Survey of the Barkly Region, Northern Territory and Queensland, 1947-48

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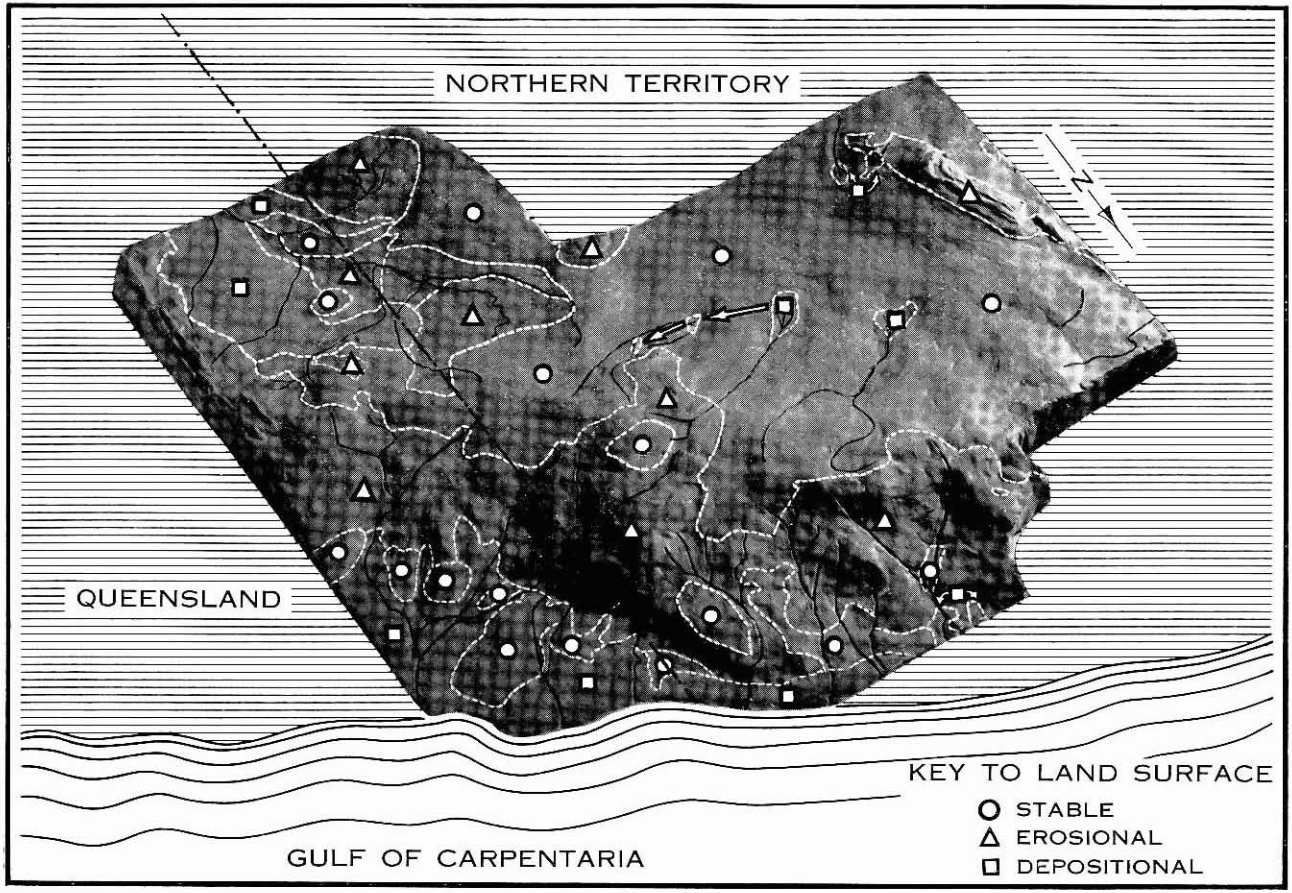

RELIEF MODEL OF BARKLY REGION

(*Frontispiece*

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FOREWORD

A field survey of the Barkly region of the Northern Territory and Queensland was conducted in 1947 and 1948. This was one of a series of surveys initiated by C.S.I.R.O. at the request of the Northern Australia Development Committee in order that an accurate knowledge of the nature of the country and its potentialities might be made available for the formulation of policies concerning development.

These surveys therefore have the objectives of describing, classifying, and mapping the country, including its surface geology, topography, soils, and vegetation; and of broadly assessing land-use potentialities by consideration of these inherent land characteristics in relation to the prevailing climate and possibilities of irrigation.

In order that country might be subdivided in a fundamental rather than superficial way, and that the lands of large regions may be so classified and mapped at a relatively rapid rate, it has been necessary to examine land characteristics in a comprehensive manner and to develop scientific methods for land classification. The general method of these surveys was initially described in reports on the survey of the Katherine-Darwin region. The method has been further developed in the survey of the Barkly region and in the more recent survey of the Townsville-Bowen region, of which a report has been published.

A preliminary report of the first year's field work in the Barkly region was distributed in mimeographed form in 1947.

RECOMMENDATIONS

It is recommended that the following additional specific investigations be conducted:

(i) An ecological study in regions of low productivity to determine principles whereby desirable modifications of natural pastures can be economically achieved by dispersal of introduced species, or by other means. An excellent opportunity for such a study is provided by the existence of the Stuart Highway, which links Alice Springs and Darwin, and so traverses a wide range of rainfall and other environmental conditions.

(ii) A study of the efficiency of pasture utilization in relation to the distance that cattle have to travel from water whilst grazing, with special reference to the Mitchell grass plains of the Northern Territory.

(iii) A hydrological study of the Gregory River basin to determine the scope for water conservation and irrigation of the flood plains of that river and its tributaries.

(iv) Preliminary trials of the growth of a wide range of fodder crops under dry-land conditions in the northern areas receiving more than 25 in. rainfall per annum.

(v) An examination of the possibilities of establishing cypress pine plantations in northern areas.

SUMMARY

(1) A comprehensive survey of the Barkly region of the Northern Territory and Queensland was conducted in 1947 and 1948 by the C.S.I.R.O. Northern Australia Regional Survey (now Land Research and Regional Survey Section).

(2) The region includes the area popularly known as the Barkly Tableland, a contiguous portion of the Georgina River basin and the inland "desert", and the country extending to the Gulf of Carpentaria. It covers an area of 120,000 square miles.

(3) The region has been described in respect to its topography and land forms, soils, vegetation, and climate.

Land Classification

(4) The origins of the various lands of the region have been studied and the lands classified on this basis into 21 geomorphological units, shown on the accompanying map.

(5) Further subdivision into 38 Land Systems has been made on the basis of present topography, soils, and vegetation, and their distribution has also been mapped. Each land system is represented by a diagrammatic cross section in the text (Tables 15-29, 31-43, 45-54).

(6) The 38 Land Systems have been grouped into 11 Land-use Groups, and the agricultural and pastoral potentialities of each have been discussed. A map with a descriptive table accompanies this report.

Climate

(7) The region has a dry monsoonal climate with an average annual rainfall ranging from 10 in. in the south to 30 in. at the coast.

(8) Rainfall is usually restricted to a short summer season, and all parts of the region have a long dry season during which the climate must be regarded as arid. The estimated average agricultural growing period is only 13 weeks at the coast and 3 weeks at inland centres. The corresponding estimated average periods of useful pasture growth are 19 and 7 weeks respectively. (These regional figures may be modified locally by the influence of topography and soil.)

(9) Temperatures are always sufficiently high for plant growth, which may, however, be adversely affected by periods of excessively high temperature. Temperatures during the wet season relative to the preceding

periods are higher in northern Australia than in other tropical countries. This is believed to be of significance to plant production, and may partly be responsible for the low nutritive value of pastures at maturity in the higher-rainfall sections.

Soils

(10) The most extensive soils of the region are lateritic soils of various kinds, grey and brown soils of heavy texture, and podzolic soils.

(11) A very large proportion of the soils are stony or highly leached, and from chemical analyses it appears that all the soils are low in phosphates. Thirty-two soil units have been described.

Vegetation

(12) Forty plant communities have been recognized and described and their distribution in relation to environmental factors discussed. These communities are of wide variety and include treeless grasslands dominated by *Astrebla* spp. (Mitchell grass) on heavy soils, low shrub or sparse tree communities in which *Acacia* spp., mallee eucalypts, and *Triodia* spp. (spinifex) are prominent in the low-rainfall areas, and a wide range of woodland and open forest communities, in many of which *Eucalyptus* spp. are dominant.

(13) Forests of *Acacia shirleyi* (lancewood) cover large areas of lateritic country and small patches of *Callitris intratropica* (cypress pine) occur on sandy country near the coast.

(14) The most extensive pastures of the region are the Mitchell grass pastures of the central and northern parts of the region; mixed pastures of medium height of the woodlands and forests in the northern half; and the spinifex and short-annual-dominant pastures of the more arid areas. The most valuable pastures of less extent are those of the bluebush swamps in the heavy-soil areas.

Agricultural Potentialities

(15) It is unlikely that dry-land agriculture of any kind will be successful in areas receiving less than 25 in. of rainfall per annum, except for localized areas specially favoured topographically.

(16) Even within this near-coastal belt low soil fertility will impose major restrictions on areas worth cultivation. Where cultivation is justified the production of fodder crops for use in conjunction with the beef-cattle industry is considered to be a more stable form of agriculture than dependence upon exportable plant products. However, there must be considerable advance in the standard of the cattle industry before even this form of agriculture can be economically applied.

(17) The small areas of levee soils of the Nicholson and Gregory Rivers and Settlement Creek would be suitable for intensive agriculture

under irrigation. Without conservation these streams could provide water for the irrigation of small areas only. Tobacco is a possible crop, but the low atmospheric humidity during the dry season, and the isolation of the areas, may be important disadvantages.

(18) The large area of heavy clay flood-plain soils along the Gregory River is similar to, but far more extensive than, those being investigated at the Kimberley Research Station on the Ord River, W.A.

(19) There may be suitable dam sites in the headwater country of the Gregory River or its tributaries, but the total catchment area is small and probably would not supply more than 130,000 ac.-ft. per annum. This would be sufficient to irrigate only a very small proportion of the commandable area.

(20) The results of the investigations at the Kimberley Research Station should be a guide to the kind of irrigated agriculture that might be established on these flood plains.

Pastoral Potentialities

(21) Over much of the region the rainfall is adequate to maintain a pastoral industry, although nowhere is it sufficient for an intensive form of pastoral development.

(22) In consequence of the marked summer incidence of rainfall the pastures of most of the region are more satisfactory for cattle than for sheep.

(23) Approximately one-third of the region is fair to good grazing country, one-third is rough country or has inferior pastures, and one-third is dry country locally known as desert.

(24) The areas served by stock water on the better pastures of the Northern Territory portion of the Barkly Tableland in 1948 have been mapped. It is evident that a considerable increase above present figures is possible by the supply of additional watering points alone, and that approximately 140 additional bores would be necessary to bring all land in this section within 5 miles of a watering point.

(25) The coastal sections, in which surface waters are more plentiful, are only partially utilized.

(26) There is scope for more efficient utilization of the pasture resources of the region by greater intensification of watering points and by fencing, both of which would also provide means for the better control, segregation, and management of stock, and for raising the general level of stock husbandry.

(27) The study of the occurrence of sub-artesian water in this portion of the region indicates that adequate stock water is available at depths of 150-450 ft. for all likely developments of the cattle industry.

(28) There is no scope for the economic improvement of the pastures of the region by methods known at the present time. The possibilities of the gradual modification of the pastures by dispersal of introduced species or by other means require examination, and principles involved would have a wide application in other semi-arid parts of Australia.

(29) An estimate of the *maximum* stock-carrying potential of the whole region is 678,000, comprising 497,000 in the Northern Territory portion and 181,000 in the Queensland portion. Estimates of annual turn-off for these two portions if lands were fully utilized are 62,900 and 24,200 respectively, totalling 87,100. About 45,000 of these constitute the estimated fattening potential of the bluebush swamps of the region but this number is likely to fluctuate according to seasonal rainfall. A total of 100,000 might be turned off if the production of young stock was emphasized, rather than the production of older stores and fat cattle. Estimates of turn-off are based on the standards of production prevailing in 1947; they do not allow for the full increase in percentages which may be achieved by improvement in husbandry.

(30) This number plus the potential output from the Katherine-Darwin region and the associated country would be sufficient to maintain a killing works in the north.

Mining Potentialities

(31) Apart from the gold mines at Tennant Creek, the main mining potentialities are in the belt of hilly country of low pastoral value in the northern and eastern parts of the region. This area includes Mt. Isa and a number of small mines and is worthy of further prospecting for mineral deposits.

PART I. INTRODUCTION TO SURVEY OF THE BARKLY REGION

By C. S. CHRISTIAN*

I. GENERAL DESCRIPTION OF THE REGION

The region surveyed covers an area of 120,000 square miles and includes the area popularly referred to as Barkly Tableland, the associated Gulf Country, the upper Georgina River basin, and portions of the inland desert country. With the exception of areas in the north-west and south-west and islands in the Gulf of Carpentaria, it covers all the country between latitudes 16° and 22° S. and longitudes 133° 30′ and 139° 30′ E. Longitude 130°, which marks the border between Queensland and Northern Territory, passes about 8 miles west of Camooweal.

The main centres are Mt. Isa on the eastern border, Camooweal at the eastern end of the Barkly Tableland, Urandangi in the Georgina basin, Burketown just outside the north-east corner of the region, Tennant Creek near the south-western corner, Elliott in the north-west, Newcastle Waters just outside the western boundary, and Borroloola in the far north. The well-known cattle stations Alexandria, Brunette Downs, Anthony Lagoon, and others are in the centre of the region.

The north-south Stuart Highway from Alice Springs to Darwin runs near the western border and the Barkly Highway from Mt. Isa to Tennant Creek traverses the southern half of the region. A network of fire-ploughed roads connecting station homesteads and leading to bores has been developed on the Barkly Tableland and in the Georgina basin. There are very few roads in the remaining portions of the region, the main ones being from Anthony Lagoon to Borroloola and from Camooweal to Burketown and Wollogorong.

The Queensland railway systems reach the eastern edge of the region at the railheads of Dajarra and Mt. Isa in the south-eastern portion. An additional railhead, Kajabbi, is accessible by stock route from the north-eastern cattle stations. Birdum, which connects with Darwin, is 140 miles north of Newcastle Waters, and Alice Springs 460 miles south. Mt. Isa, Camooweal, Alexandria, and Tennant Creek are landing points on the major north-south and east-west air routes. Many of the cattle stations have small airstrips used by a local air service operating from Alice Springs. Sea transport is confined to a small coastal boat, which runs an irregular service to various ports and islands in the Gulf of Carpentaria.

The main stock route, which leads from the western portion of the Northern Territory to Dajarra and down the Georgina Valley in Queensland, traverses the "black-soil" zone. The stock route to Alice Springs

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traverses the western margin of the region. A stock route from the north-east of the region leads to the railhead at Kajabbi.

The region may be divided broadly into four zones parallel to the coast, which runs in a south-east to north-west direction. They are the coastal plains, the rough, hilly country of the Gulf fall, the "black-soil" plains of the Barkly Tableland and the upper Georgina basin, and an inland desert zone. The region is in the dry monsoon belt of northern Australia and has an average annual rainfall varying from 10 in. in the south to 30 in. at the coast, and concentrated mostly within the December-March period. Very little rain falls during the remainder of the year.

In the higher-rainfall section woodlands and open forests dominated by eucalypts are the characteristic vegetation communities. Mitchell grass treeless plains are predominant in the "black-soil" zone, and low shrub or sparse tree communities with spinifex and short grasses occur on the lighter-textured and stony soils of the adjacent desert zone. Apart from the heavy-textured pedocals of the "black-soil" zone and flood plains of some of the northern rivers, most of the soils of the region are acidic and highly leached, or stony. Many are lateritic.

The main streams are those of the Gulf fall, which flow in a general north-eastern direction to the Gulf of Carpentaria. They are the Gregory River and its tributary the Nicholson, Settlement Creek, Calvert, Robinson, Foelsche, Wearyan, McArthur, and Limmen Bight Rivers. The Georgina River in the south-east of the region flows southward towards central Australia. In the central portions of the region small streams flow towards the internal drainage areas of the Barkly Tableland.

Apart from the silver-lead mines at Mt. Isa, the gold mines at Tennant Creek, and several very small scattered mines, stock-raising is the main form of land use within the region. Some sheep are carried in the south-east corner but most of the usable country that is served by water is grazed by beef cattle. The region exports mainly store cattle but a small proportion of fats is also marketed when stock routes permit. The main concentration of the cattle industry is on the "black-soil" zone but even there the average size of the properties is several thousand square miles. In the other three zones the density of stock is very low and most of the country is not used.

Since this survey was commenced two additional surveys dealing specifically with the cattle industry of northern Australia have been conducted, one by J. Kelly, Investigation Officer, Commonwealth Bureau of Agricultural Economics, the other by W. A. Beattie, Senior Research Officer, Division of Animal Health and Production, C.S.I.R.O. Each of these investigators has dealt with aspects of the cattle industry of this region in the course of their work. In consequence this survey has not made a study of special animal problems, of economic aspects of the animal industry, or of the effects of changes in stock husbandry on production. Material is presented in Part IX concerning land use in relation to the animal industries, particularly concerning pasture utilization, management, and improvement, and land-use potential.

II. Survey Procedure

The survey of the Barkly region was commenced by the C.S.I.R.O. Northern Australia Regional Survey unit in April 1947. Since the field work in the region was completed and during the preparation of this report, this unit was established as the Land Research and Regional Survey Section, C.S.I.R.O.

In addition to the personnel whose names appear as authors of Parts III-IX, the survey was accompanied during 1947 field season by S. T. Blake, Botanist of the Queensland Department of Agriculture and Stock, and W. Arndt, Research Officer, C.S.I.R.O.

Approximately 4,000 miles of land traverses were made in the region during 1947 and 5,000 during 1948. The field seasons were confined to the dry periods of the year to facilitate movement through the region. During the first year the maps used by the survey were Army 8 miles to 1 in. sheets and 30 miles to 1 in. maps of the Northern Territory published by the Department of the Interior. The Royal Australian Air Force photographed the region at a scale of approximately 1:50,000 during the 1947 season, but the aerial photographs were not available to the unit until after the completion of that season's field work. Base maps at scale of 4 miles to 1 in. compiled from these aerial photographs by the National Mapping Section of the Department of the Interior, Canberra, were available for the second field season and were used in conjunction with the aerial photographs.

Land Unit and Land System boundaries were marked in the aerial photographs from information gained on the land traverses. This information was transferred to the base maps, which were used by the National Mapping Section to prepare the several maps accompanying this Report.

In addition to the maps accompanying this report more detailed information concerning land units has been recorded on the following 4-mile map sheets: Brunette Downs, Walhallow, Alroy, Rankine, Avon Downs, Camooweal, Mt. Isa, Helen Springs, Beetaloo, Urandangi, Bauhinia Downs, Tennant Creek, Sandover River, Murphy Creek, Robinson River, Calvert Hills, Lawn Hill, Frew River, Westmoreland. It is not intended to publish these at the present time but the information is available if required.

III. Acknowledgments

Acknowledgments are due to many individuals and organizations who have assisted at various stages in the course of this work. The Commonwealth Bureau of Mineral Resources, Geology and Geophysics, and the

National Mapping Section of the Department of the Interior have both cooperated very actively in the actual conduct of the work, the former by making available the services of L. C. Noakes and D. M. Traves, geologists, who accompanied the field unit, and the latter by preparation of base maps from aerial photographs and maps for publication, and arranging for their reproduction. The Queensland Department of Agriculture and Stock made available S. T. Blake, who was seconded to the unit for part of the 1947 field season. Mr. Blake's services in subsequent identification of plant specimens are gratefully acknowledged.

The Division of Soils, C.S.I.R.O., joined with this Section in the conduct of the surveys and seconded G. A. Stewart as pedologist to the unit. During the course of preparation of this report, helpful discussions have been held with W. A. Beattie and J. Kelly, both of whom have freely made available data collected in their respective surveys of the cattle industry. Thanks are due to the station managers of the region for their hospitality on many occasions and their ready cooperation, which contributed a great deal to the success of the scientific investigations. It is desired to record the help of officers of the Northern Territory Administration at many times. The work of the survey could not have been conducted without the assistance of members of the field unit who have all contributed to the success of the work. Finally, the appreciation of the several authors is expressed to Miss M. Mills, Technical Secretary, for her contribution to the final preparation of this report for publication.

PART II. CLIMATE OF THE BARKLY REGION

By R. O. SLATYER* and C. S. CHRISTIAN*

I. GENERAL CLIMATIC CHARACTERISTICS

The greater part of the region is semi-arid, merging into an arid zone at the southern margins and into a narrow subhumid strip adjoining the Gulf of Carpentaria. The climate is monsoonal with well-defined wet and dry seasons, nearly all the rain being received between November and April with the greatest incidence during January and February. Light rains are sometimes received during the dry season, but the period between May and September is practically rainless. Day temperatures are high throughout the year, particularly in October, November, and December, prior to the onset of the wet season.

The weather is strongly seasonal and the year may be divided into two main seasons, a short, wet summer and a long, dry winter, with two subsidiary transitional periods between them. By the latter part of January, the wet summer season, under the influence of the north-west monsoon, is usually established. Over the drier parts of the region the monsoonal influence lasts only for a few weeks and is characterized by widespread but intermittent rainfall with more humid and slightly cooler conditions than those prevailing earlier. In the subhumid areas adjacent to the coast, the rainfall tends to be more persistent and the associated temperature and humidity effects more marked.

The monsoon usually wanes in March and a period of calms and variable winds commences and continues for about a month. Thunderstorms, with or without accompanying rains, are a feature of this period. As the temperature and humidity gradually fall the frequency and intensity of the thunderstorms decrease and the commencement of the dry season is soon indicated by the onset of steady south-east winds. In the north-western portions of the region only a little additional rain is now received, but in the remainder, and particularly in the south-eastern portions, additional light rains sometimes occur during the early winter months. The dry season, characterized by south-east winds, cooler day temperatures, greater diurnal temperature variation, and low humidity, persists until late September or October when the south-east winds subside and a second transitional period of calms and variable winds commences. Day temperatures become hotter and thunderstorms occur with increasing frequency and violence until the monsoon sets in once again.

