flat to gently undulating plains with silver-leaf box woodland over mid-height grasses, commonly three-awns and kangaroo grass. The pastures are only of moderate quality and have a moderate carrying capacity.

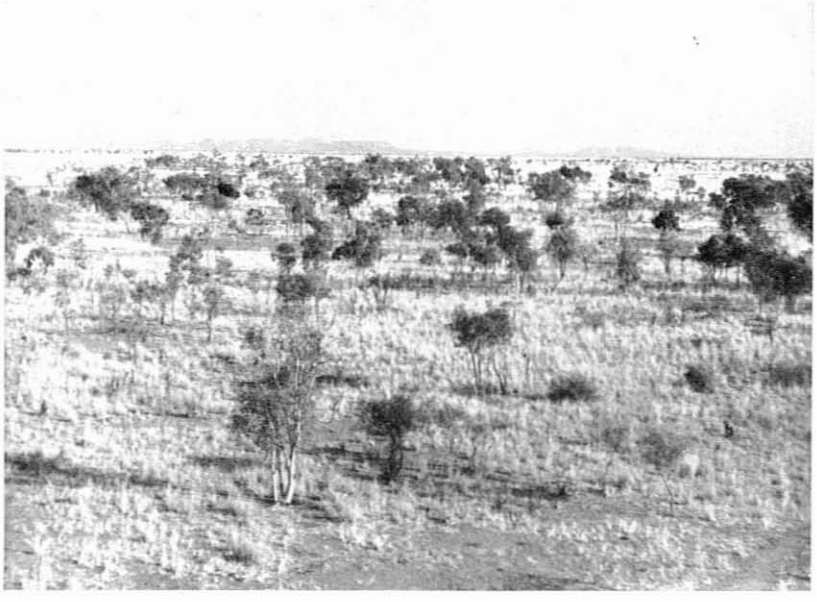

Fig. 2.—The arid short grass country occurs in the west of the area, mainly associated with the Isa highlands. It is undulating country with shallow soils, scattered low trees or shrubs, and short, apparently nutritious grasses. The country has a moderate carrying capacity.

Fig. 1.—The delta pasture land comprises the heavier soil parts of the Gilbert River "delta". The plains are mostly sparsely timbered and carry short grasses (*Chloris* and *Eriachne*) but moderate areas support mid-height and tall grasses. The country is well watered naturally and has a fairly high stocking rate.

Fig. 2.—Frontage country occurs as strips adjacent to streams. It mostly has deep coarse-textured soils with eucalypt woodland over mid-height grasses. Because of the availability of stock water this country was the first stocked and has been heavily stocked since. Buffel grass is well established on frontages near Cloncurry.

Fig. 1.—The 15,400 sq miles of blue grass–browntop plains comprise the northern lower and wetter portion of the heavy soil plains of the Carpentaria and inland plains. They are nearly flat plains, treeless or with sparse low trees, carrying mid-height grasses, especially blue grasses and browntop. The country has a fairly high stocking rate but dry season forage is of poor quality.

Fig. 2.—The 22,700 sq miles of Mitchell grass plains occupy most of the southern part of the Carpentaria and inland plains. They are gently undulating treeless plains with heavy soils carrying Mitchell grass. The country has a fairly high stocking rate and is used mostly for sheep grazing.

Fig. 1.—The 600 sq miles of eastern spinifex pasture land occurs only in the south-eastern corner of the area. The soils are sandy, the vegetation is eucalypt woodland 20–40 ft high, and the ground cover consists of patches of spinifex and patches of mid-height grasses. The country has a low stocking rate.

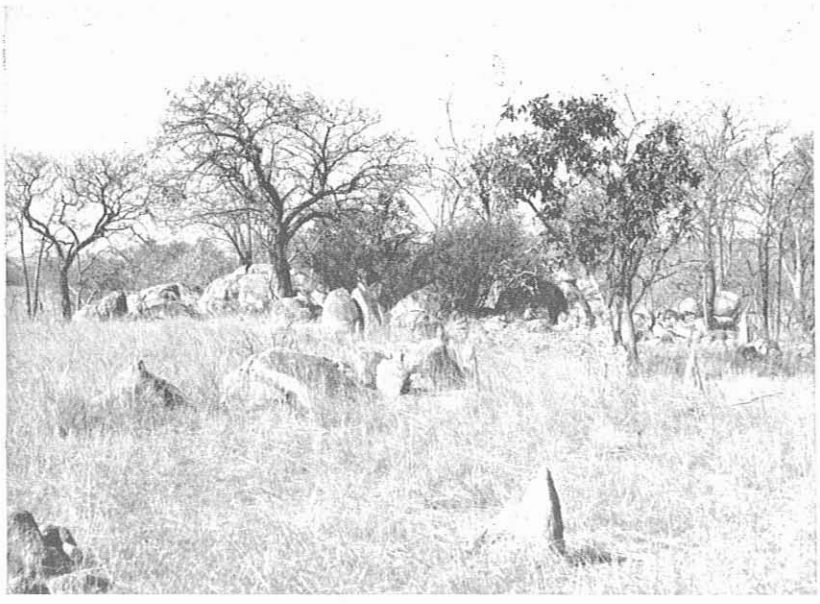

Fig. 2.—The three-awn pasture land occurs in the western lower part of the Einasleigh uplands. The vegetation is mainly a woodland of Georgetown box over a short to mid-height grass layer comprising mostly three-awns. The pasture has a low yield of poor-quality forage. The stocking rate is moderate. Granite outcrops are common in Georgetown land system.

Fig. 1.—The 10,300 sq miles of eastern mid-height grass country comprise most of the non-basalt country of low relief in the Einasleigh uplands. Soils are varied and the vegetation commonly is eucalypt woodland of ironbark, bloodwood, and other trees, over fairly dense stands of mid-height grasses, the most prominent of which are blue grasses, bunch spear grass, kangaroo grass, ribbon grass, and three-awns. The country has a moderate to high stocking rate.

Fig. 2.—Two belts of basalt country, totalling 7000 sq miles, occur in the Einasleigh uplands. The country consists of irregular stony basalt plains, the stoniness tending to decrease northwards. The red soil areas carry eucalypt woodland over fairly dense mid-height grasses. The black soil areas are treeless or carry sparse trees over dense mid-height grasses. The pastures have a fairly high yield and the country has a high carrying capacity. The northern part appears suitable for agriculture.