Dry season weather is normally very regular, and variations in the annual weather regime are mainly due to differences in the intensity of the monsoonal influence from year to year. Often when the monsoon is strongly developed, the rains that occur during the transition periods also

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TABLE 1

SUMMARY OF RAINFALL CHARACTERISTICS FOR 10 STATIONS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Borroloola													
Rainfall (points)	854	712	667	164	45	28	5	0	6	35	143	339	3058
Variability (%)†	55	71	51	108	168	156	167	0	156	115	62	60	28
No. of wet days	12	10	10	2	1	1	0	0	0	1	4	9	50
Rain/wet day (points)	71	71	67	82	45	28	0	0	0	35	36	44	61
Burketown													
Rainfall (points)	813	660	448	112	21	32	3	4	6	44	137	411	2691
Variability (%)	57	61	76	115	128	158	157	199	173	115	86	59	35
No. of wet days	10	10	7	2	1	1	0	0	0	1	3	6	41
Rain/wet day (points)	81	66	64	56	21	32	0	0	0	44	46	69	66
Lorraine													
Rainfall (points)	607	454	301	89	30	51	10	6	6	54	150	281	2039
Variability (%)	52	52	70	141	129	133	144	172	156	108	73	57	34
No. of wet days	10	8	6	2	1	1	1	0	0	2	4	6	41
Rain/wet day (points)	61	57	50	45	30	51	10	0	0	27	38	47	50
Newcastle Waters													
Rainfall (points)	516	357	235	60	21	26	10	2	14	70	158	263	1732
Variability (%)	52	62	90	147	142	141	187	176	124	86	64	64	26
No. of wet days	8	6	5	1	1	1	0	0	0	2	4	6	34
Rain/wet day (points)	65	60	47	60	21	26	0	0	0	35	40	44	51
Powell Creek													
Rainfall (points)	477	404	207	37	30	22	24	3	12	49	161	223	1649
Variability (%)	73	64	70	119	149	145	160	180	143	78	66	68	30
No. of wet days	9	7	5	1	1	1	1	0	1	3	5	7	41
Rain/wet day (points)	53	58	41	37	30	22	24	0	12	16	32	32	40
Camooweal													
Rainfall (points)	370	333	167	40	34	71	18	4	20	42	140	196	1435
Variability (%)	66	66	76	113	148	121	123	187	144	155	77	76	27
No. of wet days	8	7	5	1	1	1	1	0	1	2	4	5	36
Rain/wet day (points)	46	48	33	40	34	71	18	0	20	21	37	39	40

TABLE 1 (*Continued*)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Alexandria													
Rainfall (points)	440	316	133	38	32	60	13	3	26	47	124	175	1407
Variability (%)	63	64	78	119	135	128	155	170	142	92	69	64	32
No. of wet days	8	6	4	1	1	1	0	0	1	2	4	6	34
Rain/wet day (points)	55	53	33	38	32	60	0	0	26	29	31	29	41
Tennant Creek													
Rainfall (points)	404	354	208	35	21	35	25	6	11	40	107	139	1385
Variability (%)	70	88	107	122	154	130	145	162	148	86	63	77	36
No. of wet days	7	5	3	1	1	1	1	0	1	2	3	5	30
Rain/wet day (points)	58	71	69	35	21	35	25	0	11	20	36	28	45
Avon Downs													
Rainfall (points)	326	341	143	32	37	53	17	4	26	58	80	157	1274
Variability (%)	60	75	76	147	145	137	154	191	135	111	63	80	28
No. of wet days	6	6	3	0	1	1	1	0	1	1	3	3	26
Rain/wet day (points)	54	57	48	0	37	53	17	0	26	58	27	52	49
Urandangi													
Rainfall (points)	205	226	96	29	50	51	43	12	25	47	83	97	964
Variability (%)	69	75	96	127	140	110	137	178	122	113	89	120	39
No. of wet days	5	5	3	1	1	1	1	0	1	2	3	3	26
Rain/wet day (points)	41	45	32	29	50	51	43	0	25	24	28	34	38

* Sources of data: (1) Commonwealth Meteorological Branch, "Book of Normals—No. 1, Rainfall" (Melbourne 1950).
(2) Commonwealth Meteorological Branch—daily rainfall records.

† Variability is expressed as mean percentage deviation from the mean.

tend to be more extensive and frequent; and conversely, when monsoonal development is weak, transitional period rains are often of sporadic occurrence and confined to the months closest to the monsoon period.

(a) *Rainfall*

Rain is seldom received except during the period between the spring and autumn equinoxes. The main sources of rainfall in the region are the north-west monsoon, which provides the bulk of the rainfall, and the thunderstorms that precede and follow it. Tropical cyclones constitute an additional minor and erratic source of rainfall. During the monsoon period the rain mostly falls in periods of successive wet days interspersed by longer periods of dry weather. The wet periods are more frequent near the coast, where the intensity of rainfall is higher.

The short-lived squalls of gale force and accompanying thunderstorms of the two transitional periods usually occur in the mid afternoon. They are often associated with heavy, driving rain, particularly in the coastal areas. However, the proportion of total rainfall received from this source in these areas is low because of the high incidence of monsoon rain. In the inland regions where the monsoon is less intense, and the total rainfall lower, these storms are responsible for a larger proportion of the annual total, particularly in years when the southward movements of the monsoon are not deep enough to cause much rain.

Although tropical cyclones may bring heavy rains to the region, they are erratic in nature and of rare occurrence. Their main tracks are from east to west and from north-west to south-east. Disturbances following the former track usually develop in the Coral Sea and enter the region after passing across the Cape York Peninsula; the latter type usually arises in the Arafura Sea and enters the region after crossing Arnhem Land or the Gulf of Carpentaria.

Important features of rainfall are amount, distribution, and reliability of annual rainfall, number of rainy days per year, and the intensity of rainfall. Most of these factors show a marked relationship with distance from the coast. For the purpose of comparison, only stations having records for the years 1911-40 have been studied. The data are summarized in Table 1.

Total annual rainfall ranges from 30 in. on narrow fringes of the coast to 10 in. in the portions of the region furthest inland. Nearly half the total area receives 20 in. or more annually. The number of rainy days per year likewise decreases with distance from the coast. This relationship is well illustrated by data from the three stations Burketown (adjoining the coast), Camooweal (200 miles inland), and Urandangi (300 miles inland). At Burketown the annual rainfall of 27 in. is recorded on 41 days; Camooweal receives 14 in. on 36 days; and Urandangi 10 in. on 26 days.

The average intensity of rainfall is high, particularly near the coast where it approaches 70 points per wet day; and in the wettest months is even higher. During individual thunderstorms more than an inch of rain may be recorded in less than half an hour. At inland centres the average intensity is lower owing to the fact that falls of a few points are often interspersed between heavier registrations.

The variability of the annual rainfall, expressed as a mean deviation from the mean, differs considerably at different localities. Variability shows a less marked trend with increasing distance inland than the other rainfall characteristics. At the western margins of the region, for example, the variability at Newcastle Waters is 26 per cent., at Powell Creek 30 per cent., and at Tennant Creek 36 per cent.; but in the east the figures for Burketown are 35 per cent., for Camooweal 27 per cent., and for Urandangi 39 per cent.

(*b*) *Temperature and Humidity*

Temperature and humidity records are available for the four stations of Burketown, Camooweal, Urandangi, and Tennant Creek (Table 2). The annual temperature regime is regular and changes slowly from season to season. As distance from the coast increases, the moderating effect of the sea is less pronounced and temperatures are more extreme and atmospheric conditions more arid.

Mean temperatures are high throughout the year, the mean monthly temperature being above 60°F. for each month at all stations. In the months preceding the onset of the monsoon conditions become intensely hot and mean monthly temperature exceeds 85°F. at all stations in the region. All inland stations record monthly maxima of approximately 100°F. at this time, but at Burketown proximity to the sea keeps the maximum slightly below this level. With the commencement of the monsoon in the latter part of January a very slight drop in maximum temperature is noted at all stations, but this is only of the order of 2-3°F. even in the coastal regions where it is most marked. Little change occurs in mean temperature as minimum temperature either remains at much the same level or shows a slight increase.

It is of interest to compare these temperature trends with those in other continents where the monsoon is more strongly developed. In regions of equivalent rainfall in West Africa,* for example, the depression in maximum temperature is frequently 15-20°F., and in mean temperature 10-15°F. Such a marked depression is sufficient to cause the formation of a second peak in the annual temperature curve after the period of monsoonal influence. This feature is characteristic of most monsoonal regions but does not appear in this region, where the temperature depression is so small.

*Data from British West African Meterological Service, Accra, Gold Coast.

TABLE 2

TEMPERATURE AND RELATIVE HUMIDITY DATA FOR FOUR STATIONS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Burketown													
Maximum temp. (°F.)	93.0	91.9	91.9	91.3	86.0	82.0	81.8	84.2	88.9	92.8	94.7	94.5	89.4
Minimum temp. (°F.)	76.9	76.1	73.9	68.7	61.9	57.0	55.0	57.3	63.1	69.3	74.1	76.4	67.5
Mean temp. (°F.)	84.9	84.0	82.9	80.0	73.9	69.5	68.4	70.7	76.0	81.0	84.4	85.4	78.4
Mean relative humidity (%)	66	67	62	48	44	45	40	37	38	42	47	58	50
Camooweal													
Maximum temp. (°F.)	97.9	96.2	94.6	90.8	83.8	78.6	78.2	83.0	89.6	96.0	98.8	99.3	90.6
Minimum temp. (°F.)	75.2	74.0	70.3	63.5	55.5	49.8	47.5	51.2	58.6	66.5	71.7	74.8	63.2
Mean temp. (°F.)	86.6	85.4	82.5	77.2	69.7	64.2	62.9	67.1	74.1	81.3	85.3	86.1	76.9
Mean relative humidity (%)	49	56	49	40	40	47	40	36	32	30	34	42	41
Tennant Creek													
Maximum temp. (°F.)	97.9	96.3	94.1	89.0	81.5	76.5	76.0	81.4	88.7	94.8	98.2	98.9	89.4
Minimum temp. (°F.)	75.7	74.6	71.8	66.6	59.0	53.3	51.4	54.3	60.9	67.7	72.7	75.3	65.3
Mean temp. (°F.)	86.8	85.4	82.9	77.8	70.2	64.9	63.7	67.8	74.8	81.2	85.4	87.1	77.3
Mean relative humidity (%)	42	50	39	33	36	39	37	32	29	28	31	38	36
Urandangi													
Maximum temp. (°F.)	100.9	99.5	96.3	90.5	82.1	76.1	75.4	80.9	88.2	95.2	99.8	101.5	90.5
Minimum temp. (°F.)	74.7	73.8	68.4	58.5	52.7	47.8	45.2	47.7	54.8	63.4	69.0	73.7	60.8
Mean temp. (°F.)	87.8	86.7	82.4	74.5	67.4	62.0	60.3	64.3	71.5	79.3	84.4	87.6	75.7
Mean relative humidity (%)	36	43	38	33	39	45	39	31	26	24	24	31	34

* Source of data: Coun. Sci. Industr. Res. Aust. Pamph. No. 42 (Melbourne 1933).

With the occurrence of wetter conditions and slightly lower temperature in January and February, humidity rises and reaches its highest levels. Mean relative humidity figures for February at Burketown, Camooweal, and Urandangi are 67, 56, and 43 per cent. respectively.

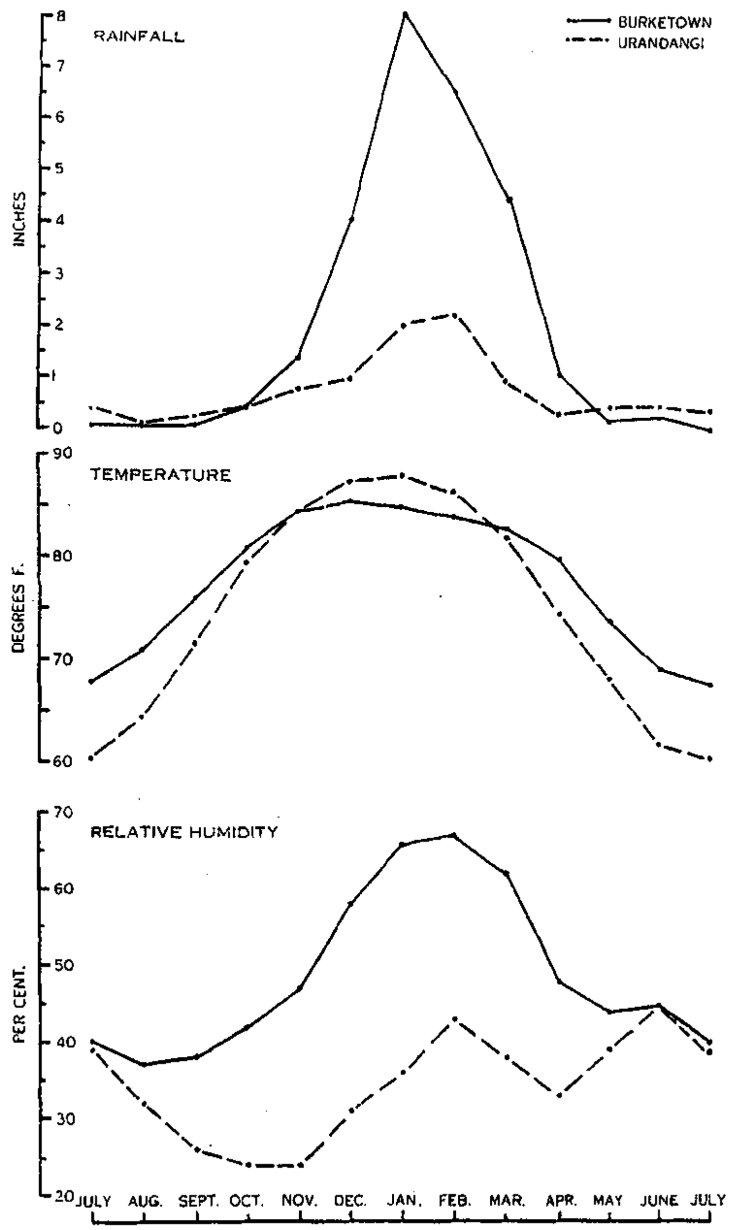

Fig. 1.—Mean monthly rainfall, temperature, and relative humidity for Burketown and Urandangi.

Lowest temperatures and humidities are recorded during the dry season, when the effect of the south-east winds serves to make living conditions much more tolerable. In July this effect is most pronounced and all stations record their coolest conditions. Mean minima are lowest at Urandangi, the figure for July being 45°F. During the months of July, August, and September all centres record their lowest mean relative humidities. The respective figures for Burketown, Camooweal, and Urandangi are 37, 30, and 24 per cent. The aridity at Urandangi can be appreciated when it is observed that the mean relative humidity for February, the wettest month, is only 43 per cent. During the dry season, dews are not uncommon on clear nights, but frost occurrence is rare (Foley 1945*), being confined to occasional frosts at inland centres during the months of June, July, and August.

In Figure 1 the rainfall, temperature, and humidity characteristics for Burketown and Urandangi are shown. The sharp incidence of rainfall in the summer months is well illustrated. This feature, and the fact that the rainfall period occurs coincidentally with a period of high temperature, and consequently of rapid evaporation and transpiration, means that the growing season in this region is very sharply defined. The water requirements for plant growth during the rainfall season are high. This is distinct from southern Australia where the rainfall is received principally in the cooler winter months when transpiration and evaporation proceed at lower rates, and plant growth persists even when small amounts of rainfall are received.

II. Climatic Factors of Significance to Plant Growth

Because of the severe limitations it imposes, incidence of rainfall is by far the most important climatic factor influencing plant growth in this region. Rainfall distribution is such that growth is confined to a short period each summer. During this period temperatures are high, but appear satisfactory for plant growth. The absence of a depression in the temperature curve at this time, as compared with other countries, may, however, be of significance to plant physiological processes. During occasional short periods of very high temperatures atmospheric conditions can be detrimental to both the growth and development of plants and of crop species in particular. At no stage during the growing period does low temperature become a limiting factor. The length of the period when rainfall is adequate for plant growth is a more important factor than total rainfall in assessing the possibilities for establishment of exotic crop and pasture species. Because of the small number of temperature and humidity recording stations in the region, the methods adopted for estimating the length of the growing period were those that could be estimated from rainfall figures alone, once the regional characteristics had been defined.

(a) *Climate in Relation to Agriculture*

In the report on the 1946 survey of the Katherine-Darwin region by Christian and Stewart (1953)† a method of estimating time of initiation

* Foley, J. C. (1945).—Frost in the Australian region. Commonw. Meteor. Bur. Aust. Bull. No. 32.

† Christian, C. S., and Stewart, G. A. (1953).—General report on survey of Katherine-Darwin region, 1946. C.S.I.R.O. Aust. Land Res. Ser. No. 1.

and the length of the period during which rainfall was adequate for the maintenance of growth of crop and forage species was described. Field experiments have shown that this method gives satisfactory estimates for Katherine and it has been applied with minor modifications to this area. The criterion used to determine the time of commencement of the season has been adopted unchanged; but the criterion for determining the period of adequate rainfall has been slightly modified to make allowance for the more arid regions that occur generally in the Barkly area.

TABLE 3

TIME OF COMMENCEMENT AND LENGTH OF PERIOD OF ADEQUATE RAINFALL

	Borroloola	Burketown	Lorraine	Newcastle Waters	Powell Creek	Camooweal	Alexandria	Tennant Creek	Avon Downs	Urandangi
Computed mean date of commencement	Jan. 17	Jan. 17	Jan. 24	Jan. 27	Feb. 2	Feb. 5	Feb. 1	Feb. 8	Feb. 4	Feb. 15
Deviation (weeks) from mean date exceeded in one-quarter of the years	5.8	6.0	5.0	3.8	4.0	4.3	5.0	4.3	4.0	5.5
Percentage of seasons with a true commencement date	100	93	93	89	73	71	83	77	65	37
Mean length of period of adequate rainfall for all years (weeks)	9.0	9.5	6.1	5.9	5.1	3.9	4.3	3.5	3.2	1.7

(i) *Time of Commencement of the Growing Period.*—Eliminating false starts in the season, it is found that the mean commencement dates for the various stations in the region are distributed over a period of about one month between mid January and mid February. The coastal stations that receive highest rainfall have the earliest commencement dates. The time of commencement at any one locality is subject to considerable variation, the degree of which is fairly uniform throughout the region. In one-quarter of the years it varies from the mean by approximately 4-6 weeks.

Where the average rainfall is low, there is a high proportion of years in which the criterion for commencement is not satisfied at any time. At Urandangi this happens in approximately two-thirds of the years. Such years must be omitted in assessments of mean commencement dates and the expected variation in these dates, although in actual practice they have the effect of increasing such variation.

Mean dates of commencement and the expected variation in the dates for 10 stations, together with the percentage of years in which a true start does occur, are shown in Table 3.

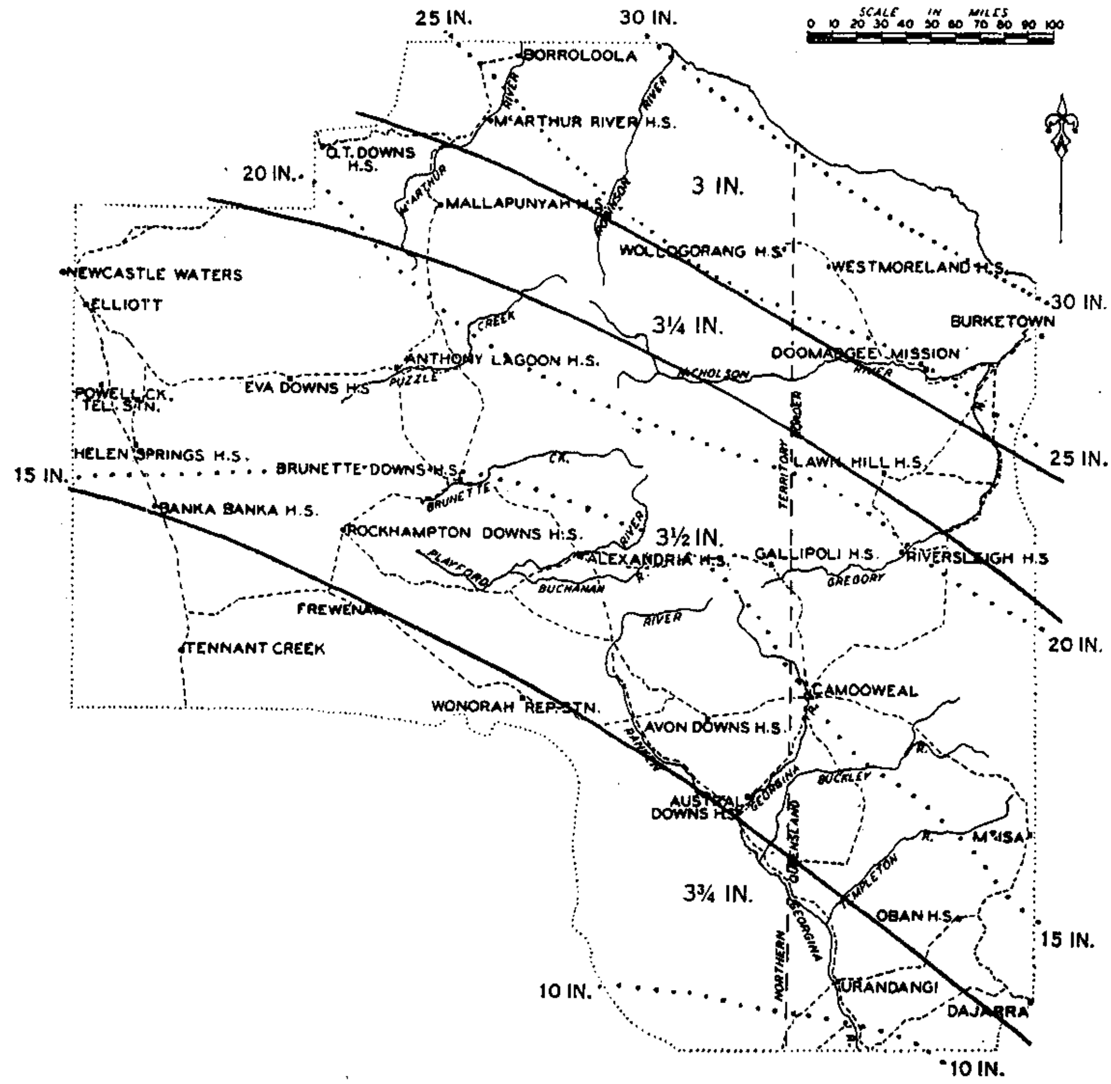

Fig. 2.—Regional subdivisions used to determine adequate rainfall criteria. Annual rainfall isohyets are indicated by dotted lines.

(ii) *Period of Adequate Rainfall.*—In order to determine the length of the period of adequate rainfall a critical figure, which was considered to be the minimum amount of rainfall needed to maintain growth for a period of 28 days, was first estimated for each part of the region. After reference to the figures for saturation deficit during the November-April period, the figure adopted for the coastal areas of higher rainfall was that used for Katherine, namely 3 in. This figure has been increased to $3\frac{1}{4}$ in. for the subcoastal strip, $3\frac{1}{2}$ in. for the central semi-arid zone, and $3\frac{3}{4}$ in. for the most inland zone (see Fig. 2). Thus the period of adequate rainfall for each section is defined as the total number of weeks over which consecutive 28-day periods, assessed at 14-day intervals, satisfy the appropriate criterion.

In Table 3, the mean length of this period for each of 10 stations in the region is shown. It will be seen that it varies from 9.0 weeks at Borroloola and 9.5 weeks at Burketown to as little as 1.7 weeks at Urandangi.

TABLE 4

ESTIMATED GROWING PERIOD

	Borroloola	Burketown	Lorraine	Newcastle Waters	Powell Creek	Camooweal	Alexandria	Tennant Creek	Avon Downs	Urandangi
Mean length of estimated growing period (weeks):										
In all years	13.0	13.3	10.0	9.6	8.6	7.1	7.6	6.7	5.9	3.1
In years when the adequate rainfall criteria were satisfied	13.0	13.8	10.6	10.3	9.9	9.0	9.1	9.0	8.6	8.5
Percentage of years when estimated growing period equals or exceeds										
12 weeks	69	63	24	25	17	11	17	13	10	3
16 weeks	34	37	3	7	7	4	3	3	0	0

(iii) *Estimated Growing Period*.—The length of the period of adequate rainfall, as defined above, does not represent the exact length of the growing season, which may continue for a limited period. This may vary according to the type of crop, soil, and agriculture, and may be influenced slightly by additional light rains that do not satisfy the criteria. Provided adequate rainfall has been recorded, a period of 4 weeks is added to represent the subsequent amount of additional growth that may normally be expected. This represents the total length of the estimated growing period (Table 4). The absence of any growing period in a proportion of years at most localities reduces the significance of a calculated mean. In order to give a more comprehensive picture the mean length of the period in years when a season was considered to occur is also included in Table 4, together with the percentage of years when the estimated growing period equals or exceeds 12 and 16 weeks. Regional trends in the time of commencement of the season and the length of the estimated growing period are shown in Figure 3.

(iv) *Other Climatic Factors.*—Intensity of rainfall is another climatic factor of importance to dry-land agriculture. Particularly in the higher-rainfall areas, falls of more than 2 in. per day can be expected at any time between the spring and autumn equinoxes. It is evident that under such conditions soil erosion on cultivated land is a hazard to be considered.

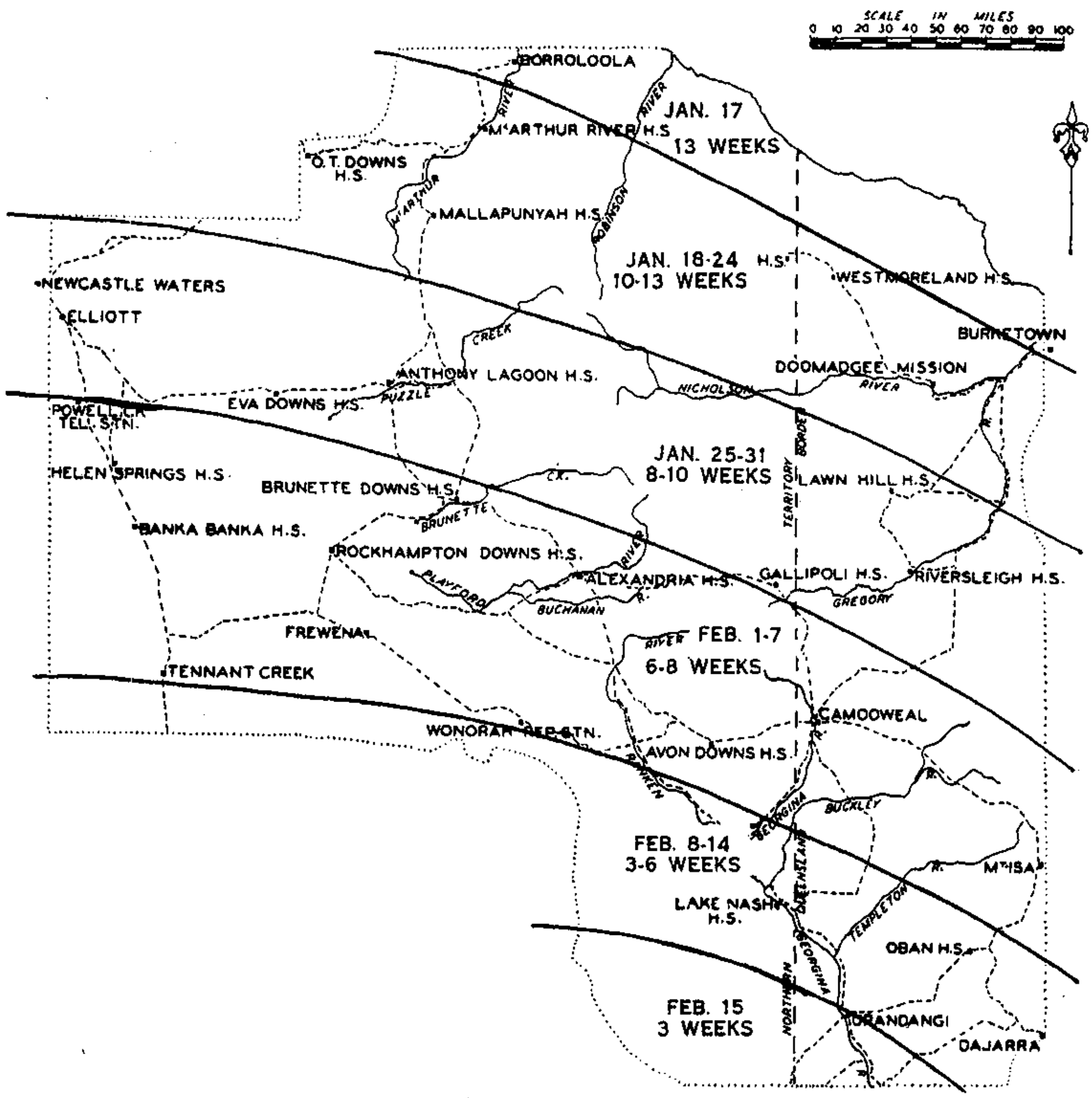

Fig. 3.—Map showing time of commencement and length of estimated agricultural growing period.

In view of the very high temperatures that prevail in this region, even in January and February, damage to crops during very hot and dry spells in the growing period may be an important factor. The occurrence of such damaging periods could be expected to increase with distance inland, and thus be greater in the areas with lower rainfall.

(*b*) *Climate in Relation to Growth of Natural Pastures*

In order to estimate the total period each season during which sufficient rain is received for the initiation and maintenance of useful growth of natural pastures in this region, a similar method of assessment with less stringent criteria has been used. The criteria involved, which apply to the inducement of growth in an established adapted perennial plant in contrast to the establishment of a crop species from seed, were based on limited observations of response of species to rainfall.

(i) *Time of Commencement.*—The criterion used in determining the time of commencement of the period of rainfall adequate for agricultural crops has been expanded in relation to pasture growth to allow for the cumulative effect of rainfall on an established pasture. Thus on heavy soils, which carry the most important pastures of the region, moisture conditions are considered adequate for the commencement of regrowth

TABLE 5

TIME OF COMMENCEMENT OF USEFUL PASTURE GROWTH

	Borroloola	Burketown	Lorraine	Newcastle Waters	Powell Creek	Camooweal	Alexandria	Tennant Creek	Avon Downs	Urandangi
Computed mean date of commencement	Dec. 27	Dec. 23	Dec. 26	Dec. 31	Jan. 4	Jan. 2	Jan. 10	Jan. 11	Jan. 15	Jan. 13
Deviation (weeks) from mean date exceeded in one-quarter of the years	4.0	4.1	5.1	6.0	6.0	5.8	5.7	6.5	7.3	6.1

of perennial pasture plants when a minimum total of either 2 in. of rain is received in 1 week, 3 in. over a period of 2 weeks, or 4 in. over 3 weeks. The date of commencement is considered to be the last day of the period in which the criterion has been satisfied. This criterion applies to pasture growth and no false starts are recognized as all growth is of use. Following a break, the season may be restarted when the criterion for adequate rainfall (defined below) is satisfied.

Using this method it is found that the mean commencement date for any station is 3-4 weeks earlier than the commencement of the agricultural season. The time of commencement is earliest at the coastal stations and becomes later as distance from the coast increases (Table 5). At any locality it shows considerable variation, the degree of which is related in general to distance inland.

(ii) *Period of Useful Pasture Growth.*—In order to estimate the duration of useful growth during the summer rainfall period, a rainfall requirement equal to two-thirds of the requirement for crop species has been adopted. Thus in the coastal regions a minimum total of 2 in. is required in a period of 28 days and in the most inland regions, $2\frac{1}{2}$ in. When there occurs a 28-day period in which less than the critical figure is received, a break in the season is assumed. Such breaks occur on the average in only one-third of the years at the most inland stations and one-half of the years at the coastal stations. They are usually of 3-4 weeks' duration. Occurrences of more than one break per year are rare.

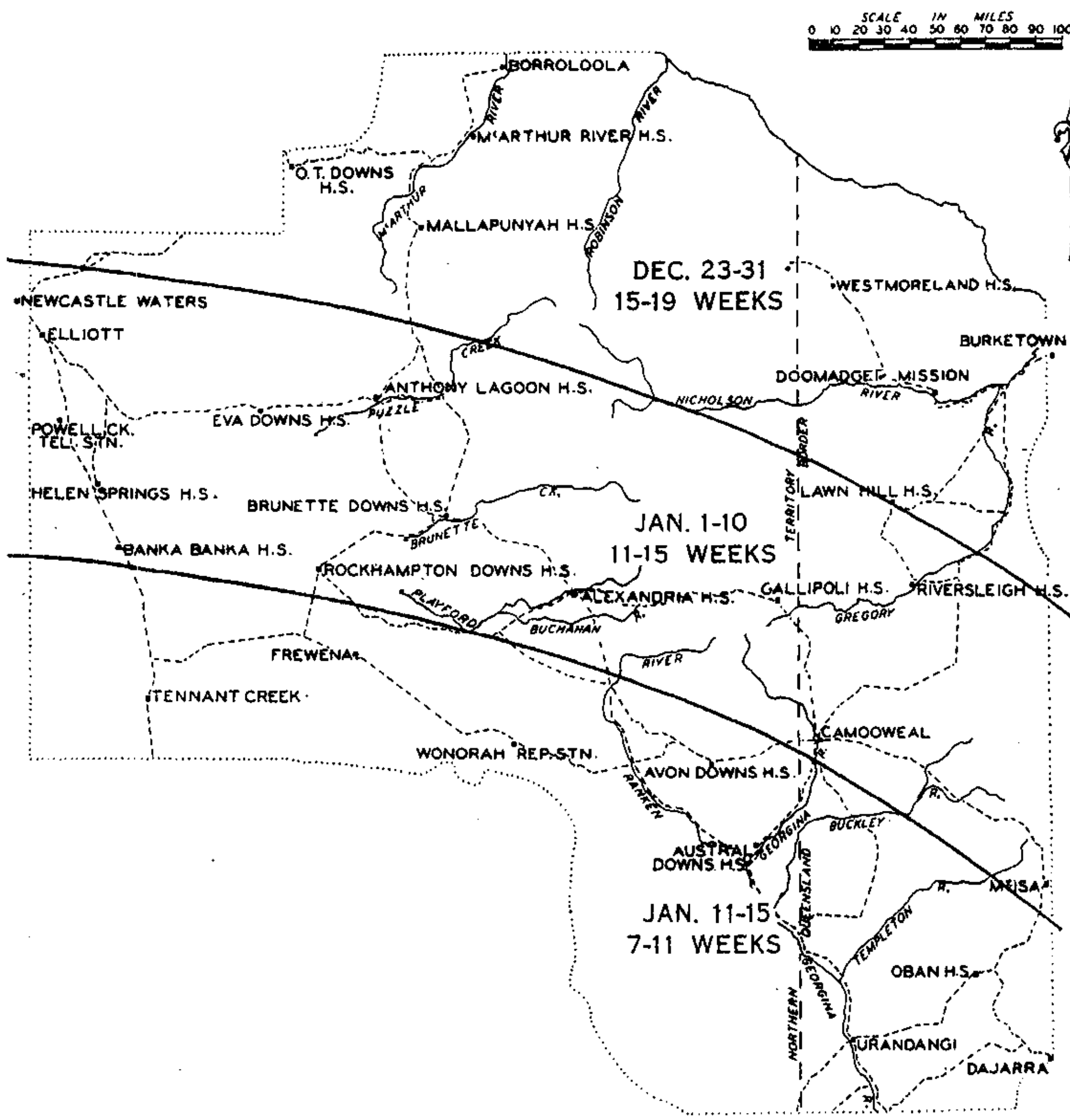

Fig. 4.—Map showing time of commencement and length of period of useful pasture growth.

Following a break, pasture growth is considered to have restarted in the next 28-day period that receives adequate rainfall. To the last of these periods of adequate rainfall a period of 4 weeks is added, as for crop species, to allow for continued growth on conserved moisture and on light falls of rain, which may be of some value at that stage even though they do not satisfy the criteria. In assessing the total period each year during which useful pasture growth occurs, the separate periods of adequate rainfall are summed, on the assumption that useful growth is made during each period.

By this procedure it is found that the mean total length of the period of useful pasture growth ranges from 19.3 weeks at Borroloola to 7.0 weeks at Urandangi (see Fig. 4), compared with 13.0 and 3.1 weeks respectively for the estimated agricultural period at these localities. Data for the mean total length of the period of useful pasture growth, together with figures for the percentage of years in which the total length of the period at each station equals or exceeds 8, 12, and 16 weeks, are shown in Table 6.

TABLE 6

LENGTH OF PERIOD OF USEFUL PASTURE GROWTH

	Borroloola	Burketown	Lorraine	Newcastle Waters	Powell Creek	Camooweal	Alexandria	Tennant Creek	Avon Downs	Urandangi
Computed mean total length of period of useful pasture growth (weeks)	19.3	17.6	16.3	13.9	12.7	12.7	11.0	10.2	9.5	7.0
Percentage of years when total length of period equals or exceeds										
8 weeks	100	100	100	93	93	97	90	90	80	60
12 weeks	93	93	86	71	60	61	50	40	33	30
16 weeks	86	70	66	46	37	25	10	10	10	0

The figures should not be accepted too literally and their interpretation should be conditioned by a consideration of variation in soils and topography in different parts of the region. The figures have particular reference to the response of perennial pasture plants and apply primarily to areas of heavy soils that carry such vegetation. The estimates for areas that contain light-textured soils may need modification before they have full practical significance. In addition, local depressions and regions of internal drainage, which by virtue of their topographical advantage have a higher moisture status than surrounding areas and so are usually more valuable pasture areas, could not be detected by a study of climatic data alone. Basically, however, climatic trends do serve to subdivide the region and the figures in Table 6 offer useful guides to these basic regional differences.

A study of the pastoral growing season in north-eastern Australia, using $P/(T+10)$ relationships, has been made by Miles (1947).* This method has been applied to the four stations for which temperature records are available. In Table 7 this method of estimating the length of the pastoral growing season is compared with the adequate rainfall method.

TABLE 7

COMPARISON OF TWO METHODS OF ASSESSING CLIMATE IN RELATION TO PASTURE GROWTH

	Burketown	Camooweal	Tennant Creek	Urandangi
(1) Based on $P/(T+10)$ relationships				
Mean date of commencement	Dec.	Jan.	Jan.	Jan.
Mean length of pastoral growing season	13 weeks	6 weeks	5 weeks	4 weeks
(2) Based on adequate rainfall				
Mean date of commencement (approx.)	Late Dec.	Early Jan.	Mid Jan.	Mid Jan.
Mean total length of period of pasture growth (approx.)	18 weeks	13 weeks	10 weeks	7 weeks

The estimates obtained by the two methods for commencement of season are quite similar, but the adequate rainfall method indicates a much longer growing period, even though the $P/(T+10)$ criterion can be resolved into a rainfall requirement of less than 2 in. per month. This is primarily due to the fact that Miles restricts the duration of the season to months that are "wet" in 50 per cent. of the years, and in the final assessment only months in this predetermined period are considered. On the other hand the method based on rainfall alone takes into account all rain that falls in the summer period and satisfies the criterion, and also allows for a carry-over period of growth resulting from moisture stored in the soil.

(iii) *Occurrence and Influence of Winter Rainfall.*—The occurrence of winter rainfall in this region is of considerable importance in view of its damaging effect on standing dry feed and its influence on pasture growth in parts of the region where winter-active species are sufficiently

* Miles, J. F. (1947).—The pastoral and agricultural growing season in north-eastern Australia. *J. Aust. Inst. Agric. Sci.* 13 (1-2): 41-9.

numerous. In order to assess the extent and frequency of winter rainfall occurrence, rainfall data have been examined, and weekly totals exceeding 1 in. recorded. The frequency of falls increases from the north-west to the south-east. At Borroloola and Newcastle Waters such falls have occurred in one-sixth of the years under consideration, and at Urandangi in three-fifths. In the central pasture sections the frequency is one-quarter at Anthony Lagoon, three-fifths at Brunette Downs, one-third at Alexandria, one-third at Avon Downs, and two-fifths at Camooweal. Burketown has a frequency of one-fifth. More than one such fall seldom occurs in any one year in any part of the region.

The frequency of winter rainfall is of little importance in the north-west portion of the region. It is of significance on the central pasture sections because of its damaging effect, as few winter-active species occur. In the south-east, where the frequency is highest, the damaging effect is offset to a degree by the greater number of winter-active annual species.

PART III. OUTLINE OF THE GEOLOGY OF THE BARKLY REGION

By L. C. NOAKES* and D. M. TRAVES*

I. INTRODUCTION

The Barkly region forms part of the north-eastern corner of the Australian Pre-Cambrian Shield, which has provided a relatively stable basement since Pre-Cambrian time throughout the greater part of the Northern Territory, Western Australia, and South Australia, with extensions into New South Wales and Queensland. The stability of the Shield has, in general, controlled the subsequent geological development of the areas under which it lies. In the first place, the Shield has rarely been submerged to allow the deposition of additional sediments, and in the second place, those sediments which have been deposited on the Shield remain for the most part unfolded because the Shield has protected them against recurrent earth stresses. As a result, the geological history of most regions situated on the Shield is one of long periods of erosion punctuated by rare incursions of shallow transgressive seas. These produced younger sediments, remnants of which are still found as mantles overlying the folded Pre-Cambrian rocks of the basement.

The geological history of the Barkly region closely follows this general pattern. The rocks of the region may be divided into two major groups: the folded and metamorphosed rocks of the Shield outcropping in the eastern, northern, and western portions of the region (Lower Proterozoic) and the sediments which were deposited in three great transgressive seas of Upper Proterozoic, Middle Cambrian, and Lower Cretaceous time. These unfolded sediments, with terrestrial deposits of Tertiary age, overlie the folded basement and outcrop in the southern and central portions of the region with outliers farther north.

The mineral wealth of the region is almost entirely restricted to the Pre-Cambrian basement in which intrusive igneous rocks have introduced gold at Tennant Creek, silver-lead-zinc-copper deposits at Mt. Isa, silver-lead deposits at Lawn Hill and McArthur River, and copper at Redbank. However, areas in which the basement is exposed are of comparatively little value apart from the existence of known and prospective mineral fields, because for the most part they are dissected, with sandy or skeletal soils which could not support a flourishing pastoral industry.

On the other hand, the younger sediments, although practically devoid of mineral deposits, provide the soils and an essential part of the water supply on which the pastoral potential of the region is based. The pastoral industry of the Barkly Tableland owes its existence to the supplies of subartesian water stored in the Cambrian sediments and to the pedocalcic soils provided by Cambrian dolomite and limestone and by Tertiary alluvia.

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

II. Pre-Cambrian

No outcrop of Archaeozoic rocks is known in the Barkly region, and all the Pre-Cambrian rocks are referred to the Proterozoic Era. The relative ages of the several groups of Pre-Cambrian rocks have not yet been clearly established, but folded rocks which show mineralization and which have been intruded by granitic rocks in a number of places are regarded as Lower Proterozoic and the little-folded and unmineralized sandstones, unconformably overlying the folded strata, are regarded in most places as Nullagine or Upper Proterozoic deposits.

(*a*) *Lower Proterozoic*

Folded Pre-Cambrian strata occur in two main belts: a major meridional belt which borders the region on the east and north-east, and a smaller belt on the western margin, between Newcastle Waters and Tennant Creek.

(i) *Carpentaria Complex*.—The rocks of the major belt, which stretches from Dajarra in the south, northward through Mt. Isa and Lawn Hill, and thence north-westward across the McArthur River, have been grouped under the informal term Carpentaria complex because, although unconformities undoubtedly occur within the belt, insufficient mapping has been done to subdivide the complex into units or to delineate units such as the Mt. Isa shales, Lawn Hill Series, etc., which previous workers have named but incompletely mapped.

The complex consists of metamorphosed sediments, basic and acid lava flows, and intrusives such as dykes and sills. In general, the degree of metamorphism, the severity of folding, and, probably, the age of the sediments increase from north to south.

In the south-eastern corner of the region, the complex consists of steeply folded greenstone, quartzite, sandstone, slate, and phyllite. In most places, dips are very steep to vertical and the trend of both bedding and folding is meridional. The sediments have been intruded by granite and gneiss, outcrops of which are elongated in a northerly direction. Farther north, in the vicinity of Mt. Isa, shale, quartzite, limestone, and greenstone, although steeply folded, have not been highly metamorphosed, and farther north still, in the Lawn Hill area, quartzites, limestone, and shale show less alteration and more gentle domal structures. Alteration and folding of the same order are found also in sandstone, shale, and limestone of the complex cropping out in the Nicholson and McArthur River Valleys where fold axes show northerly trends. Granite intrudes sediments of the complex along portion of the valley of the Nicholson River, north-west of Lawn Hill.

Sandstone, limestone tuff, and conglomerate, with interbedded lava flows, occur in the Redbank area, north of the Nicholson River. These beds are gently folded and may be some of the youngest members of the complex. Quartzite, shale, and limestone between O.T. Downs Station and the McArthur River have also been fairly gently folded.

Lower Proterozoic rocks along the western margin of the region have been divided into the Warramunga Group, in the neighbourhood of Tennant Creek, and the conformably overlying Ashburton Sandstone which crops out along the Stuart Highway, north of Tennant Creek as far as Newcastle Waters.

(ii) *Warramunga Group.*—The group consists mainly of interbedded sandstones, tuffaceous sandstone, and shale. The degree of metamorphism is low, but the sediments have been fairly strongly folded along easterly-trending fold axes, and in most places dips are steep. Granite and porphyry intrude the sediments, and small masses of these rocks, together with dykes of porphyry, crop out in the area.

(iii) *Ashburton Sandstone.*—The formation consists of sandstone, quartzite, and conglomerate with some beds of shale. They have been moderately folded, mainly into dome and basin structures with axes trending north-westerly. Steep dips are found in some places but in others the strata are gently inclined.

The sediments of the Warramunga Group and most of those of the Carpentaria complex are geosynclinal, i.e. deposited in major troughs — the Warramunga geosyncline in the west and the Carpentaria geosyncline in the east. It was the eventual folding of these Lower Proterozoic sediments which completed the "welding" of the older Pre-Cambrian rocks into a relatively stable basement, and subsequent sedimentation in the Barkly region was epicontinental, i.e. deposited in widespread but relatively shallow seas, transgressing the stable basement.

A more detailed discussion of the age of these Pre-Cambrian sediments and of the suggested structural framework of the basement will not be attempted in this outline, but is included in a geological report on the region by Noakes and Traves.*

(b) *Upper Proterozoic*

Arenaceous sediments regarded as Upper Proterozoic have been mapped in two localities: the Pilpah Range east of Barkly Downs, in the south-eastern corner of the region, and between Calvert Hills and Borroloola near the Gulf of Carpentaria.

(i) *Pilpah Sandstone.*—This formation forms the isolated ridges of the Pilpah Range and occurs as outliers unconformably overlying sediments of the Carpentaria complex or resting on granite. The unit consists mainly of medium- to coarse-grained sandstone and quartzite in which shallow-water structures, such as ripple marks, are commonly pre-

* Noakes, L. C., and Traves, D. M.—A geological reconnaissance of the Barkly region of the Northern Territory and Queensland. To be published as a bulletin of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics.

served. The beds have been gently folded, or perhaps only monoclinally tilted, and, where examined, dip at less than 25° to the west.

(ii) *Robinson Beds*.—These beds outcrop on the dissected tableland in the headwaters of the Robinson River but were not examined in the field. Beds unconformably overlying sediments of the Carpentaria complex were mapped by photographic interpretation and tentatively named the Robinson beds. These appear to consist mainly of sandstone and quartzite, well jointed and sub-horizontally disposed.

The age of these two formations is uncertain, but they are younger than the Carpentaria complex and older than the Middle Cambrian Barkly Group and are regarded as remnants of sediments deposited in a transgressive sea of Upper Proterozoic (Nullagine) age — the first of the three great transgressions which are recorded in the Barkly region. There are probably other outcrops of these Upper Proterozoic sediments in the region which have not been differentiated from gently folded members of the Carpentaria complex.

III. Palaeozoic

The Barkly region was a land mass for most of Palaeozoic time, with only two major events serving to break the monotony of erosion. After strong erosion of both Lower and Upper Proterozoic sediments, volcanics were poured out toward the western margin of the region in Lower (?) Cambrian time (Helen Springs volcanics) and were followed later by sediments deposited in a transgressive sea of Middle Cambrian age (the Barkly Group). However, much of this mantle of Cambrian volcanic and sedimentary rock still persisted in Mesozoic time, so that erosion in Palaeozoic time, subsequent to the Cambrian, must have been very slow and the relief of the Barkly region fairly low.

(i) *Helen Springs Volcanics*.—These volcanics occur as isolated outcrops in the vicinity of Helen Springs, and can be traced southward into the Tennant Creek area. In most places, they form downs or low, rounded hills and consist mainly of basalt, dolerite, and pyroclastic material. In the Helen Springs area, volcanic rocks occur both as flows poured out on the eroded surface of the Ashburton sandstone and as dykes and plugs which intrude the formation.

The Helen Springs volcanics are similar to Lower Cambrian volcanics found in both the Ord-Victoria region and the Katherine-Darwin region and there is little doubt that they are about the same age.

(ii) *Barkly Group*.—This group includes the complete sequence of sediments deposited in the transgressive seas which submerged a very large portion of the region in Middle Cambrian time, and was roughly bounded to north-east and south-west by the belts of Lower Proterozoic rocks. Opik (unpublished data) has shown that two distinct transgressive seas were involved. An earlier transgression from the north-westerly quarter submerged most of the areas now known as the Barkly Basin and the Georgina Valley. Later, in Middle Cambrian time, a second sea transgressed western Queensland, and finally, in Upper Middle Cambrian time, extended westward, south of latitude 19°, submerging the land ridge between the two seas. This ridge, about the longitude of Camooweal, was subsequently covered by sediments in the final widespread sea of Upper Middle Cambrian time.*

The Barkly Group consists mainly of dolomite and limestone, sandstone, chert, and shale. Nodules and lenses of chert are common in most of the sediments. In most places, the sediments are near to horizontal with probably basin structures beneath the Barkly Basin and the Georgina Valley.

Despite the long periods of erosion to which the region has been subject since Cambrian time, sediments of the Barkly Group still underlie or outcrop on nearly half the surface area of the region, although they are largely restricted to the Barkly Basin and the Georgina Valley.

IV. Mesozoic

The period of erosion initiated at the end of Cambrian time seems to have persisted for some 300 million years and to have included most of the Palaeozoic and Mesozoic time. Erosion or perhaps near still-stand was finally interrupted in Lower Cretaceous time, at least in most of the northern portion of the region, when gradual sinking produced at first isolated fresh-water lakes and finally the third great marine invasion. This third transgression followed, essentially, the pattern of the previous invasions, and a shallow transgressive sea flowed in from the north and north-west to submerge the mature surface of the region at least as far south as latitude 18°, and probably farther. The area now known as the Gulf of Carpentaria was submerged in the general sinking, and the subsequent transgression extended over a large part of central Queensland. The limits of the Lower Cretaceous sea in the Barkly region cannot be clearly established because some of the mantle of sediments deposited has been removed; but the western belt of Pre-Cambrian rocks seems again to have formed the western shore-line, and the central and northern parts of the eastern belt of Pre-Cambrian rocks were apparently only thinly covered.

* Subsequent work, mainly by Dr. A. A. Opik, Bureau of Mineral Resources, Geology and Geophysics, indicates that limestones at Camooweal and in many places in the Georgina Valley, which are at present mapped as part of the Barkly Group, may in fact be Upper Proterozoic in age and thus considerably older than the Middle Cambrian Barkly Group. Further detailed mapping, intended to resolve this problem, will probably result in the restriction and re-definition of the Barkly Group, but these changes will not involve any basic alterations in the land systems delineated in this publication because these are based, as far as geology is concerned, on lithology rather than on age, and the lithological characteristics of both proved Cambrian and possible Proterozoic sediments included in the present Barkly Group are very similar.

(i) *Mullaman Group.*—Lower Cretaceous sediments, both lacustrine and marine, are called the Mullaman Group and can be traced south-easterly from the Katherine-Darwin region where the name was first applied. Outcrops are now mainly restricted to the northern portion of the Barkly Basin, with isolated outliers in the Gulf Fall. Fresh-water sandstone with plant remains at the base of the group has been found at Newcastle Waters and Creswell, and estuarine deposits occur in outliers near Borroloola.* Most of the sediments are marine and consist mainly of shale and siltstone with some limestone. The maximum thickness of the group is approximately 500 ft. toward the northern margin of the Barkly Basin, but in outliers farther north the sediments are only 30-40 ft. thick.

V. Cainozoic

With the retreat of the Lower Cretaceous sea the record of marine sedimentation in the region ends and the history of the Cainozoic Era is one of erosion and the accumulation of terrestrial deposits.

The Cainozoic Era can be logically divided only into the Tertiary cycle of erosion and the Recent cycle of erosion, which seems to have been initiated in Pliocene time. Terrestrial deposits of the era are, therefore, discussed under the headings "Tertiary" and "Pliocene to Recent".

(*a*) *Tertiary*

The Tertiary cycle of erosion began before the end of Cretaceous time, on a land surface which already showed little relief.

By about Middle Tertiary time, this surface was a peneplain, parts of which can still be identified because mature laterites were developed over large tracts of it and have not been entirely removed. This land surface, which marked the end point of Tertiary erosion, extended northward well beyond the limits of the present coastline and, in the Barkly region, was underlain in many places by sediments of the Mullaman Group, which were very thin in places, and by Cambrian strata of the Barkly Group. The monotony of the flat to gently rolling topography of the land surface developed on these sediments was relieved in places by residual ridges and hills of Pre-Cambrian rocks. The Georgina Basin had already been established as an internal drainage basin and the topography of the Georgina Valley was much as it appears now.

Lateritization was widespread toward the end of the cycle when rivers were at grade and erosion was so reduced that deep, stable soil profiles were established and allowed to persist. However, the study of soils in particular indicates that swampy conditions prohibited the

* In the course of more detailed mapping, a veneer of Lower Cretaceous sediments, including both lacustrine and marine beds, has been found between Camooweal and Yelvertoft.

formation of laterite over large tracts of the Barkly Basin and along the Georgina Valley.

The occurrence of lake limestones with flint nodules in the same areas suggests that ground and surface waters charged with lime and silica leached from lateritic soils were fed into lakes during the same period with eventual concentration and precipitation with the onset of more arid climate after lateritization.

There is no sound evidence on which the exact age of lateritization can be based. It happened somewhere between Eocene and Pliocene, perhaps in Oligocene or Miocene time, and there is little reason to depart from a tentative Miocene age. However, there is evidence for only one period of mature lateritization in the Barkly region.

Known terrestrial deposits accumulated in the Tertiary cycle of erosion, between Cretaceous and Miocene (?) time, and consist, therefore, of mantles of alluvium in the Barkly Basin, areas of limestones with chert nodules in both the Barkly Basin and the Georgina Valley, and a widespread veneer of laterite. The alluvium and the laterite are fully discussed in Part VI of this report.

The Tertiary limestones occur in irregular outcrops in three main areas, towards the centre of the Barkly Basin and in the vicinity of Austral Downs and Urandangi in the Georgina Valley.

Outcrops in the Barkly Basin have been named the Brunette limestone, and those in both localities in the Georgina Valley, the Austral Downs limestone.

(i) *Brunette Limestone.*—This limestone is white to brown, amorphous to crystalline, massive limestone and commonly outcrops as boulders and fragments of skeletal material. Some of the limestone is siliceous and may contain nodules of flint or chalcedony.

(ii) *Austral Downs Limestone.*—This is essentially similar to the Brunette limestone, and outcrops as scattered fragments of skeletal limestone in contrast to the cream-coloured, slab-like outcrops of limestone and dolomite of the Barkly Group. The silica content of the limestone is very irregular, and in most places silica has been deposited as lumps of flint or chalcedony which are easily distinguishable from the remainder of the rock. The maximum thickness of the Brunette and Austral limestones would not exceed 50-70 ft.

(iii) *Verdon Limestone.*—Isolated outcrops of limestone also occur as poorly bedded deposits which form the cap of mesas in the vicinity of Riversleigh Station, in the Gulf Fall. The limestone is tough, crystalline to amorphous, and massive, and is about 40 ft. thick. It contains abundant pebbles of chert some of which has been derived from Cambrian limestone, and a bed in which shells and fossil bones have been found. Palaeontological evidence is not yet conclusive and the limestone could be either Cretaceous or Tertiary in age.

(b) *Pliocene to Recent*

The Tertiary cycle of erosion was closed and the Recent cycle initiated by differential movements, mainly warping, which although comparatively gentle brought considerable topographical changes in the northern and eastern portions of the region and smaller and less spectacular modifications of the Tertiary land surfaces elsewhere. The main features of these movements as they affect the Barkly region were the sinking of the area now known as the Gulf of Carpentaria, with probable complementary up-warping of land to the south, and minor differential uplifts along the belts of Lower Proterozoic rocks toward the eastern and western margins of the region. Differential movements which took place perhaps about the same time but far to the south, in South Australia, affected the Barkly region by inducing some rejuvenation of the internal drainage system of south-western Queensland, which eventually reached the upper Georgina River.

The account of the modifications made to the Tertiary land surface in the present cycle of erosion properly belongs to geomorphology, but additional terrestrial and estuarine deposits were laid down during the processes of modification.

Additional alluvia were deposited in the Barkly Basin and particularly in the Georgina Valley. Small irregular patches of limestones, perhaps of pedological origin, formed near some streams in the Barkly Basin. Calcareous loess (wind-blown material) was deposited in one area in the Barkly Basin and some light-textured alluvia were wind-sorted in the Georgina Valley. In the Gulf Fall, considerable areas of alluvium were deposited in the flood plains of streams, and limestone and travertine were deposited along some of the streams or in the vicinity of springs.

The most extensive Quaternary deposits in the region are the estuarine alluvia which were laid down following a major eustatic rise in sea-level in late Pleistocene time which completed the flooding of the Gulf of Carpentaria. Some of these deposits were subsequently uncovered by the slight fall in sea-level in mid-Recent time and in places have now been weakly dissected.

PART IV. GEOMORPHOLOGY OF THE BARKLY REGION

By G. A. STEWART*

I. GENERAL TOPOGRAPHY

The region is an area of low relief, ranging from sea-level at the Gulf of Carpentaria to 1400 ft. near the south-eastern margin and 1300 ft. near the western margin. A very large portion of the region lies between 600 and 1000 ft. The region may be divided into four main topographic zones:

(i) Coastal plains, which constitute an irregular band along the coast and slope gently to the Gulf of Carpentaria. Their width ranges from 15 to 85 miles and their altitude from sea-level to 300 ft.

(ii) The eastern and northern hilly country, lying in a north-west—south-east belt adjoining the coastal plain and continuing southward along the eastern margin of the region. Its width varies from 95 miles in the north to 10 miles at the eastern margin of the surveyed region in the south. Altitudes range from about 50 ft. along the edge of the coastal plain to 1400 ft. near Mt. Isa. Slopes are steep but the local relief is generally less than 300 ft. and there is a close pattern of shallow steep-sided valleys or gorges and steeply sloping ridges and hills.

(iii) The central and southern plains, which cover a very large area extending from the southern edge to the north-western corner of the region. Their altitude is 600 ft. in the south and in the central portion of the Barkly internal drainage area, but this increases to 1000 ft. at the south-west, northern, and eastern margins. The topography is undulating to nearly flat.

(iv) Western low hills in a narrow north-south belt adjoining the central plains near the western edge of the region. This belt is 5-20 miles wide and about 160 miles long. The altitude ranges from 750 to 1300 ft. but the local relief is rarely more than 200 ft.

II. GEOMORPHOLOGICAL DIVISIONS

The region has been divided into three geomorphological divisions based on the major drainage systems. Each division has characteristic streams and land forms.

(i) *Gulf Fall Division.*—This division is drained by the streams which flow into the Gulf of Carpentaria. It includes all the coastal plains, most of the northern and eastern hilly country, and small parts of the north-eastern portion of the central plains. The major streams are the McArthur, Foelsche, Wearyan, Calvert, Robinson, Nicholson, and Gregory Rivers. The average annual rainfall ranges from 30 in. at the coast to 15 in. in the most inland portions.

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The eastern and northern hilly zone has an intensive pattern of small drainage lines which carry the rapid run-off from the stony hills. Throughout the coastal plain the larger streams have deeply entrenched beds and flow into the Gulf through well-defined estuaries. Small streams may terminate in swampy subcoastal flats. Some streams have well-developed anabranches, e.g. the Gregory River system has at least three permanently flowing channels.

(ii) *Georgina Basin Division*.—This division is drained by the southward-flowing Georgina River and its tributaries, which are part of the large central Australian internal drainage basin. The division includes part of the central and southern plains and a small southern portion of the northern and eastern hilly zone. The major tributaries are the Ranken, James, Buckley, Templeton, and Woodruffe Rivers. The average annual rainfall is low, ranging from 15 in. at Camooweal in the north to 10 in. at Carandotta in the south.

The streams, which flow for only short periods after heavy rains, are confined to a single channel where they cross resistant rocks but on soft alluvia they are braided. The drainage patterns are very variable. The eastern hills have an intensive pattern of small drainage lines, the more undulating parts of the plains have dendritic patterns of moderate intensity, and the nearly flat plains have anabranched streamlines.

(iii) *Barkly Basin Division*.—This division includes most of the central and part of the southern plains and the western low hills. Areas in the south have no apparent surface drainage but the remainder is drained by short streams which empty into local internal drainage basins.

The main foci for drainage are the bluebush swamps of the central Barkly Basin. The major streams are the Gosse River, Brunette Creek, Tennant Creek, Phillip Creek, Newcastle Creek, Puzzle Creek, Playford River, and Buchanan River. The average annual rainfall ranges from 23 in. in the north to 10 in. in the southern areas. The streams flow only for short periods after heavy rains and in dry years the swamps do not receive any water. In general, the drainage pattern is widely spaced but in the western low hills there are intensive patterns of small drainage lines which carry the rapid run-off from the stony hills. South of a line between Powell Creek and Lake Nash the only streams are those which rise in stony hills, meander through the gently undulating plain for short distances, and terminate in seasonally flooded swamps.

III. Origin of Land Surfaces

Following the deposition of Cretaceous sediments, the region was uplifted and exposed to a long period of erosion in Tertiary times. The land surface was reduced to a gently undulating plain with extensive swamps and some lakes in the central, western, and south-eastern sections, and some residual hilly country in the east and north. Lateritization occurred over much of the region with the exception of the areas occupied by swamps and lakes, steeper hills, and some sections of calcareous sediments in the south. The Tertiary land surface has been preserved, with very little alteration, over large areas of the region. The age of this surface is not clearly established but is regarded probably as Miocene and this is accepted for the purpose of this report. This point is more fully discussed by Noakes and Traves.* Where this surface has not persisted, erosion or deposition has produced a younger land surface. Thus areas of the present land surface can be grouped according to whether they form part of the Stable Land Surface, the Erosional Land Surface, or the Depositional Land Surface. These three groupings are tentatively referred to as geomorphological subdivisions. Areas representing these occur in each of the major geomorphological divisions of the region. Further subdivision into geomorphological units may be made on the basis of present land forms and the geomorphological processes which have operated within each of the geomorphological subdivisions.

The major forces which have contributed to the modification of the Miocene land surface within the region are:

(i) Differential land movements involving the down warping of the area occupied by the Gulf of Carpentaria with the consequent rejuvenation of the coastal-flowing streams in the Gulf Fall Division.

(ii) Weak rejuvenation of the Georgina River system, apparently due to movements outside the region surveyed, probably at the same time as the coastal movements.

(iii) Slight upward movement of the Pre-Cambrian rocks of the western and eastern margins.

(iv) Drier climatic conditions, prevailing at times in the post-Miocene period, particularly in the inland areas, which led to drying up of the inland lakes and swamps and induced erosion by upsetting the vegetation equilibrium.

Subsequent phenomena which were significant in determining the present land surfaces were:

(i) A eustatic rise in sea-level in Pleistocene time which completed the drowning of the Gulf of Carpentaria and led to deposition on the lower portions of the Miocene land surface.

(ii) A small eustatic emergence in Recent time which caused slight entrenchment of Gulf flowing streams and the exposure of large areas of coastal alluvia.

The history of the development of present land forms within each of the three geomorphological subdivisions is to some degree different and

* Noakes, L. C., and Traves, D. M.—A geological reconnaissance of the Barkly region of the Northern Territory and Queensland, with notes on mineral deposits. To be published as a bulletin of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics.

largely depends on the extent to which the Tertiary land surface has been modified and on the processes by which modification has been brought about.

(a) *The Geomorphological History of the Gulf Fall Division*

In Miocene time the area occupied by this division consisted mainly of upland lateritic plains, but it included the edge of the swampy areas in the centre of the region and also some residual unlateritized hills. The modification of the Miocene land surface was initiated by differential earth movements involving the downwarping of the Gulf of Carpentaria. The consequent rejuvenation of the streams flowing to the Gulf has led to considerable dissection of the warped slope of the Miocene land surface in this division. The Tertiary land surface has been completely removed over large areas but lateritic remnants still remain and, at the bottom and uppermost portions of the slope, extensive areas of the lateritized plain persist. At the head of the slope there are also non-lateritized areas previously occupied by the Tertiary swamps. Dissection is still encroaching upon the remaining portions of the Miocene land surface.

In consequence of extensive erosion in the Gulf Fall, extensive areas of alluvia were deposited on the flood plains of the coastal rivers and, subsequent to the major eustatic rise in sea-level in Pleistocene time, in shallow estuaries and bays of the Gulf of Carpentaria. Except for the coastal fringe these alluvia have been raised above flood level by the Recent eustatic emergence of approximately 20 ft., followed by weak entrenchment of the streams.

Not all of the eroded material reached the areas now occupied by the coastal plains. Apparently some areas of alluvia, and also some limestones near O.T. Downs Homestead, were deposited higher up the river courses as a result of the establishment of temporary base levels imposed by the resistant rocks. These temporary levels have now been lowered by stream erosion and the older flood plains are no longer liable to flooding and deposition.

(b) *The Geomorphological History of the Georgina Basin Division*

At the time of lateritization the area occupied by this division included large swamps and lakes, upland lateritic plains and non-lateritic plains, and residual hilly country. Slight rejuvenation of the Georgina River occurred presumably as a result of differential movements farther south, perhaps about the same period as the major earth movements which rejuvenated the streams of the Gulf Fall Division. As a consequence, dissection began of the Tertiary swamps, the lake alluvia and limestone, which occupied a large proportion of the Miocene land surface. In addition, dissection of the hilly country in the eastern section of the division was apparently accelerated by slight differential uplift of the eastern belt of Pre-Cambrian rocks.

After the rejuvenation of the Upper Georgina had been initiated the relatively hard limestones formed in the Tertiary lakes impeded stream entrenchment and imposed a temporary base level which forced streams to deposit some of their burden of silt. Thus large areas of alluvial deposits were laid down upstream from the limestone barriers. Some of these alluvia, particularly light-textured alluvia, were subsequently resorted by wind action. As slow entrenchment proceeded there has been weak dissection of the remaining sections of the Miocene land surface and the low divide at the head of the Georgina River has been gradually shifted northwards at the expense of the Barkly Basin. Recent alluviation has occurred along the braided streams and in small depressions on the plains.

(c) *The Geomorphological History of the Barkly Basin Division*

Of the three geomorphological divisions, the Barkly Basin Division has suffered the least modification since the period of lateritization. At that time swamps and lakes were extensive but there were also large areas of both lateritic and non-lateritic upland plains. Dry climatic periods in post-Miocene time have caused the lakes and swamps to dry up and, under present climatic conditions, many streams no longer reach the centre of the internal drainage area. The only areas of dissection are in the western, north-eastern, and central southern part of the division, where erosion is continuing slowly.

The lateritic land surface has not been completely removed in these areas, but in the western section, underlying unlateritized rocks have been exposed. Near Tennant Creek there is evidence of differential uplift of the western belt of Pre-Cambrian rocks, but in the other areas it is likely that loss of vegetative cover at the onset of a dry climatic period in the post-Miocene time was at least partly responsible for accelerating erosion and may have been a very potent factor. In some areas wind has resorted some sandy soils into poorly defined dunes and has deposited calcium carbonate from the dried Tertiary lakes on parts of the lateritic plain near their northern margins.

At the present time deposition is taking place on a small scale in the distributary systems which are the effluent areas of the present drainage systems.

IV. Geomorphological Units

The main practical objective of the geomorphological study of the region is to subdivide the present land surface as completely as possible into mappable units of distinctive origin and land form. These are referred to as geomorphological units. The Stable Land Surface, the Erosional Land Surface, and the Depositional Land Surface have each been divided into seven units. The distribution of these is shown on the geomorphological map which accompanies this report. Figures 5-7 illustrate this subdivision into geomorphological units and show diagrammatically the relationships between the various units within the Gulf Fall, Georgina Basin, and Barkly Basin Divisions respectively.

(*a*) *The Stable Land Surface and its Geomorphological Units*

This geomorphological subdivision is the gently undulating Miocene land surface with predominantly lateritic soils which has been recognized in many parts of the continent. In addition to gently sloping plains with deep lateritic soils and unlateritized hills similar to those observed in the Katherine-Darwin Region (Christian and Stewart 1953*), the following additional features associated with this land surface have been recognized in this region:

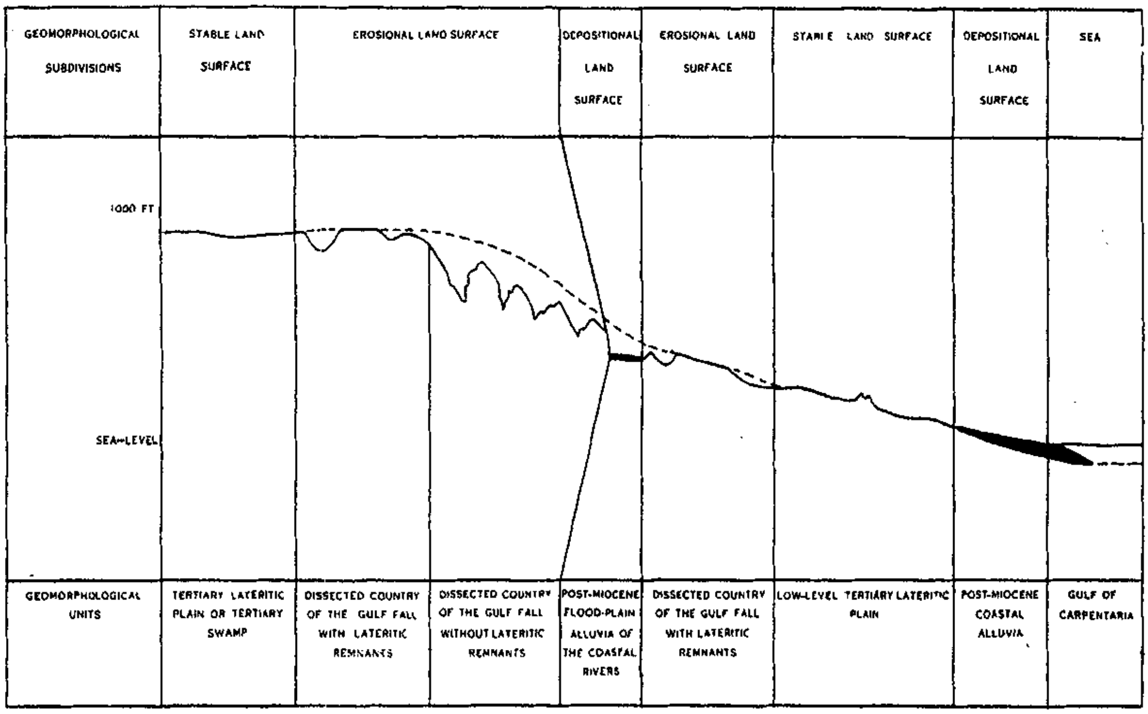

Fig. 5.—Diagrammatic cross section of Gulf Fall showing relationship of the geomorphological subdivisions and units.

(1) Gently undulating plains with leached but non-lateritic soils.

(2) Low-lying areas which were probably seasonal swamps with a water table at or above the surface for considerable portions of each year.

(3) Limestones and alluvia deposited in internal drainage lakes of the Miocene land surface.

(4) Aeolian lime derived from Tertiary lake deposits which had been deposited on low rises on the lateritic plain or as impregnations in the lateritic soils.

The nature of the lateritic soils is closely related to the nature of the parent materials. Sandstones of the Ashburton beds and the Carpentaria

* Christian, C. S., and Stewart, G. A. (1953).—General report on survey of Katherine-Darwin region, 1946. C.S.I.R.O. Aust. Land Res. Ser. No. 1.

complex have given red or yellow deep sandy soils with a weakly developed ferruginous zone of brown rounded concretions or concretionary laterite, and mottled and pallid zones which can be recognized only by the altered colouring of the parent rock. Both of these latter zones may be extensively silicified to form "quartzite billy".

The sediments of the Mullaman Group have given deep, well-developed lateritic profiles up to 80 ft. thick. The surface soil may be either podzolic (grey) or red earth (red), but both have similar lower horizons. The ferruginous zone, which may be up to 6 ft. thick, is generally concretionary

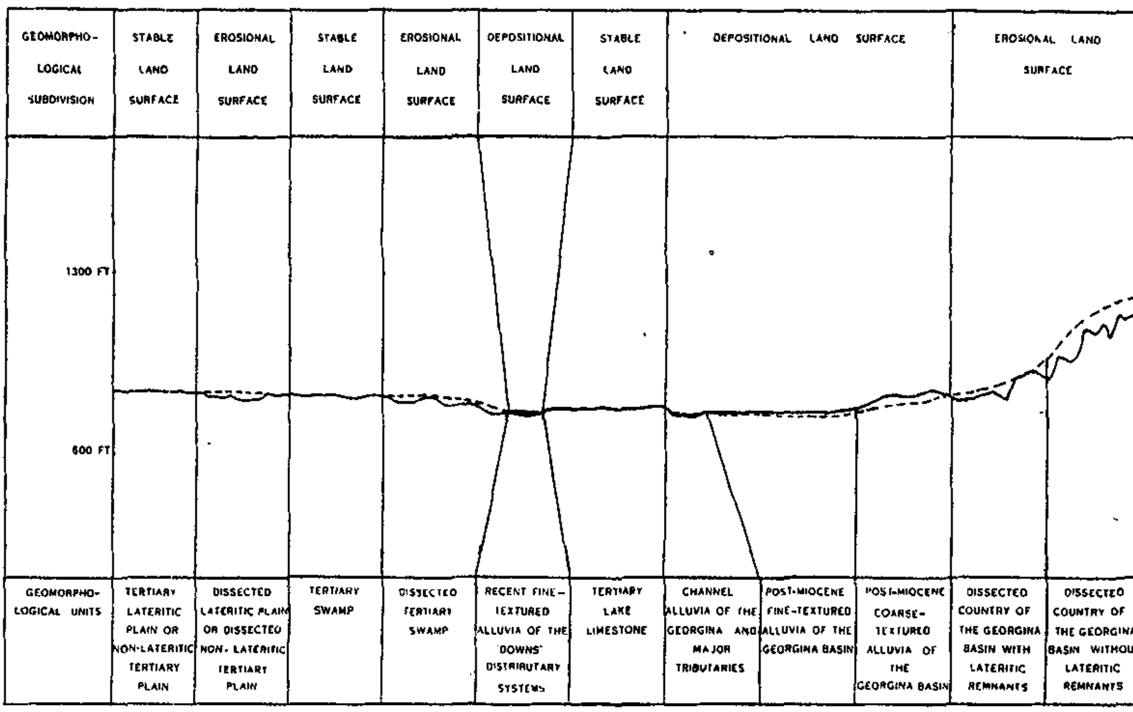

Fig. 6.—Diagrammatic cross section of Georgina Basin showing relationship of the geomorphological subdivisions and units.

at the top but is vermicular in the middle and lower parts. The mottled zone is marked with striking mottling and it gradually merges into the pallid zone. Silicification is common and in the mottled and pallid zones, depending on the fineness of the sediments, there may be either "quartzite billy", porcellanite, or hardened kaolin.

The limestones and dolomites of the Barkly Group have generally given relatively shallow profiles, depending on the amount of impurities in the sediments. They have red earth surface soils, variable ferruginous zones, and mottled and pallid zones which contain high proportions of chert fragments in places silicified to form "breccia billy".

The metamorphics of the Carpentaria complex and Warramunga Group and those areas of the Barkly Group which have large proportions of calcareous shales or sandstones give lateritic soils in the upper horizons similar to those on the Mullaman Group.

The seven geomorphological units of the Stable Land Surface are as follows:

(i) *Low-level Tertiary Lateritic Plain.*—This unit occurs only in the Gulf Fall as an irregular broken band parallel to the coast but separated from it by the Post-Miocene Coastal Alluvia. It is a gently undulating plain 50-300 ft. above sea-level and is the downwarped portion of the Miocene lateritic land surface. It has not been significantly dissected because of its low relief. In general the Tertiary lateritic soils have been preserved complete, but scattered small areas have truncated profiles.

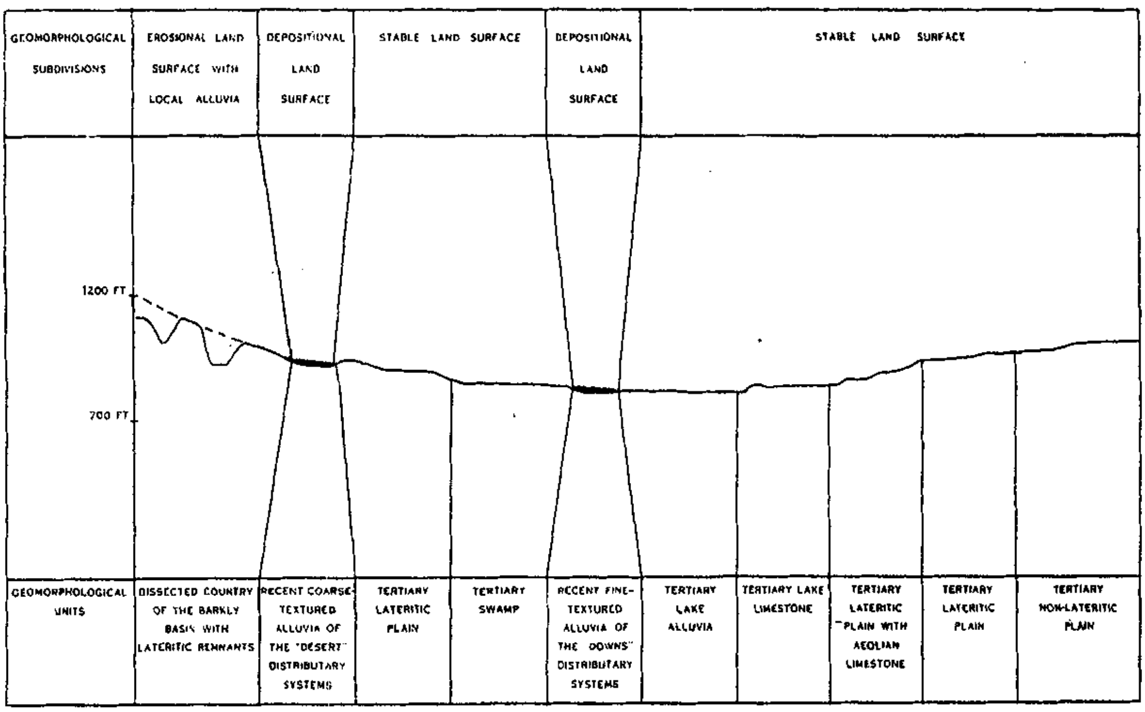

Fig. 7.—Diagrammatic cross section of Barkly Basin showing relationship of the geomorphological subdivisions and units.

To the north-east this unit is fringed by Post-Miocene Coastal Alluvia and in the beds of the Foelsche and Gregory Rivers these sediments overlie lateritic formations similar to those of the Low-level Tertiary Lateritic Plain. To the south-west this unit is adjoined or partially surrounded by the Dissected Country of the Gulf Fall without Lateritic Remnants. In the latter unit the streams have been sufficiently rejuvenated to dissect and remove the Tertiary lateritic surface, and dissection is encroaching on the Low-level Tertiary Lateritic Plain from the south-west (Fig. 5).

The deep Tertiary lateritic soils have completely masked the influence of structure of the parent rocks on the drainage pattern. The highly permeable soils combined with low relief have given rise to a graded dendritic stream pattern of low intensity.

(ii) *Tertiary Lateritic Plain.*—This very extensive unit occurs in the north and north-east portions of the Barkly Basin and neighbouring areas of the Gulf Fall, in the west and south of the Barkly Basin, and in smaller areas in the northern part of the Georgina Basin.

It is gently undulating plain from 700 to 1100 ft. above sea-level, the lower elevations being around the margins of the Tertiary Swamp in the central Barkly Basin. In general the Tertiary lateritic soils have been very slightly truncated. Some sandy soils have been weakly resorted by wind and also have received some accession of sandy material from neighbouring high country which is now very stony.

The Tertiary Plain was formed on a large range of base rocks including the Warramunga Group, Carpentaria complex, Ashburton sandstones, Pilpah sandstones, Robinson beds, Helen Springs volcanics, Barkly Group, and Mullaman Group (i.e. all pre-Tertiary rocks). The Tertiary lateritic soils vary with the nature of the parent material, but all are highly permeable. In the northern and eastern sections, where the rainfall is higher, soils are permeable and relief is gentle, and drainage follows the Tertiary drain lines which are of very broadly-spaced dendritic pattern. In the southern and western areas rainfall is lower and run-off is so slight that there is no evidence of drainage systems. Streams that rise in neighbouring higher stony country may flow through this unit for some distance before dispersing in seasonally flooded swamps.

(iii) *Non-lateritic Tertiary Plain.*—This unit occurs over a moderate but somewhat broken area in the southern section of the region, in both the Barkly and Georgina Divisions. The topography is gently undulating and elevation varies from approximately 750 ft. in the north and west to 650 ft. at Lake Nash.

This unit was part of the old Tertiary land surface but lateritic soils were formed only in isolated small areas, the remainder being leached red soils on limestone or skeletal soils. The leached red soils have the characteristics of soil formed under good drainage. The reason for non-formation of lateritic horizons may be that the underground drainage in the limestones was good and prevented water-logging of the deep subsoil, and climatic conditions were too dry to supply sufficient water to raise the geologic water table to near surface level.

The southern portion of slightly greater relief has been weakly truncated with local re-deposition in poorly defined drainage depressions. The northern portion has no drainage systems owing to the combination of low relief, permeable soils, and low rainfall.

(iv) *Tertiary Swamp.*—This is a very large unit of the central portion of the Barkly Division, and extends into the Georgina and Gulf Divisions, with a smaller isolated area in the south of the region. The topography is very broadly and very gently undulating or nearly flat. Elevations range from 670 to 950 ft. above sea-level, the higher elevations being along the margins of the Tertiary Lateritic Plain. The heavy "black soils" of the former swamp lie adjacent to the soils with laterite horizons, but neither underlies or overlies the other. The senile nature of the drainage pattern indicates that their present relationship could not have been brought about by post-Tertiary erosion and/or deposition. It is concluded that these areas were swamps during the lateritic cycle and did not undergo the strong leaching of the lateritic uplands. Rather, they had a water table at or above the surface for parts of the year and received slight accession of material eroded or leached from the higher country. Under the present low rainfall the swamps and also the Tertiary Lakes have dried up. The very slight rejuvenation of streams by lowering of base level at drying of the lakes has not been sufficient to cause significant dissection. The underlying rocks are of the Barkly and Mullaman Groups. The present soils are of mixed origin, being partly residual on these underlying rocks and partly formed on material deposited in the swamp.

The drainage pattern is very broadly spaced and dendritic, owing to the extremely low relief, the intermediate to low rainfall, and the cracked soils that are very permeable when dry. Under continuous rain the soils would seal, but as most of the rain occurs as short heavy storms between which the soils have a chance to dry out and crack, the run-off is not high.

(v) *Tertiary Lake Limestone.*—This unit occurs in a number of small isolated areas in the central part of the Barkly Basin and two large areas in the Georgina Basin. The limestones form only thin veneers over the underlying rocks.

The limestones are 650-780 ft. above sea-level in the Barkly Basin, 650-750 ft. near Austral Downs, and 550-700 ft. in the Lake Nash — Carandotta area. The topography is generally gently undulating but the Georgina and its major tributaries have incised stream beds 30-60 ft. deep. These limestones, which are silicified in many places, were probably deposited during the period of lateritization. This was a period of very slow erosion and in the formation of the lateritic soils the rocks near the surface were extremely leached. The main constituents leached out were the bases, particularly lime from the calcareous rocks of the Barkly Group and silica. Much of this lime and silica was deposited in the Tertiary lakes.

In the Barkly Basin the stream rejuvenation which followed drying of the Tertiary lake was insufficient to cause any appreciable erosion or dissection.

In the Georgina Basin the slight post-Tertiary rejuvenation has resulted in some dissection. Although stream erosion has been impeded by the Tertiary limestones, the main streams have been able, over a long period of time, to deepen their courses. In the Austral area they have cut narrow courses with steep stony banks through the hard limestones, but away from the main channels erosion and dissection are slight. In the Lake Nash — Carandotta area the Georgina River skirts the edge of, or flows through, the Tertiary Lake Limestones. It has cut a broad U-shaped bed with fairly steep banks within which there are braided stream channels. The limestones appear to be softer than those of the Austral area but away from the Georgina River dissection has been slight.

In general, run-off appears to be slight and the drainage pattern is of low intensity but streams flow through these areas from surrounding units.

(vi) *Tertiary Lake Alluvia.*—This unit occurs as one medium-sized and a number of small areas in the lowest parts of the Barkly Basin, at elevations of 660-700 ft., in the central and western section. The general topography is nearly flat but the soils have very strongly marked gilgais. The alluvia are fine-textured and calcareous but, in contrast to the alluvia of internal drainage lakes in southern Australia, are not saline. With the present-day low rainfall, run-off is not sufficient to fill the old lakes but in seasons of very heavy rainfall (about once in every 15 years according to local information) the lake bottom may be flooded for short intervals. At present the internal drainage streams effluent their water into seasonally flooded swamps around the margins of the old lake area. As this flooding is more regular (3 in every 4 years) and deposition is appreciable, these swamps are described and mapped separately as Recent Fine-textured Alluvia of the "Downs" Distributary Systems.

(vii) *Tertiary Plain with Aeolian Limestone.*—There is a single medium-sized area of this unit in the lower central portion of the Barkly Division at altitudes ranging from 740 to 800 ft. The topography is undulating with low north-west — south-east rises (WNW.-ESE. trend) of soft limestone alternating with gently sloping areas of Tertiary lateritic soils impregnated with calcium carbonate. From the presence of calcium carbonate in lateritic soil profiles it is apparent that the accession of lime was, at least in part, post-Miocene. The lime apparently originated as aeolian loess from the Tertiary Lake Limestones of the central Barkly Basin. The limestones were probably exposed by occasional drying of the shallow lakes during the period of lateritization and in subsequent arid cycles and were subject to wind action before being stabilized by vegetation in more recent times.

The shallow soils of the low rises are not very permeable but apparently the deep permeable soils of the inter-rise absorb most run-off locally as the only drainage patterns discernible are small, shallow, poorly defined depressions.

(b) *The Erosional Land Surface and its Geomorphological Units*

The extent and nature of erosional land surfaces differ in the three divisions. This is directly attributable to the different stream cycles in the various divisions already discussed. The seven geomorphological units are distinguished partly in the nature of the land surface which was dissected, the stage to which dissection has proceeded, their present land forms, and their geographical location.

(i) *Dissected Country of Gulf Fall.*—This is the major unit of the Gulf Fall and includes all but the most southerly portion of the northern and eastern hilly zone. The topography varies from steep ridges to low hills with narrow V-shaped valley or valleys with narrow flats along the lower courses of some of the main streams. Altitudes range from 1400 ft. in the south to about 50 ft. at the edge of the alluvial plain near Borroloola.

Dissection, which was initiated by the earth movements involving the downwarping of the area occupied by the Gulf of Carpentaria, is still actively proceeding. It has completely removed the Tertiary land surface, which now persists only at higher levels to which dissection has not yet extended or lower levels where there was insufficient rejuvenation of the streams for dissection to occur. In the Westmoreland area Low-level Tertiary Lateritic Plains extend to the foot of dissected hills. These were probably hilly parts in the Tertiary land surface and did not have a cover of lateritic soils, but as they are active dissection areas and are similar in nature to the remainder of the unit they are included in this unit.

The major geological formation is the Carpentaria complex, which is very steeply folded in the south-east (dips 60-80°) and moderately folded (20-50°) in the central and north-west sections. The complex contains a wide variety of rock types including shales, slates, quartzites, and limestones. There also are large areas of gently dipping, jointed sandstones and quartzites of the Robinson beds and dolomites, limestones, and shales, almost horizontally bedded, of the Barkly Group. Both the Carpentaria complex and Robinson beds have drainage patterns which are relatively intense and structurally controlled, either by erosion of softer beds where folded or by erosion along joints where bedding is sub-horizontal. The sub-horizontal beds and lack of jointing in the Barkly Group give dendritic drainage pattern of slightly less intensity. Near Undilla adjacent beds of very different hardness, hard limestones and soft shales, are responsible for the development of a stepped topography.

(ii) *Dissected Country of Gulf Fall with Lateritic Remnants.*—There are small scattered areas of this unit at the northern edge of the Tertiary Lateritic Plain or at the south-eastern margin of the Low-level Tertiary Lateritic Plain. The altitude of the former ranges from 800 to 1000 ft. above sea-level and the latter from 100 to 200 ft. Steep scarps lead from the Tertiary Plain to rolling lower slopes. The remnants of the low-level plain are low mesas with more gentle, but stony, dissection slopes. This unit is one of active erosion and the remnants of the Tertiary lateritic formations are intermixed with areas where the underlying non-lateritized rocks have been exposed. Rocks of the Mullaman Group are exposed between Calvert Hills and O.T. Downs and rocks of the Barkly Group to the south of Undilla. The remaining areas have rocks of the Carpentaria complex. This unit is drained by an irregular but very intense pattern of very small drainage lines.

(iii) *Dissected Country of Barkly Basin with Lateritic Remnants.*—The three main areas of this unit are near the edges of the Barkly Basin and are at relatively high elevations:

(1) The western low hilly zone extending from Elliott to Tennant Creek, ranging from 750 to 1300 ft. above sea-level.

(2) An area to the north of Alexandria Homestead from 850 to 1000 ft. above sea-level.

(3) An area to the east and south of Wonorah Repeater Station from 800 to 1000 ft. above sea-level.

The topography varies from rolling to low hilly, with a maximum range of relief of approximately 200 ft. near Tennant Creek. Many of the drainage lines have alluvial flats of variable extent.

In general, dissection has not gone beyond the lateritic profile but underlying rocks have been exposed in the Elliott-Tennant Creek area.

Near Tennant Creek some streams are actively dissecting their headwaters and they have exposed the underlying metamorphics of the Warramunga Group. The existence of terraces and immature valley-in-valley forms as well as probably normal faulting along the northern edge of the Honeymoon Range four miles north of Tennant Creek suggests that the post-Miocene erosion is due to slight rejuvenation by differential uplift. Similarly the dissected low hilly country of the Ashburton Range north of Tennant Creek and also the dissected country north of Alexandria may have had some differential uplift. However, this dissection can also in part be attributed to wind erosion following the loss of vegetative cover in more arid periods which followed the period of lateritization. In both cases the adjacent sandy lateritic soils show evidence of wind resorting into poorly defined dunes which are now well vegetated. The resorting could have occurred only when vegetation was very much less than at present. As both areas are adjacent to low sandstone hills showing evidence of lower lateritic horizons it is suggested that the original upper lateritic horizons of these areas were stripped by wind and deposited as poorly defined dunes on adjacent lower areas of sandy lateritic soils. It is possible that water erosion has also been accelerated by loss of vegetative cover.

Drainage patterns in this unit vary considerably. Most of the western area has a structurally controlled pattern of moderate to high intensity, with well-defined streamlines flowing on to the neighbouring lower Tertiary Lateritic Plain. Near Tennant Creek and to the north of Alexandria Homestead the stream intensity is less, the streams are more poorly defined, and alluvial flats are more extensive.

Near Wonorah there are no streams and drainage terminates in broad alluvial depressions.

(iv) *Dissected Country of the Georgina Basin without Lateritic Remnants.*—The single area of this unit is in the south-east corner of the region. The topography ranges from low hills to ridges. Narrow river flats occur in the valleys of the larger streams. Elevations range from 900 ft. along the western edge to 1400 ft. along the divide between this unit and the Dissected Country of the Gulf Fall. This unit is similar to neighbouring portions of the Dissected Country of the Gulf Fall without Lateritic Remnants. There are only a few small isolated patches of Tertiary lateritic remnants adjacent to its western lower edge. In Tertiary time most of this unit was probably a higher area of more rugged relief subject to continuous erosion with slopes too steep for the formation of lateritic soils.

The degreė of dissection is least in the western portion of the unit, but is of the order of 200 ft. in the eastern mapped area. Similar country extends east to Duchess and Cloncurry. This relatively high area of dissection forms the headwaters of south-westerly-flowing tributaries of the Georgina River, the southerly-flowing Burke and Wills Rivers, and the northerly-flowing Leichhardt and Cloncurry Rivers, i.e. it forms a block of high country with resistant rocks which is being dissected by streams flowing in all directions. This dissection has probably been assisted by differential uplift of the Pre-Cambrian rocks in the east. These Pre-Cambrian rocks include the steeply folded Carpentaria complex and also granites. The former has strong north-south folding which gives marked structural control of drainage and a topography with north-south sharp ridges and valleys. The granites have an intense dendritic pattern of small drain-lines and a more rounded topography.

(v) *Dissected Country of Georgina Basin with Lateritic Remnants.*—There are a number of small areas of this unit in the north-eastern section of the Georgina Basin. They have undulating to low hilly topography and range from 900 ft. above sea-level near Barkly Downs to 1100 ft. in the eastern portion near the Gulf-Georgina divide. These are areas of weak post-Miocene dissection of the Tertiary Lateritic Plain and dissection generally has not proceeded in depth beyond the lateritic profile. To the south this unit adjoins the more actively dissected country of the Georgina Basin and also the extensive post-Miocene alluvia. The underlying rocks are of the Carpentaria complex and the Barkly Group, but as dissection has generally not gone beyond the lateritic horizons the nature of underlying rocks has not influenced the nature of the drainage pattern, which is of moderate density and irregular.

(vi) *Dissected Tertiary Swamp.*—This unit, which has a broadly or gently undulating topography, occurs only in the western half of the Georgina Basin, at altitudes ranging from 850 ft. in the north to 560 ft. near Urandangi. Weak dissection of the Tertiary Swamp formation has exposed the underlying calcareous sediments of the Barkly Group on which heavy clay soils similar to those of the Tertiary Swamp have formed. This unit is differentiated from the Tertiary Swamp by its more undulating topography and considerably more intensive dendritic stream pattern, both of which are products of the weak post-Tertiary dissection.

(vii) *Dissected Tertiary Non-lateritic Plain.*—The only area of this unit is in the south-western section of the Georgina Basin, where it occurs in a complex with Dissected Tertiary Swamp at an altitude of 700-1100 ft. above sea-level. It has a broadly undulating to rolling topography. The complex area is one of gentle dissection with a stream pattern of moderate intensity, and has both heavy clay soils and shallow desert soils formed on the calcareous sediments of the Barkly Group. Apparently the areas of shallow desert soil in the complex have formed where limestone outcrops occurred on the Miocene surface or where weak dissection has removed the leached non-lateritic Tertiary soils and exposed the underlying limestones.

(c) *The Depositional Land Surface and its Geomorphological Units*

The extent of the depositional land surfaces differs considerably in the three geomorphological divisions, and their nature varies with the kind of material which has been eroded.

(i) *Post-Miocene Coastal Alluvia.*—The Gulf of Carpentaria is fringed by an irregular band of Post-Miocene Coastal Alluvia ranging in width from 4 to 90 miles and in altitude from sea-level to 300 ft. The topography is nearly flat to gently undulating with levee formations along the major streams. There is a very gentle general slope towards the Gulf. At Lawn Hill and Gregory Downs these sediments are considerably higher than the inland edge of the sediments further north-west. These more inland sections are probably flood-plain deposits, the near coastal ones estuarine deposits. A slight sea recession in Recent time exposed the lower deposits and was sufficient to allow the major streams to entrench their beds. Deposition is now active only in the near coastal sections that are liable to flooding. The change has been so slight that, in general, the anabranched stream pattern of deposition is still retained.

There are two definite groups of soils which are related to differences in the sources of the alluvia. Where the alluvia are derived mostly from non-calcareous rocks, e.g. the metamorphics of the Carpentaria complex and sandstones of the Robinson beds, the highly leached soils have sandy or loamy surfaces and mottled clay subsoil. The alluvia derived from calcareous rocks, e.g. sediments of Barkly Group, have grey heavy clay soils with fine calcareous concretions.

(ii) *Post-Miocene Flood-plain Alluvia of Coastal Rivers.*—This unit occurs as five small areas along the middle and upper courses of some of the Gulf Fall rivers, and ranges in altitude from 100 to 400 ft. The topography is gently undulating to nearly flat with levee formations along major streams. These are the alluvia deposited on the flood plains of rivers apparently held to temporary base levels by resistant strata. The streams have since lowered their courses by cutting into these strata. The alluvia are not liable to flooding or deposition under present rainfall conditions. The alluvia, which have mostly been derived from calcareous rocks, have heavy clay soils with fine calcareous concretions. Near O.T. Downs Homestead there are also some limestones in the northern lower portion of the post-Miocene sediments.

(iii) *Post-Miocene Fine-textured Alluvia of Georgina Basin.*—There are several areas of this unit in the central and southern portions of the Georgina Basin. They are very gently sloping to nearly flat plains ranging from 700 ft. above sea-level in the north near Camooweal to 550 ft. in the south near Carandotta. In general these extensive alluvia are separated from the Georgina River by areas of resistant, weakly dissected, Tertiary limestone. A well 35 miles east of Urandangi shows Post-Miocene Fine-textured Alluvia, approximately 50 ft. thick, overlying Tertiary limestone. The nearest outcrop of Tertiary limestone is approximately 30 miles to the south-west. Apparently the Tertiary limestones were deposited chemically in lakes as these dried during an arid period subsequent to the period of lateritization. During a later period of erosion the surface grade of the Tertiary limestones was insufficient to permit the streams to carry their burden entirely and the hardness of the limestones impeded the lowering of the stream beds. Alluvial deposits were spread over and behind the areas of Tertiary limestone except in the immediate vicinity of the weakly entrenched Georgina River. The stream pattern is typically depositional, that is, greatly anabranched, but the streams are now weakly entrenched and the plains are not liable to flooding.

(iv) *Post-Miocene Coarse-textured Alluvia of Georgina Basin.*—This unit is intermixed with the previous unit, but in any one area is at a slightly higher level. The topography is undulating with some weak dune development. It occurs at altitudes of 750 ft. to 550 ft. All evidence of the depositional stream pattern has been completely obscured by wind resortment. The soils found on the alluvia are deep and permeable and the only drainage lines in this unit flow through it from neighbouring higher units.

(v) *Channel Alluvia of Georgina and Major Tributaries.*—There are elongated bands of this unit along some of the major stream courses of the Georgina Basin. The topography consists of intricately braided stream channels interspersed with undulating to nearly flat areas. In general the inter-stream areas are only slightly lower than the surrounding plains, but in the softer Tertiary limestones the lower Georgina has a broad U-bed with braided channels in the broad bottom. The inter-braid areas are liable to periodic flooding but there is no evidence of deposition on the higher areas.

(vi) *Recent Coarse-textured Alluvia of "Desert" Distributary Systems.*—The small isolated areas of this unit occur in the western section of the Barkly Division in or at the edge of the Tertiary Lateritic Plain. Streams that rise in the western low hills do not reach the central lower part of the internal drainage area, but effluent their waters in the distributary areas that comprise this unit. Elevations range from 1000 ft. near Tennant Creek to 800 ft. near Helen Springs. The topography is a network of low, narrow rises interspaced by narrow flats, with some large flats and small streamlines. The shallow alluvia are liable to short seasonal flooding, with some deposition, after heavy rains in the dissected areas.

(vii) *Recent Fine-textured Alluvia of "Downs" Distributary Systems.*—Most of this unit occurs as small scattered areas around the edge of the Tertiary Lake Alluvia, or in shallow depressions in the Tertiary Swamp of the central Barkly Basin, but there are also some isolated areas in the Georgina Basin. They range from 720 ft. above sea-level in the Barkly Basin to 550 ft. near Carandotta in the Georgina Basin. The unit consists of a fine network of low narrow rises and depressions in the lowest part of the local topography which are the dispersion areas of present-day drainage. Fine-textured sediments, mostly derived from "black-soil" plains, are being deposited but as the streams are mature and topography is gentle the amount of erosion and deposition is not great.

In the Barkly Basin this unit generally represents parts of the Tertiary lake marginal areas which are still liable to flooding even by the reduced stream flow of the present-day low rainfall.

In the Georgina Basin this unit has a slightly different origin. The area on the Ranken River occupies a depression in the Tertiary Lake Limestone. The areas east of Austral Downs Homestead, east of Carandotta Homestead, and north-east of Headingly Homestead occur between the areas of the Post-Miocene Fine-textured Alluvia and the still exposed areas of the Tertiary Lake Limestone. They appear to be the last remaining areas of limestones that have not been so deeply covered by Post-Miocene Alluvia.

PART V. HYDROLOGY OF THE BARKLY REGION

By D. M. TRAVES* and G. A. STEWART†

Rainfall in this region is confined to short summer wet seasons separated by dry seasons of eight or more months and thus water resources are particularly important to any form of development.

I. SURFACE WATER RESOURCES

As the water supply characteristics and the nature of streams are different in each of the geomorphological divisions, these divisions are described separately.

(a) *Gulf Fall*

This division has an average annual rainfall ranging from 30 in. at the coast to 15 in. in the south. The streams rise in hilly country mostly within the section of lower rainfall. Their courses are youthful near the sources but where they flow through the broad coastal plains they are mature and meandering. The channels of the streams are deeply cut but are filled only for short periods after heavy rains. For most of the wet season, stream flow is only a small fraction of channel capacity and in many streams flow ceases during the dry season.

There are many springs in the hilly country but the only ones large enough to maintain permanently flowing streams are those that feed the Gregory River and Lawn Hill Creek. In its lower course the Gregory River has three anabranches with permanently flowing water. Whitehouse (1940)‡ concludes that the dry season flow of these streams is decreasing; for example, at Riversleigh in June 1919 the flow was 155 cusecs and in June 1931 it was only 115 cusecs.

The larger non-permanent streams have large permanent waterholes. In general, the surface water supply is adequate for present stock and domestic requirements except in the hilly country between Thorntonia and Mt. Isa and the "black-soil" plains to the east of the Gregory River. There is some scope for conservation of water by dams in the dissected hilly country, for example, Rifle Creek near Mt. Isa has been dammed to supply water for the township. However, the rainfall of the hilly country is lower than along the coast and the catchment areas are not large. The Gregory-O'Shannessy Rivers above Riversleigh have a total catchment area

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‡ Whitehouse, F. W. (1940).—Studies in the late geological history of Queensland. Univ. Qd. Pap., Dep. Geol. 2 (1).

of only 3000 sq. miles and the mean annual rainfall ranges from 15 in. near Camooweal to 20 in. at Riversleigh. Two-thirds of the catchment area is dissected hilly country and the remainder is gently sloping Tertiary land surface. Nimmo (1948)* has estimated mean annual run-off for the whole catchment of the Nicholson, Gregory, and Albert Rivers as 0.35 in. The near coastal parts are gently sloping alluvial plains and provide little run-off. Thus the hilly country and gently sloping Tertiary land surface of the headwaters must contribute most of the water received by these streams. If a run-off of 1 in. per annum in the hilly country and of $\frac{1}{3}$ in. per annum on the gently sloping Tertiary land surface are assumed, the annual run-off for the Gregory-O'Shannessy catchment above Riversleigh is approximately 130,000 acre-feet. As these are the main streams in the region, the scope for conservation of water for irrigation is obviously limited.

(*b*) *Georgina Basin*

The mean annual rainfall ranges from 10 in. in the south to 17 in. in the north. The hills in the eastern portion of the division have an intensive pattern of small streamlines. On the plains the streams are mature and are either braided or deeply-cut single channels. They flow only for short periods after heavy rains and the Georgina, James, and Ranken Rivers are the only ones with permanent waterholes. The water of these holes is milky in appearance owing to the high content of clay in suspension.

There are only a few very small springs and their meagre water supplies have little importance. Soakage water has been obtained by digging wells in the sandy beds of some of the streamlines at the foot of the eastern hills. Because of the very small areas of catchment and the low rainfall the eastern hilly country offers little scope for water conservation. On the plains, low overshot dams have been made on some streams, for example at Austral Downs and Avon Downs Homesteads. In the past it has been found to be more economical to instal and equip bores than to extend this form of water conservation. However, the use of heavy earth-moving equipment could conceivably change this position.

The surface water supply is far from adequate to meet stock and domestic requirements, particularly near the end of the dry season. The present development of the pastoral industry is dependent largely on underground water supplies.

(*c*) *Barkly Basin*

This division is characterized by widely-spaced shallow streamlines which terminate in seasonally flooded swamps, and large areas have no apparent surface drainage. Mean annual rainfall ranges from 23 in. in

* Nimmo, W. (1948).—Fourth Ann. Rep. Bur. Invest. Dep. Lds. Qd. p. 14.

the north to 10 in. in the south. Streams flow only for short periods after heavy rains and only the largest streams such as the Buchanan and Playford Rivers and Brunette and Creswell Creeks have permanent waterholes. Like the streams of the Georgina Basin this water is also milky in appearance owing to the high content of clay in suspension. The meagre water supply of the few small springs in this division is of little economic importance.

The gentle topography and low rainfall do not provide suitable conditions for water conservation by dams. Low overshot dams have been constructed on some streams, for example the Buchanan River, but, as in the Georgina Basin, further development of this form of water conservation is unlikely unless costs can be reduced by the use of heavy earthmoving equipment.

In general, this division is very poorly provided with surface water and utilization of the natural pastures has been made possible only by the utilization of the underground water resources, which are discussed in the following section.

II. Underground Water Resources

Because of the lack of surface water resources in the Barkly Region, underground water plays an important role in the development of the region. In the northern and western portions of the Gulf Fall some wells and bores have been sunk in the broader valleys which are surrounded by catchment areas. The water obtained is generally ground water and is fairly free of dissolved salts except in limestone areas where calcium and magnesium salts have gone into solution.

In the eastern hilly portion of the region, where much of the country is not suitable for development, the need for supplementary underground water is not great. Supplies of underground water have been obtained in the dissected Cambrian limestones of the Thorntonia, Undilla, and Morestone areas, but available records provide little information on the supply and origin of the water. Satisfactory bore sites can be selected only by the study of local geological structures. At Mt. Isa moderate supplies are obtained from shallow bores sunk close to the Leichhardt River and from others which enter fault zones or other structural traps in the folded and faulted Pre-Cambrian Carpentaria complex. In the area occupied by Pre-Cambrian rocks between Mt. Isa and Dajarra, no bores have been sunk because underground water has not been required. However, in the event of mining being developed, underground water could probably be obtained at carefully selected bore sites.

At Tennant Creek the water supply is inadequate, being provided by bores sunk near the Old Telegraph Station, north of the township, where the water level stands at between 200 and 250 ft. below the surface. Other bores in the broad valleys or close to the granite-slate contact yield some water which is generally of a poor quality, suitable only for use in mines and treatment plants.

In the central portion of the region, in the grasslands of the Barkly Tableland, there is a large sub-artesian basin which provides ample supplies for the pastoral industry. The positions of bores tapping this supply are recorded on the land traverse map. The water is raised to the surface by pumps driven either by windmills or by engines. It is retained in the basin-like, sub-horizontally bedded Cambrian sediments of the Barkly Group and, as far as can be judged, is held in porous sediments in some places and cracks, joints, and cavities in others, particularly in the dolomites and limestones. For this reason the bore logs do not indicate specific continuous aquifers but rather numbers of beds which provide rather irregular aquifers depending on the lithology or the incidence of fractures and cavities. In each bore there is a static water level to which the water rises, and from plotting the heights of these individual levels it is shown that the static water level or pressure surface is broadly in conformity with the ground surface, which is basin-shaped. The pressure surface ranges from 500 ft. to 600 ft. above sea-level and is divided into two sub-basins, one corresponding to the internal drainage basin around the Brunette Lakes and the other to the Georgina Basin. In the central portion of the Brunette Basin the pressure surface is approximately 550 ft. above sea-level and rises to 600 ft., as shown by a contour which passes close to Rockhampton Downs, Alroy Downs, Alexandria, Brunette Downs, and Anthony Lagoon Homesteads. In the east, the higher portion of the pressure surface approximately corresponds to the surface divide between the Brunette Lakes and the Georgina Basin. In the Georgina Basin the pressure surface is approximately 550 ft. above sea-level but falls to 500 ft. in the vicinity of Headingly and Warwick Downs.

The difference in depth between the static water level and a major supply of water at any bore is dependent on the position and efficiency of the aquifer penetrated. Bore data show that at some places major supplies are found at or close to the static water level and in others an additional hundred feet or more of Cambrian sediments has to be penetrated before an adequate supply is found. At all sites, however, the water rises to the pressure surface, which means that pumps need only be lowered to just below the static water level.

It is not possible, at present, to predict the depth to an adequate supply of water at any specific locality, but in general, supplies are reached in less than 500 ft. The difference in elevation between the ground surface and the approximate depth to which water will rise in the bore can be predicted fairly accurately by subtracting the pressure surface level from the ground surface height.

Headingly Bore 3 may be quoted as a typical example of bore data:

Surface height above sea-level	620 ft.
Depth from surface to static water level	133 ft.
Depth to pump level	138 ft.
Depth to main supply	155 ft.
Total depth of bore	169 ft.

These figures show that the altitude of the pressure surface in this locality is 487 ft. and that the main supply was obtained 22 ft. below the pressure surface. The fact that the pump level is above the main supply shows that the water is confined or pressure water.

III. Quality of Water in the Sub-Artesian Basin

Most of the bores in the Tableland produce a good supply of water. As a general rule, a minimum output of over 2000 gal. per hour is required by test before they are equipped. The quality of the sub-artesian water varies but the average is fairly good. Approximately 50 per cent. of the bores yield water fit for human consumption, whilst over 90 per cent. yield water fit for stock. There is a lack of chemical analysis for most bores but the salt contained in the sub-artesian water appears to consist mainly of sodium chloride and calcium and magnesium sulphates and carbonates.

From information supplied by graziers, it appears that there are two areas in which a large proportion of bores give water not suitable for stock, one in the Brunette Downs section of the Barkly Basin and one near Headingly and Carandotta in the Georgina Basin.

Chemical analyses of two of the bore waters are:

Brunette Downs Bore 24

Taste	Saline
Indication	Alkali
Solids in suspension	22.45 grains per English gal.
Total solids	627.27 grains per English gal.
SO_3	107.3 grains per English gal.
Al_2O_3	3.15 grains per English gal.
CaO	23.08 grains per English gal.
MgO	1.1 grains per English gal.

Brunette Downs Bore 35

Total solids	529.2 grains per English gal.
$CaSO_4$	78.9 grains per English gal.
$MgSO_4$	80.0 grains per English gal.
$MgCl_2$	2.0 grains per English gal.
NaCl	339.4 grains per English gal.
Hardness	148

An excessive amount of fluorine, up to 4 p.p.m., has been found in one bore on the Barkly Tableland. The following is a chemical analysis of the water:

Total solids	207.0 grains per English gal.
$CaSO_4$	38.0 grains per English gal.
$MgSO_4$	26.3 grains per English gal.
NaCl	108.3 grains per English gal.
Hardness	60
Fluorine	4 p.p.m.

It is interesting to note that this water does not contain a high concentration of salts and except for the fluorine content would be quite potable. Water containing more than 2 p.p.m. of fluorine is harmful to humans and stock, although smaller amounts are beneficial. At present there is no explanation for the occurrence of the relatively high content of fluorine. It is not known how widespread the occurrence is but it is reported that excessive fluorine occurs in a small number of bores in addition to the one discussed above.

Because of the possible presence of excessive quantities of fluorine it is advisable for stations to obtain a chemical analysis of water from all new bores.

It is not known whether continuous pumping results in any diminution of the fluorine content, or whether sinking bores to a greater depth would tap better-quality water.

IV. Future Supply of Sub-artesian Water

The sub-artesian basin is recharged by natural waters percolating downwards through pervious rocks. In the centre of the tableland, much of the surface is a heavy clay soil forming an impervious layer on which lie bluebush swamps. In some areas in the central portions and in many areas towards the edges, the sandy "deserts" provide good intake areas for recharge. There is no way of calculating the actual rate of recharge of the basin but calculations from the land systems map show that approximately 23,000 sq. miles of sandy "desert" could act as intake areas for the Brunette Basin.

At present there are about 100 bores in this area. With full development of the cattle industry this may be raised to 200. If this number of bores pumped 20,000 gal. per day for 300 days each year, it would need only 0.025 per cent. of the average rainfall of approximately 15 in. per annum to penetrate into the basin in order to replace the water pumped.

There is no knowledge of any decrease in supply from bores owing to a decrease in reserves but decreases due to silting up or corrosion or deposition in the bore casing have occurred. As far as is known, the static water level is constant. The supplies of underground water appear to be more than adequate for the future development of the cattle industry.

PART VI. SOILS OF THE BARKLY REGION

By G. A. STEWART*

I. INTRODUCTION

The region has a wide range of soils varying from extremely leached lateritic soils of the Tertiary land surface to shallow Calcareous Desert soils and Desert Loams in the southern drier areas. Factors which have contributed to the distribution and diversity of soils are:

(1) The range in average annual rainfall from 10 in. in the south to 30 in. at the Gulf of Carpentaria.

(2) The relict Tertiary plains which have highly leached, generally lateritic soils formed under a past wetter climate.

(3) The extensive areas of Post-Tertiary Alluvia on which a variety of mature soils have formed.

(4) The dissected hilly country which has skeletal soils or rock outcrops.

(5) The range of parent materials of residual soils, ranging from basic volcanic and highly calcareous rocks to granitoid rocks and sandstones.

II. GROUPING OF THE SOILS

Excluding a wide variety of undescribed skeletal soils and minor alluvial soils, the soils have been classified into 32 soil units. As the survey was a broad-scale reconnaissance it was not possible to define soils series. The soil unit corresponds approximately to the soil family but as the series within the families could not be defined, they have been called soil units. Where possible these have been grouped tentatively into Great Soil Groups. These have been further amalgamated into five pedogeographic units (Table 8).

(i) *Very Strongly Leached Soils of the Tertiary Land Surface*.—In the Tertiary Period deep, highly leached, generally lateritic soils were formed over large areas of Australia. On the Stable Land Surface (which comprises the following geomorphological units: the Tertiary Low-level Lateritic Plain, Tertiary Lateritic Plain, Tertiary Non-lateritic Plain, and Tertiary Lateritic Plain with Aeolian Limestone) they have been preserved to the present time with little apparent alteration. In some parts of the first three geomorphological units the surface soil has been partly eroded and some areas of sandy soils have been weakly resorted by wind. In the fourth geomorphological unit a late Tertiary or post-Tertiary deposition of aeolian lime has given the Calcareous Lateritic soils.

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TABLE 8

GROUPING OF THE SOILS OF THE BARKLY REGION

	Tentative Great Soil Group	Soil Unit
I. Very strongly leached soils of the Tertiary Land Surface	Lateritic Red Earths	(i) Tertiary Lateritic Red Earths
		(ii) Tertiary Lateritic Red Sands
	Lateritic Podzolic soils	(iii) Tertiary Lateritic Podzolic soils
	Yellow Podzolic soils	(iv) Tertiary Lateritic Flats
	Red Earths	(v) Tertiary Non-lateritic soils
	?	(vi) Podzolic Truncated Lateritic soils
II. Strongly leached soils of the Gulf Fall	Yellow Podzolic soils	(vii) Shallow Yellow Podzolic soils
		(viii) Deep Yellow Podzolic soils
		(ix) Sandy Yellow Podzolic soils
	Meadow Podzolic soils	(x) Meadow Podzolic soils
	Red Earths	(xi) Limestone Red soils
		(xii) Leached Brown Levee soils
III. Moderately to weakly leached soils with carbonate horizons	Red-brown Earths	(xiii) Alluvial Red-brown Earths of Gulf Fall
		(xiv) Alluvial Red-brown Earths of Georgina Basin
	Desert Loams	(xv) Granitic Desert Loams
	Grey and Brown Soils of Heavy Texture	(xvi) Heavy Grey Pedocals
		(xvii) Heavy Brown Pedocals
		(xviii) Northern Heavy Grey Pedocals
		(xix) Southern Heavy Grey Pedocals
		(xx) Kilgour Heavy Grey Pedocals
		(xxi) Distributary Heavy Grey Pedocals
		(xxii) Drylake Heavy Grey Pedocals
	Brownish Grey Calcareous Desert soils	(xxiii) Limestone Calcareous Desert soils
		(xxiv) Igneous Calcareous Desert soils
	Mallee soils?	(xxv) Calcareous Lateritic soils

TABLE 8 (*Continued*)

	Tentative Great Soil Group	Soil Unit
IV. Non-calcareous soils of the lower rainfall areas (less than 20 in. per annum)	Brown Soils of Light Texture	(xxvi) "Bundella" soils (xxvii) Red-brown Desert Alluvial soils
	Miscellaneous soils on alluvia	(xxviii) Sandy Distributary Complex (xxix) Podzolic Desert Alluvial soils
V. Soils of the Littoral		(xxx) Coastal Sand Dune soils (xxxi) Salt Marsh soils (xxxii) Solonetzic soils

(ii) *Strongly Leached Soils of the Gulf Fall.*—Strongly leached soils have been formed on some gently sloping areas of the dissected country and on portions of the Post-Miocene Alluvia of the Gulf Fall where the rainfall is higher. The Limestone Red soil and Shallow Yellow Podzolic soils have formed on limestones and shales respectively of the Carpentaria complex, but there are only small areas of both these soils. The Deep Yellow Podzolic, Sandy Yellow Podzolic, Meadow Podzolic, and Leached Brown Levee soils occur on portions of the Post-Miocene Coastal Alluvia derived from non-calcareous rocks.

(iii) *Moderately to Weakly Leached Soils with Carbonate Horizons.*—These soils are widely distributed, occurring from the Gulf of Carpentaria in the north to the desert margins in the south. The "black soils" of the grassland plains of the Barkly Tableland and Burketown areas are the most extensive soils of this group. They are formed on highly calcareous or basic igneous rocks or alluvia derived from these. The Desert Loam soils are formed on granitic and gneissic rocks. The remainder cover small areas only.

(iv) *Non-calcareous Soils of the Lower-rainfall Areas.*—All of these soils are formed on alluvia which are largely derived from non-calcareous rocks. The "Bundella" soil is formed on alluvia derived from the mixed rocks of the Carpentaria complex. The parent material of the other three soils, which occur only in small areas, is largely derived from dissection of the highly leached Tertiary lateritic formations.

(v) *Soils of the Littoral.*—These soil units occur in a band 2-10 miles wide along the shore line of the Gulf of Carpentaria. The sand dunes are fixed but the soils are deep sands with no profile differentiation. The salt marsh soils are liable to saline inundation by king tides. The solonetz soils are just above the level of tidal inundation but may be liable to flooding by saline waters diluted by stream floodflow.

III. Description of the Soils

(i) *Tertiary Lateritic Red Earths.*—These soils are formed on a variety of rocks of the Mullaman, Barkly, and Warramunga Groups and the Carpentaria complex. They occur extensively on gently undulating topography on the Tertiary Lateritic Plain. In the southern part of the region lighter textured profiles have a sand surface horizon and increase in texture only to sandy clay loam.

This profile is very similar to the Tertiary Lateritic Red Earth described by Christian and Stewart (1953).*

0-6 in.	Grey-brown sandy loam.
6-15 in.	Reddish brown sandy clay loam.
15-45 in. +	Red-brown to red light clay, overlying heavy ferruginous gravel or massive laterite.

This profile overlies mottled and pallid zones, which were observed only in quarries or dissected areas.

(ii) *Tertiary Lateritic Red Sands.*—Highly arenaceous sediments of the Ashburton sandstones and Carpentaria complex were the parent materials of these deep sandy soils. They occur on gently undulating to undulating topography in the north-eastern and western sections of the Tertiary Lateritic Plain of the Barkly Basin. Poorly defined low sand dunes occur in some places and these areas may have accumulated some sandy material from neighbouring higher country from which most of the sandy surface soil has been removed.

0-5 in.	Grey-brown to brown sand.
5-15 in.	Brown sand.
15-60 in. +	Red-brown or yellow-brown sand overlying pisolitic ferruginous gravel and massive laterite. In many cases the altered colouring of the highly siliceous parent sandstone is the only evidence of mottled and pallid zone.

(iii) *Tertiary Lateritic Podzolic Soils.*—These soils were formed on gently undulating topography on a variety of rocks of the Carpentaria complex, the Robinson beds, and the Mullaman Group. They occur on the Tertiary Lateritic Plain in the northern section of the Barkly Basin and in the Gulf Fall, and on the Low-level Tertiary Lateritic Plain of the Gulf Fall. They are similar to the Tertiary Lateritic Podzol of the Katherine-Darwin region.

0-6 in.	Grey sand.
6-20 in.	Yellowish grey sand.
20-30 in.	Yellow-grey sandy loam with ferruginous gravel overlying massive laterite, mottled and pallid zones.

(iv) *Tertiary Lateritic Flats.*—Depressions within any of the three previously described upland lateritic soils have Tertiary Lateritic Flat soils. In the Katherine-Darwin region, where the mean annual rainfall

* Christian, C. S., and Stewart, G. A. (1953).—General report on survey of Katherine-Darwin region, 1946. C.S.I.R.O. Aust. Land Res. Ser. No. 1.

ranges from 35 to 60 in., the lateritic flats are flooded in the wet season and the soils are Meadow Podzolics. In this region of lower rainfall (10-30 in.) the flats are not flooded and the soils are Yellow Podzolics.

Depending on the nature of the parent material, the soils may vary in texture from deep sands to clay loams. The following is a medium-textured profile. Some profiles have heavier gravel horizons than the described profile.

0-5 in.	Lightish grey sandy loam.
5-12 in.	Yellowish grey loam.
12-40 in.	Yellow-grey with grey and red-brown mottling clay loam or light clay with light ferruginous gravel.
40 in. +	Very light grey, with yellow-brown and red-brown mottling, light clay, may have soft ferruginous gravel.

(v) *Tertiary Non-lateritic Soils.*—Limestones of the Barkly Group were the parent materials of these leached red soils, which occur on gently undulating topography only on the Tertiary Non-lateritic Plain.

0-4 in.	Brown sandy loam.
4-16 in.	Red-brown sandy clay loam.
16-27 in.	Brownish red light clay, massive but porous.
27-36 in.	Brownish red light clay, with fragments of limestone, massive but porous.
36 in. max.	On limestone.

(vi) *Podzolized Truncated Lateritic Soils.*—Exposed mottled and pallid zones of lateritic formations, originally formed on sediments of the Mullaman Group, are the parent materials of these soils. They occur on moderate to gentle slopes below the steep dissection scarps only in the Dissected Country of the Gulf Fall with Lateritic Remnants.

0-4 in.	Grey-brown loam with heavy ferruginous gravel.
4-10 in.	Yellow-brown clay loam with moderate ferruginous gravel.
10-36 in.	Yellow-brown light clay with light ferruginous gravel.
36 in. +	Mottled light grey, red, yellow-brown kaolinitic clay of the mottled zone.

(vii) *Shallow Yellow Podzolic Soils.*—These are residual soils on shales of the Carpentaria complex and occur as very small areas on lower slopes in the Dissected Country of the Gulf Fall. The shallow Yellow Podzolic soil of the Katherine-Darwin region and the Rainyerri sandy loam of the lower Ord River Valley, Western Australia (Burvill, unpublished data) are very similar to these soils.

0-5 in.	Yellow-grey fine sandy loam.
5-11 in.	Light yellowish grey fine sandy loam.
11-18 in.	Yellow-grey clay loam to light clay, may have some rusty yellow-brown mottling.
18-27 in.	Some decomposing shale increasing with depth to 27 in. max.

(viii) *Deep Yellow Podzolic Soils.*—These soils are formed on Post-Miocene Coastal and Flood Plain Alluvia of the Coastal Rivers derived largely from non-calcareous rocks. The topography is gently undulating.

Lighter-textured forms occur on higher parts near the streams and heavier-textured forms on the lower parts of the topography.

0-5 in.	Grey fine sandy loam, with light ferruginous gravel.
5-15 in.	Light grey-brown fine sandy loam with light ferruginous gravel.
15-23 in.	Mottled light grey-brown, yellow-grey sandy clay loam with light ferruginous concretions—transition zone.
23-60 in. +	Yellow-grey light clay with yellow-brown, red-brown mottling, with light soft ferruginous gravel.

(ix) *Deep Sandy Yellow Podzolic Soils.*—The parent materials of these soils are the coarser-textured Post-Miocene Coastal Alluvia derived from non-calcareous rocks or highly siliceous sandstones of the Carpentaria complex. Soils formed on the former parent material occur on gentle slopes adjacent to streams where they emerge on to their alluvial plains. Soils formed on the sandstones occur as irregular small areas on lower gentle slopes in the Dissected Country of the Gulf Fall.

0-4 in.	Yellowish grey sand.
4-30 in.	Yellowish grey to light yellowish brown sand.
30-66 in. +	Greyish yellow clayey sand with slight light grey, red-brown mottling.

(x) *Meadow Podzolic Soils.*—In poorly drained slight depressions of the Post-Miocene Coastal Alluvia derived from non-calcareous rocks there are Meadow Podzolic soils. They are probably flooded for short periods each wet season.

0-3 in.	Grey sandy loam with rusty staining along root channels, light fine ferruginous concretions.
3-10 in.	Mottled yellow-grey, yellowish grey and yellow-brown light clay with light fine ferruginous concretions.
10-30 in.	Grey, with yellow-grey mottling, medium clay with light ferruginous concretions.
30 in. +	Grey to yellowish grey, with rusty mottling, clays or stratified sediments.

(xi) *Limestone Red Soils.*—These soils occur over small areas on gentle slopes on limestones of the Carpentaria complex in the northern part of the Dissected Country of the Gulf Fall. They are very similar to the Limestone Red soils of the Katherine-Darwin region.

0-3 in.	Brown sandy loam.
3-10 in.	Reddish brown sandy clay loam.
10-56 in.	Dark brownish red light clay, massive but porous.
56-72 in. +	Dark brownish red light clay with light ferruginous concretions.

(xii) *Leached Brown Levee Soils.*—These are relatively minor soils which occur on the levees of Gulf streams which rise in non-calcareous rocks.

0-4 in.	Grey-brown loamy fine sand.
4-12 in.	Brown loamy fine sand.
12-36 in. +	Reddish brown fine sandy loam to clay loam, massive but porous, firm to hard.

(xiii) *Alluvial Red-brown Earths of the Gulf Fall.*—The small areas of these red-brown earths occur on better-drained low rises of the calcareous Post-Miocene Coastal Alluvia in association with large areas of Heavy Grey Pedocals.

0-5 in.	Dull brown fine sandy loam.
5-30 in.	Dark red-brown medium heavy clay.
30-45 in. +	Reddish brown medium heavy clay with moderate carbonate concretions.

(xiv) *Alluvial Red-brown Earths of the Georgina Basin.*—These are also formed on low rises or old levee formations associated with Heavy Grey-brown Pedocals but the parent materials of this soil unit are the Post-Miocene Fine-textured Alluvia of the Georgina Basin.

0-6 in.	Greyish brown loam with some fine waterworn gravel.
6-36 in.	Dark red-brown medium clay.
36-48 in. +	Brown sandy clay with light carbonate concretions.

(xv) *Granitic Desert Loams.*—The granites and gneisses, which occur only in the south-eastern portion of the region, generally have boulder outcrops or shallow gritty soils, but on gentle slopes there are some small areas of these Desert Loam soils.

0-6 in.	Brown gritty sandy loam.
6-16 in.	Dark brown gritty clay loam to light clay.
16-36 in.	Dark brown gritty clay loam to light clay with some fragments of decomposing rock.
36-45 in. max.	Grey-brown, brown, yellow-brown very gritty sandy clay with moderate carbonate concretions and much decomposing rock.

(xvi) *Heavy Grey Pedocals.*—Much of the "black-soil" plains of the Barkly Tableland and Georgina River valley belongs to this unit. The soils occur on gently undulating to nearly flat topography on a variety of fine-textured calcareous parent materials. These include the extensive Tertiary Swamp, limestones and other rocks of the Barkly Group, Tertiary Lake Limestones, extensive nearly flat areas of calcareous fine-textured alluvia of the Gulf and Georgina Divisions, basic Helen Springs volcanics, and some small areas on basic metamorphics (greenstones) of the Carpentaria complex.

A typical profile is:

0-2 in.	Grey heavy clay, self-mulching, cracked when dry.
2-5 in.	Grey heavy clay, lumpy, cracked.
5-36 in.	Grey heavy clay, cracked, coarse columnar with gypsum and/or carbonate concretions.
36 in. +	Grey or mottled grey, brownish grey, olive grey, heavy clay with gypsum and/or carbonate concretions.

Major variants are:

(1) On the Tertiary Swamp the soils mostly have light chert gravel on the surface. Where gilgai forms occur they have very gravelly banks. There are also some very gravelly low rises without gilgais.

(2) Residual soils on limestones of the Barkly Group vary as above but there are no very gravelly rises.

(3) Residual soils on the Tertiary Lake Limestone generally have pebbles of silicified material scattered on the surface and gilgais are uncommon.

(4) Soils on calcareous fine-textured alluvia are generally not gravelly, but in the Georgina Division gilgai forms may have waterworn gravels on the rises.

(5) On Helen Springs volcanics some gilgai forms occur but the rises are not gravelly and the gilgais may be linear.

(xvii) *Heavy Brown Pedocals.*—These differ from the Heavy Grey Pedocals only in their grey-brown to dark brown colour. They are formed on similar parent materials and have similar variants but generally they occur in better-drained or lower-rainfall areas than the Heavy Grey Pedocals.

(xviii) *Northern Heavy Grey Pedocals.*—These differ from the Heavy Grey Pedocals in having poorer structure in the surface soil and fine manganiferous concretions throughout the profile. They occur in higher rainfall or more poorly-drained areas than the Heavy Grey Pedocals. They are similar to the Cununurra Clay of the lower Ord River valley and the Heavy-textured Grey Pedocals of the Katherine-Darwin region.

They are formed on some of the calcareous portions of the Post-Miocene Coastal Alluvia and on wetter portions of the Tertiary Swamp on flat or nearly flat topography.

0-1 in.	Olive-grey heavy clay, self-mulching.
2-5 in.	Olive-grey heavy clay lumpy with fine carbonate concretions and fine black manganiferous concretions.
5-36 in.	Olive-grey heavy clay, cracked, coarse columnar with carbonate and manganiferous concretions.
36 in. +	Olive-grey or mottled heavy clay, may have gypsum.

(xix) *Southern Heavy Grey Pedocals.*—The Tertiary Swamp areas of the low rainfall country to the south-west of Lake Nash have Southern Heavy Grey Pedocals. They have a lighter-textured surface and, instead of the gilgais and broad cracks of the other heavy pedocals, they have sinkholes up to 24 in. deep and 15 in. in diameter. They may be flooded for short irregular periods by the Sandover River, which effluents on to them, or by run-off from neighbouring higher country. The lighter-textured surface seems to be due to admixture with material eroded from neighbouring country. In the central parts of the larger flats the soils are intermediate between Heavy Grey Pedocals and the profile described below.

0-2 in.	Yellowish grey clay loam, very weakly laminated.
2-15 in.	Yellowish grey light medium clay with light fine carbonate concretions, nutty to blocky.
15-48 in.	Yellowish grey medium heavy clay with light fine carbonate concretions, cracked, fine columnar.
48 in. +	Mottled heavy clay, may have gypsum and amorphous carbonate.

(xx) *Kilgour Heavy Grey Pedocals.*—These soils are formed on shales of the Mullaman Group on undulating topography. They are darker in colour than the Heavy Grey Pedocals and are gypseous but not calcareous.

0-1 in.	Dark grey heavy clay, self-mulching.
1-6 in.	Dark grey heavy clay, lumpy with cracks.
8-30 in.	Dark grey heavy clay, cracked into large blocks, with light gypsum.

30-40 in.	Transition zone.
40 in. +	Grey or light grey heavy clay with yellow-grey or yellow-brown mottling, light gypsum, gradually merging into soft decomposing shales.

(xxi) *Distributary Heavy Grey Pedocals.*—The Recent Fine-textured Alluvia of the "Downs" distributary systems, which occur in the lowest parts of the local topography, have Distributary Heavy Grey Pedocal soils. They are seasonally flooded for irregular periods, being the foci of internal drainage basins. They have an irregular surface with a fine network of low narrow rises and shallow depressions, but the soils on both rises and hollows are similar.

0-8 in.	Grey to light grey heavy clay with light carbonate concretions, very friable, cracked.
8-15 in.	Grey heavy clay, light carbonate concretions, lumpy.
15-60 in. +	Grey heavy clay with carbonate concretions, cracked into large columns.

(xxii) *Drylake Heavy Grey Pedocals.*—These drybog soils occur only on the Tertiary Lake Alluvia and, although they occupy low parts of the topography of the Barkly Basin, they are no longer flooded owing to the low run-off from the surrounding country under the present-day low rainfall. They are similar to the Distributary Grey Pedocals, but are extremely friable or ashy, crack to over 6 ft. deep, and have an irregular sinkholey surface.

(xxiii) *Limestone Calcareous Desert Soils.*—These soils are formed on calcareous sediments of the Barkly Group and the Carpentaria complex and on the Tertiary Lake Limestones. They occur in portions of all three divisions on gently undulating to low hilly topography. The general profile colour may vary from brown to grey, and the texture from sandy loam to clay loam.

0-2 in.	Dull brown fine sandy loam, laminated.
2-7 in.	Dull brown fine sandy loam, well-developed soft crumb structure.
7-15 in.	Dull brown fine sandy loam with lime concretions and fragments of limestone.
15-25 in. max.	Yellow-brown fine sandy loam with many rock fragments, some concretions, overlying limestone on calcareous shale.

(xxiv) *Igneous Calcareous Desert Soils.*—In the vicinity of Helen Springs Homestead basic volcanic rocks with undulating topography have Igneous Calcareous Desert soils. The volcanics have been exposed by local dissection of the Tertiary lateritic formations.

0-1 in.	Grey-brown sandy clay loam, laminated.
1-6 in.	Grey-brown sandy clay loam with light lime concretions, soft nutty structure.
6-15 in.	Very light grey-brown heavy sandy loam with much lime, fragments of decomposing volcanics.
15 in. max.	On rock.

(xxv) *Calcareous Lateritic Soils.*—The post-Tertiary deposition of aeolian limestone on Tertiary lateritic soils has produced these soils. Subsequent leaching has redistributed some of the lime and the present distribution of the lime ranges from the surface to the mottled zone. A typical intermediate profile is:

0-4 in.	Dull brown loamy sand with organic matter.
4-18 in.	Brown loamy sand, powdery, with light carbonate concretions, light ferruginous concretions.
18-33 in.	Very heavy carbonate layer, almost travertine, with some ferruginous gravel.
33 in. +	Upper mottled zone material with some carbonate concretions.

(xxvi) *"Bundella" Soils.*—These soils are formed on the Post-Miocene Coarse-textured Alluvia of the Georgina Basin. The alluvia are derived from the granites and gneisses and the mixed rocks of the Carpentaria complex. They have been weakly resorted by wind into very poorly-defined dunes with an undulating topography. The highest rises have deep sand soils and the lower slopes have a loam overlying clay. The following is a profile of intermediate texture from a middle slope.

0-8 in.	Brown sandy loam.
8-16 in.	Reddish brown sandy clay loam.
16-36 in.	Red-brown with slight yellow-grey mottling sandy clay.
36-60 in. +	Yellow-grey with yellow-brown, red-brown mottling, very compact sandy clay.

(xxvii) *Red-brown Desert Alluvial Soils.*—These red-brown soils are formed on local alluvia largely derived from dissection of the lateritic horizons. The texture is variable, depending on the nature of parent material. Heavier-textured soils are derived from the dissection of Lateritic Red Earths.

0-2 in.	Grey-brown loam, may be laminated.
2-8 in.	Dull brown sandy clay loam.
8-36 in. +	Reddish brown light clay may have slight yellow-grey mottling.

Lighter-textured soils are formed on material eroded from Lateritic Red Sand and underlying sandstones.

0-8 in.	Grey-brown loamy fine sand.
8-16 in.	Orange-brown clayey fine sand.
16-66 in. +	Bright orange-brown fine sandy loam.

(xxviii) *Sandy Distributary Complex.*—These soils are restricted to the Recent Coarse-textured Alluvia of the "Desert" distributary systems. The topography is irregular and includes a network of narrow rises and depressions which may extend into large flats with definite stream channels. Flooding is of relatively short duration but the flats are lower and flooded for longer periods than the depression-rise complex.

(1) *Rise Soils*

0-6 in.	Grey-brown sand.
6-36 in.	Yellow-brown sand.
36-48 in. +	Yellow-brown clayey sand.

(2) *Depression Soils*

0-4 in.	Brownish grey sandy loam.
4-12 in.	Grey-brown sandy clay loam.
12-36 in. +	Brown light sandy clay.

(3) *Flat Soils*

0-6 in.	Light grey-brown fine sandy loam.
6-15 in.	Light greyish brown fine sandy loam.
15-24 in.	Light greyish brown with rusty brown mottling sandy clay loam.
24-48 in. +	Light yellowish grey with rusty brown mottling fine sandy clay, compact.

(xxix) *Podzolized Desert Alluvial Soils.*—These are also formed on local alluvia derived largely from the erosion of upper lateritic horizons, but they occur in higher rainfall or in more poorly-drained areas than the Red-brown Desert Alluvial soils.

0-4 in.	Off-grey sandy loam.
4-8 in.	Yellow-grey with slight yellow-brown mottling sandy clay loam with light ferruginous gravel.
8-26 in. +	Greyish yellow with rusty brown mottling sandy clay with light ferruginous gravel.

(xxx) *Coastal Sand Dune Soils.*—Along the Gulf of Carpentaria coastline there are scattered sand dunes which have yellow-brown deep sandy soils. Only the fore dunes are not fixed by vegetation but all the soils are immature.

0-8 in.	Yellowish grey sand.
8-48 in. +	Yellow-grey to yellow-brown sand, may have some shells.

(xxxi) *Salt Marsh Soils.*—The portions of Post-Miocene Coastal Alluvia that are still liable to tidal inundation have Salt Marsh soils which generally have little or no vegetation.

0-½ in.	Salt and clay.
½-5 in.	Off-grey medium heavy clay with yellow-grey mottling, moist.
5-30 in. +	Light grey clay loam with red and yellow-red mottling, saturated.

(xxxii) *Solonetzic Soils.*—On neighbouring country that is slightly higher than the salt marsh the soils are solonetzic. These appear to be liable to flooding only by tidal waters diluted by stream flood flow.

0-2 in.	Light grey fine sandy loam.
2-16 in.	Yellow-grey light clay, hard lumpy, slight rusty brown mottling.
16-30 in.	Light yellow-grey clay, moist mellow, slight rusty brown mottling.
30-48 in. +	Light yellow-grey clayey sand with slight rusty brown mottling, wet.

IV. Agricultural Characteristics of the Soils

At present there is no agriculture in the region, and all pastoral development is based on the utilization of native pastures. There are two general soil characteristics of major importance:

(1) From chemical analysis of samples taken throughout the regions it appears that all the soils are low in phosphates and phosphatic fertilizers would be required for all agricultural crops and for many exotic pasture species.

(2) A very large proportion of the soils in the higher rainfall areas is either very stony or of low fertility.

In Part II it has been indicated that except for specially favoured locations the probable inland climatic limit of any form of agriculture is approximately along the line joining O.T. Downs and Punjaub. Therefore, only the soils which occur within this section are discussed from the point of view of dryland agriculture. The following characteristics have been considered in assessing agriculture suitability: slope and liability to erosion, drainage and liability to flooding, nature of surface soil (including stoniness), nature of subsoil, water-holding capacity, assessment of degree of leaching and chemical fertility, nature of occurrence (large or small unit areas) and associated soils, and salinity. In general, the soils are not very satisfactory.

(i) *Tertiary Lateritic Podzolic Soils.*—There are relatively large areas of these soils on gentle slopes in the higher rainfall areas but the ferruginous zone is overlain by a leached sandy surface soil of very low fertility. The soils are considered unsuitable for agriculture.

(ii) *Tertiary Lateritic Flat Soils.*—These soils, which may be waterlogged for short periods, are of very low fertility. They occur as narrow bands within the previously described soil. They are unlikely to be utilized agriculturally as the surrounding soils are unsatisfactory.

(iii) *Shallow Yellow Podzolic Soils.*—The small areas of these soils are always associated with skeletal soils on hilly topography. In many places they are stony. They are highly leached and are of low agricultural potential.

(iv) *Deep Yellow Podzolic Soils.*—There are large areas of these soils on gently undulating topography in the higher rainfall section. They have a woodland or open forest vegetation but the soils are of low fertility and are "spewey" when wet.

(v) *Sandy Yellow Podzolic Soils.*—These deep, extremely leached, very light-textured soils occur in the higher rainfall sections, but they are heavily timbered and are of low fertility.

(vi) *Meadow Podzolic Soils.*—These poorly-drained soils, which are waterlogged in the wet season, occur as narrow bands through the two previous soils. They are heavily timbered and of low fertility.

(vii) *Limestone Red Soils.*—These are similar to the soils at Katherine on which dryland agricultural experiments are being conducted. In this region they occur as small scattered areas within skeletal soils, and could not be readily developed for agriculture because of their isolation.

(viii) *Leached Brown Levee Soils.*—The narrow bands of these soils along major Gulf rivers are suitable for agriculture but because of their small areas separated by inferior soils they are not likely to be developed under dryland conditions.

(ix) *Alluvial Red-brown Earths of the Gulf Fall.*—These soils, which appear suitable for agriculture, occur only as very small areas within heavy pedocal soils and their development would be feasible only if the heavy soils were also developed.

(x) *Northern Heavy Grey Pedocals.*—The Cununurra clay of the Kimberley Research Station, Western Australia, is similar to these heavy clay soils. They occur on very gentle slopes, their fertility is moderate, and they have little or no timber. There are some large areas near Burketown in the higher rainfall country which may be suitable for agricultural development. These soils are very susceptible to erosion by gullying.

(xi) *Coastal Sand Dune Soils.*—These scattered patches of deep sandy soils are not satisfactory for agriculture.

(xii) *Salt Marsh Soils.*—The high salt content and liability to flooding prevent any agricultural development of these soils.

(xiii) *Solonetzic Soils.*—The irregular areas, liability to flooding, and tough impermeable clay subsoil make these soils unsuitable for agriculture.

There are only two soils which need to be considered in relation to irrigation possibilities. The Leached Brown Levee soils, which occur in narrow bands along some of the Gulf rivers, are light-textured soils which would be suitable for irrigation. The Heavy Grey Pedocals of the Gregory Land System and the Northern Heavy Grey Pedocals of the Balbirini Land System are agriculturally similar to the Cununurra Clay of the Kimberley Research Station, where irrigation experiments are in progress to determine the possibilities of using such soils under irrigation.

PART VII. VEGETATION OF THE BARKLY REGION

By R. A. PERRY* and C. S. CHRISTIAN*

I. INTRODUCTION

The Barkly region includes a wide variety of climatic and edaphic conditions and the vegetation is correspondingly complex. The long dry season which is a feature of the monsoon climate of this part of Australia has a dominating effect on the selection of the type of plant communities and formations, e.g. there are no rain forests for these cannot withstand the long winter drought although the summers are probably warm enough and wet enough to support them. Many of the dominant trees, including a proportion of the eucalypts, are dry-season deciduous and are thus better able to withstand the long, dry winter.

Edaphic factors are important in determining the distribution of the plant communities, e.g. on the Barkly Tableland, which is mainly an area of Heavy Grey Pedocal soils, the most extensive community is the *Astrebla pectinata* association, a Grassland 2-3 ft. high. However, the intermixed areas of various lighter-textured soils which also occur on the Tableland carry Woodland or Shrub Woodland communities.

The most important factor influencing the distribution of plant communities is the supply of water. This is a complex of factors which includes topography (as it affects drainage), internal drainage and permeability of the soils, water-holding capacity and wilting point of the soils, and amount of water received, including rainfall and water contributed by run-off from other areas. To some extent these factors which influence water supply act as compensating factors. The distribution of the *Eucalyptus brevifolia* association can be used as an example of the effect of water supply on the distribution of a community. The *E. brevifolia* association is widely spread throughout the southern, lower-rainfall parts of the region, where it occurs on hills and slopes but extends across flats which are less well drained. However, in the more northern parts of its area of distribution, where the rainfall is higher, it is restricted to the steeper, well-drained parts of the topography. There are many other communities with a distribution determined by the compensating effect of two or more of these factors which affect water supply.

Forty communities (associations and alliances) have been recognized and described and in addition there are 11 communities which occur in small miscellaneous habitats. In Figure 8 these communities are plotted on a graph using rainfall and drainage as the coordinates. Preferably each

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community should be represented by an area, but if this were done the figure would become too complicated, as many of the areas overlap. For

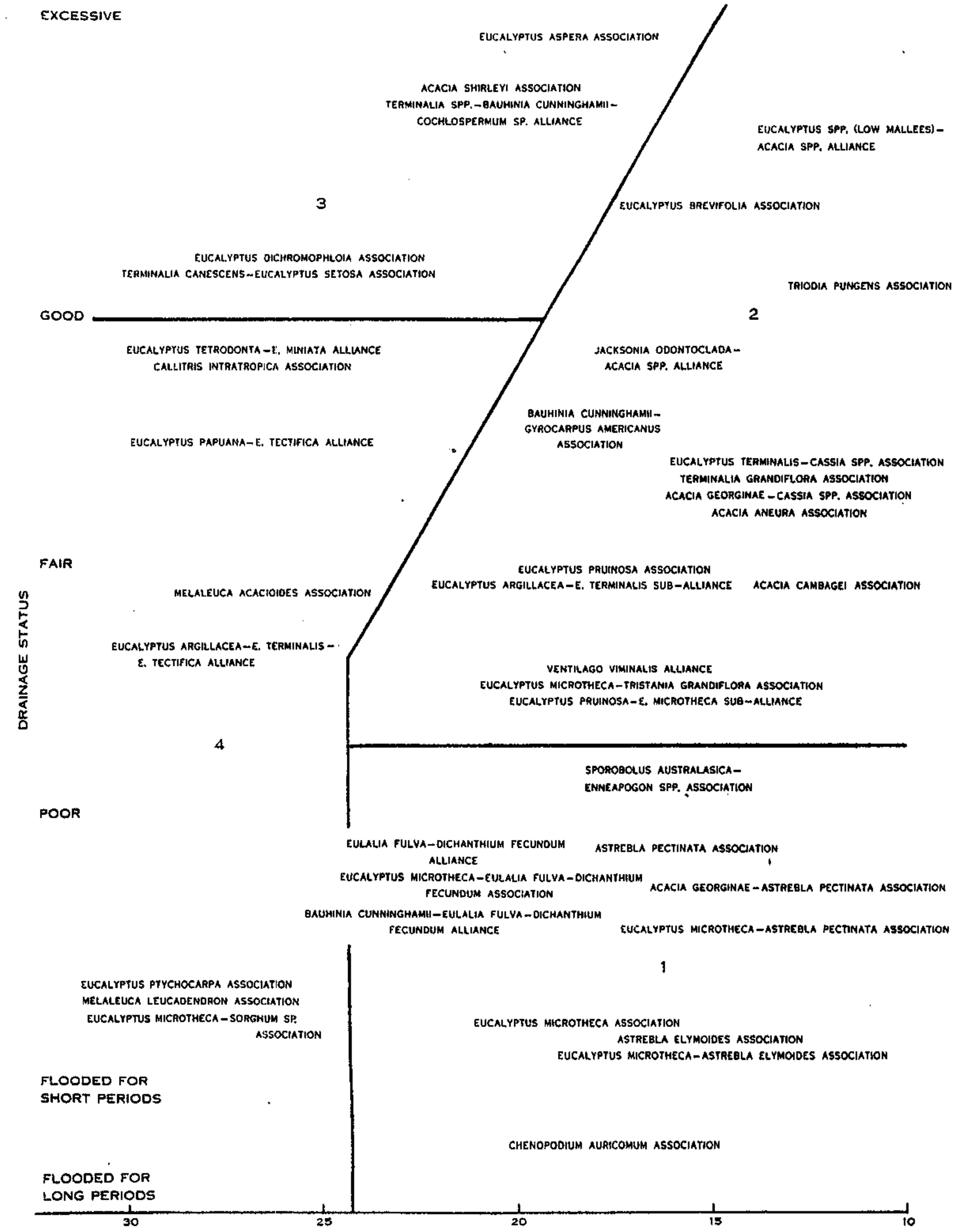

Fig. 8.—Vegetation communities of the Barkly region, grouped according to the average annual rainfall and drainage status of their habitats.

simplicity, each community is represented by approximately the middle point of the area over which it occurs on Figure 8.

For convenience in describing and discussing the communities they have been divided into four groups. The lines separating these groups are superimposed on Figure 8. The four groups are:

(1) Communities on poorly-drained areas (heavy clay soils) under low to medium rainfall. With the exception of the *Chenopodium auricomum* association, which is a Shrubland, the communities in this group are Woodlands with a well-developed grass understorey, or Grasslands. The grass understoreys of the Woodlands are similar in floristics and structure to the Grasslands.

(2) Communities on fairly- to excessively-drained areas (not heavy clay soils) mainly under low rainfall. Most of the communities in this group are Woodlands or Shrub Woodlands but the *Triodia pungens* association is a Shrub Grassland, the *Eucalyptus* spp. (low mallees)—*Acacia* spp. alliance a Shrubland, and the *Jacksonia odontoclada* — *Acacia* spp. alliance a Scrub. The Woodlands do not have a grass understorey similar to the Grasslands of group 1.

(3) Communities on well- to excessively-drained areas (not heavy clay soils) under medium to high rainfall. With the exception of the *Acacia shirleyi* association, which is a Forest, these are all Woodlands or Shrub Woodlands.

(4) Communities of high-rainfall areas other than those with excessive drainage. These are all Woodlands, Open Forests, or Forests.

In addition to these four groups there are 11 unclassified communities which occur in miscellaneous habitats such as along watercourses, on sand dunes, and in lagoons and swamps.

In the following pages there is a brief description of each of the communities within these groups. In each case the land systems in which the communities occur are noted in parentheses immediately after the community name. Small areas of a community may be found in other land systems as mapped but only because the area is too small to be mapped as the correct land system.

In the community descriptions rainfall has been described as high, medium, or low. The average annual rainfall corresponding to these classes is approximately:

High	25-30 in.,
Medium	20-25 in.,
Low	10-20 in.

The use of formulae in Tables 9-12 is described by Christian and Perry (1953).* As used in the tables in this paper the height figures are given in feet.

* Christian, C. S., and Perry, R. A. (1953).—The systematic description of plant communities by the use of symbols. *J. Ecol.* 41: 100-105.

TABLE 9

COMMUNITIES ON POORLY-DRAINED AREAS (HEAVY CLAY SOILS) UNDER LOW- TO MEDIUM-RAINFALL CONDITIONS

Alliance	Association	Structural Type and Formula	Locality	Mean Annual Rainfall (in.)	Topography	Soils
Higher order relationships not established	*Astrebla pectinata*	Grassland $C_2^3y\ C_1^1y\text{-}x$	Barkly Tableland and along Georgina River	12-25	Nearly flat to gently undulating	Heavy Grey Pedocals or Heavy Brown Pedocals
Higher order relationships not established	*Astrebla elymoides*	Grassland $C_2^3y\ C_1^1y\text{-}x$	Barkly Tableland and along Georgina River	12-25	Shallow depressions and drainage lines in nearly flat to gently undulating country	Heavy Grey Pedocals or Heavy Brown Pedocals
Eulalia fulva-Dichanthium fecundum	Not defined	Grassland $C_2^4y\text{-}x\ C_1^2y\text{-}x$	North of Barkly Tableland	20-30	Nearly flat to gently undulating	Northern Heavy Grey Pedocals
Eucalyptus microtheca (see also Table 12)	*Eucalyptus microtheca-Astrebla pectinata*	Woodland $A_2^{20}z\ C_2^3y\ C_1^1y$	Barkly Tableland and along Georgina River	12-25	Nearly flat to gently undulating	Heavy Grey Pedocals or Heavy Brown Pedocals
	Eucalyptus microtheca-Astrebla elymoides	Woodland $A_2^{20}z\ C_2^3y\ C_1^1y\text{-}x$	Barkly Tableland and along Georgina River	12-25	Shallow depressions and drainage lines in nearly flat to gently undulating country	Heavy Grey Pedocals or Heavy Brown Pedocals
	Eucalyptus microtheca-Eulalia fulva-Dichanthium fecundum	Woodland $A_2^{20}z\ C_2^4y\text{-}x\ C_1^2y\text{-}x$	North of Barkly Tableland	20-30	Nearly flat to gently undulating	Northern Heavy Grey Pedocals
	Eucalyptus microtheca	Shrub Woodland $A_1^{15}z\ B_2^3z\ C_2^3z\ C_1^1z$	Barkly Tableland	Approx. 20	Nearly flat—lowest parts of Barkly internal drainage basin	Drylake Heavy Grey Pedocals

TABLE 9 (*Continued*)

Alliance	Association	Structural Type and Formula	Locality	Mean Annual Rainfall (in.)	Topography	Soils
Higher order relationships not established	*Acacia georginae-Astrebla pectinata*	Woodland $A_1^{15}z\text{-}y\ C_2^{3}y\ C_1^{1}y$	Near Georgina River	12-20	Nearly flat to gently undulating	Heavy Grey Pedocals or Heavy Brown Pedocals
Bauhinia cunninghamii-Eulalia fulva-Dichanthium fecundum	Not defined	Woodland $A_2^{20}z\ C_2^{4}y\text{-}x\ C_1^{2}y\text{-}x$	North of Barkly Tableland	23-30	Nearly flat to gently undulating	Northern Heavy Grey Pedocals
Higher order relationships not established	*Chenopodium auricomum*	Shrubland $B_2^{3}y\ C_2^{3}z\ C_1^{1}z\text{-}x$	Barkly Tableland and along Georgina River	12-25	Nearly flat—flooded for several months each year	Distributary Heavy Grey Pedocals
Higher order relationships not established	*Sporobolus australasicus-Enneapogon* spp.	Grassland $C_1^{\frac{1}{2}}y$ + (gilgai)z	Barkly Tableland and along Georgina River	12-25	Very low gravelly rises	Gravelly or stony Heavy Grey Pedocals
An intensified group of communities referred to as gilgai communities		Grassland $C_2^{3}y\ C_1^{1}y\text{-}x$	Widely distributed throughout region	12-30	Gilgai depressions	Heavy Pedocals

COMMUNITIES ON FAIRLY- TO EXCESSIVELY-DRAINED AREAS (NOT HEAVY CLAY SOILS) MAINLY UNDER LOW RAINFALL

Alliance	Association	Structural Type and Formula	Locality	Mean Annual Rainfall (in.)	Topography	Soils
Eucalyptus pruinosa-E. microtheca	*Eucalyptus pruinosa-E. microtheca* sub-alliance	Shrub Woodland $A_2^{20}z\ A_1^{10}zz\ B_2^{4}zz\ C_2^{5}y\text{-}x + (C_1^{1}y)z + (\text{gilgai})y$	Near Creswell Downs Homestead	Approx. 20	Nearly flat to gently sloping	Northern Heavy Grey Pedocals or transitions to Tertiary Lateritic Flat soils
	Eucalyptus pruinosa	Shrub Woodland $A_2^{20}z\ A_1^{10}zz\ B_2^{4}z\ C_2^{3}y\ C_1^{1}y$	Southern half of region	10-25	Lower slopes and valley bottoms	Red-brown Desert Alluvial soils, and some deeper, less well-drained lateritic soils
	Eucalyptus microtheca-Tristania grandiflora	Woodland $A_1^{15}z\ C_2^{3}y\ C_1^{1}y$	Near Elliott	20-25	Low flat areas near "black-soil" plains	Sandy Tertiary Lateritic Flat soils
Higher order relationships not established	*Eucalyptus brevifolia*	Woodland or Shrub Woodland $A_2^{20}z\ B_2^{5}z\text{-}y\ C_2^{3}y\ C_1^{1}z$	Extensive in all except highest rainfall parts	10-30	Gentle to steep slopes	Lateritic soils or skeletal soils on "acid" rocks
Eucalyptus argillacea-E. terminalis	*Eucalyptus argillacea-E. terminalis* sub-alliance	Woodland $A_2^{25}z\ A_1^{10}zz\ C_2^{3}y\text{-}x\ C_1^{1}z$ or Shrub Woodland $A_2^{20}z\ B_2^{4}z\text{-}y\ C_1^{1}y\text{-}x$	Widespread—Woodland in north, Shrub Woodland in south	10-30	Variable	Red-brown Desert Alluvial soils and Granitic Desert Loams in south, deep yellow podzolic soils, Podzolic Truncated Lateritic soils and skeletal soils on limestones in north
	Eucalyptus terminalis-Cassia spp.	Shrub Woodland $A_2^{20}z\ A_1^{10}zz\ B_2^{3}z\ C_1^{1}z\text{-}y + (\text{gilgai})z$	South-eastern part of region	10-20	Gentle slopes, undulating or low rises	Limestone Calcareous Desert soils and skeletal soils on limestone

TABLE 10 (*Continued*)

Alliance	Association	Structural Type and Formula	Locality	Mean Annual Rainfall (in.)	Topography	Soils
Higher order relationships not established	*Terminalia grandiflora*	Woodland $A_2{}^{20}z\text{-}zz\ C_1{}^1y$	Near Helen Springs Homestead	10-20	Undulating	Igneous Calcareous Desert soils
Higher order relationships not established	*Acacia aneura*	Woodland $A_1{}^{15}z\ B_2{}^5z\ B_1{}^1zz\ C_2{}^2z\ C_1{}^1z$	Southern edge of region	10-15	Low hills and gentle slopes	Weakly truncated Tertiary Non-lateritic soils and Red-brown Desert Alluvial soils
Higher order relationships not established	*Acacia cambagei*	Shrub Woodland $A_1{}^{15}z\ B_2{}^4z\ C_2{}^3zz\ C_1{}^1y$	South-eastern part of region (near Georgina River)	10-20	Gentle slopes and low rises	Alluvial Red-brown Earth soils
Higher order relationships not established	*Acacia georginae*-*Cassia* spp.	Shrub Woodland $A_2{}^{15}z\ A_1{}^{10}zz\ B_2{}^3z\ C_1{}^1z\text{-}y$ + (gilgai)z	South-eastern part of region (near Georgina River)	10-20	Gentle slopes and low rises	Limestone Calcareous Desert soils or Red-brown Desert Alluvial soils
Ventilago viminalis	Not defined	Shrub Woodland $A_2{}^{20}z\ A_1{}^{15}z\ B_2{}^4z\text{-}y\ C_1{}^1y\ (C_3{}^3y)z$	Southern half of region in vicinity of Barkly Tableland	10-25	Nearly flat to gently undulating fringe to "black-soil" plains	Variable transition soils
Higher order relationships not established	*Bauhinia cunninghamii*-*Gyrocarpus americanus*	Woodland $A_2{}^{20}z\ C_2{}^3y\text{-}z\ C_1{}^1y\text{-}z$	Near Elliott	20-25	Gently undulating	Tertiary Lateritic Red Sands
Higher order relationships not established	*Triodia pungens*	Shrub Grassland $A_1{}^6zz\ B_1{}^6zz\ C_2{}^3y\ C_1{}^1zz$	South-eastern part of region	10-15	Nearly flat plains and very gentle slopes	Tertiary Non-lateritic soils
Eucalyptus spp. (low mallees)-*Acacia* spp.	Not defined	Shrubland $B_2{}^6y\ C_2{}^3y\ C_1{}^1zz$	Southern part of region	10-20	Low stony rises and fairly steep slopes	Gravelly lateritic or skeletal soils on "acid" rocks
Jacksonia odontoclada-*Acacia* spp.	Not defined	Scrub $B_2{}^6x\ B_1{}^2zz\ C_2{}^3z\ C_1{}^1z + (A_1{}^{15}zz)$	Southern half of region	15-25	Nearly flat to gently undulating	Deep sandy soils

TABLE 11

COMMUNITIES ON WELL- TO EXCESSIVELY-DRAINED AREAS (NOT HEAVY CLAY SOILS) UNDER MEDIUM TO HIGH RAINFALL

Alliance	Association	Structural Type and Formula	Locality	Mean Annual Rainfall (in.)	Topography	Soils
Higher order relationships not established	*Eucalyptus dichromophloia*	Woodland or Shrub Woodland $A_2{}^{25}z$ $A_1{}^{10}zz$ $B_2{}^{6}z\text{-}y$ $C_2{}^{3}y$ $C_1{}^{1}z$	Northern half of region	20-35	Gentle slopes to steep rocky slopes	Skeletal on acid rocks and Tertiary Lateritic soils
Higher order relationships not established	*Eucalyptus aspera*	Shrub Woodland $A_1{}^{15}zz$ $B_2{}^{4}z$ $C_2{}^{3}zz$ $C_1{}^{1}zz$	Northern half of region	25-30	Steep rocky areas	Rock outcrop areas ("acid" rocks)
Terminalia spp.-*Bauhinia cunninghamii*-*Cochlospermum* sp.	Not defined	Shrub Woodland $A_1{}^{15}z$ $B_2{}^{4}z$ $C_2{}^{3}z\text{-}x$ $C_1{}^{1}z\text{-}y$	Northern half of region	20-30	Generally steep slopes	Rock outcrops (limestone) and skeletal on limestones
Higher order relationships not established	*Terminalia canescens*-*Eucalyptus setosa*	Shrub Woodland $A_1{}^{15}z$ $B_2{}^{6}z$ $C_2{}^{3}y\text{-}z$ $C_1{}^{1}z$	North of Lawn Hill Homestead	25	Gentle slopes and breakaways	Skeletal
Higher order relationships not established	*Acacia shirleyi*	Forest $A_2{}^{30}x$ $C_2{}^{3}zz$ $C_1{}^{1}zz$	Northern half of region	20-30	Steep slopes and breakaways (except in Beetaloo Land System where it occurs on gently sloping to almost flat country)	Skeletal (except in Beetaloo Land System where it occurs on Tertiary Lateritic soils)

TABLE 12

COMMUNITIES OF HIGH-RAINFALL AREAS OTHER THAN THOSE WITH EXCESSIVE DRAINAGE

Alliance	Association	Structural Type and Formula	Locality	Mean Annual Rainfall (in.)	Topography	Soils
Eucalyptus tetrodonta-E. miniata	Not defined	Shrub Open Forest or Shrubland Open Forest $A_3^{35}y$ $A_2^{25}z$ $A_1^{15}z\text{-}y$ $B_2^{5}z\text{-}y$ $B_1^{2}z$ $C_2^{3}z$ $C_1^{1}z$	Northern parts of region	Approx. 30	Gently sloping	Sandy soils (mostly lateritic podzols)
Higher order relationships not established	*Callitris intratropica*	Forest or Shrub Forest $A_3^{40}y$ $A_1^{10}z\text{-}y$ $B_2^{5}z$ $B_1^{2}zz$ $C_2^{3}z$ $C_1^{1}y$	Northern parts of region	Approx. 30	Gently sloping to sloping	Sandy soils (mostly lateritic podzols) and some skeletal soils
Eucalyptus papuana-E. tectifica	Not defined	Woodland $A_3^{40}z$ $A_2^{30}z$ $A_1^{15}z$ $C_2^{4}y\text{-}x$ $C_1^{1}z$	Near Gulf of Carpentaria	Approx. 30	Levees of major rivers	Levee soils
Eucalyptus argillacea-E. terminalis-E. tectifica	Not defined	Woodland $A_2^{25-50}z$ $A_1^{15}z$ $C_2^{4}y\text{-}x$ $C_1^{1}z$	Near Gulf of Carpentaria	25-30	Nearly flat	Alluvial Yellow Podzolic soils—some Tertiary Lateritic Flat soils
Higher order relationships not established	*Melaleuca acacioides*	Woodland $A_1^{15}z$ $C_2^{3}z$ $C_1^{1}y$	Northern half of region	25-30	Gentle slopes, flats between hills	Shallow Yellow Podzolic soils
Higher order relationships not established	*Melaleuca leucadendron*	Open Forest $A_2^{20}y$ $C_2^{3}z$ $C_1^{1}y\text{-}x$	Near Gulf of Carpentaria	25-30	Depression areas	Tertiary Lateritic Flat soils
Eucalyptus microtheca (see also Table 9)	*Eucalyptus microtheca-Sorghum* sp.	Woodland $A_2^{30}z$ $A_1^{15}z$ $C_3^{6}y$ $C_2^{3}y$ $C_1^{1}z$	Near Gulf of Carpentaria	Approx. 30	Nearly flat areas	Heavier Alluvial Yellow Podzolic soils
Higher order relationships not established	*Eucalyptus ptychocarpa*	Shrub Open Forest $A_3^{50}y$ $A_1^{20}y$ $B_2^{6}z$ $C_3^{5}zz$ $C_2^{3}y$ $C_1^{1}y$	Northern part of region	25-30	Seepage areas or areas with extra run-off from nearby areas	Various—mostly sandy

The status of the communities described is not always the same, for example, some communities are associations but others are alliances or sub-alliances. Where alliances have been described without their constituent associations it has not been practicable to define the associations.

Common names are placed in parentheses following the botanical names. The names used throughout this paper are those commonly used in northern Australia and may not conform to "Standardized Plant Names".* This practice has been adopted because many common names are so firmly established in northern Australia that the use of some "standardized" plant names, chosen from usage elsewhere, would only lead to confusion within the region. For instance, the widespread bluebush, *Chenopodium auricomum,* confined almost entirely to the northern half of Australia, is listed in "Standardized Plant Names" as golden goosefoot, a name which has never been heard by the authors in the field in northern Australia although it is the accepted standardized plant name in other parts of the continent.

The nomenclature of the eucalypts used in this report follows that of Blake (1953).† Nomenclature for other genera, excepting the grasses, follows that of Ewart and Davies,‡ and that of the grasses is according to current revisions.

II. Description of the Major Plant Communities

(a) *Communities on Poorly-drained Areas (Heavy Clay Soils) under Low to Medium Rainfall*

The 12 communities in this group are listed in Table 9. This group is best developed on the nearly flat to gently undulating plains of the Barkly Tableland and extends down the Georgina River. These communities are economically the most important of the region as they provide the best pastures.

Associations of this group are mainly Grasslands or Woodlands which have a well-developed grass understorey structurally and floristically similar to the Grasslands. Thus the *Eucalyptus microtheca — Astrebla pectinata* association can be considered as the *Astrebla pectinata* association plus scattered trees of *E. microtheca.* The *Acacia georginae — Astrebla pectinata,* the *Eucalyptus microtheca — Astrebla elymoides,* and the *Eucalyptus microtheca — Eulalia fulva — Dichanthium fecundum* communities are formed in a similar way.

* Coun. Sci. Industr. Res. Aust. Bull. No. 156 (1942).

† Blake, S. T. (1953).—Botanical contributions of the Northern Australia Regional Survey. I. Studies of northern Australian species of *Eucalyptus. Aust. J. Bot.* 1 (2): 185-352.

‡ Ewart, A. J., and Davies, O. B. (1917).—"The Flora of the Northern Territory". (McCarron, Bird and Co.: Melbourne.)

The *Chenopodium auricomum* association is a Shrubland growing on heavy clay soils which are flooded for several months each year. These areas occur where the streams flowing into the Barkly internal drainage basin flood out and lose themselves. These streams do not reach the lowest part of the Barkly internal drainage basin under present rainfall conditions. It is on the lowest parts, which constitute the Drylake Land System, that the *Eucalyptus microtheca* association grows.

The *Sporobolus australasicus* — *Enneapogon* spp. association is a sparse short Grassland occupying only small areas in comparison with the other communities of this group. It occurs only on small, very low rises, with gravelly or stony heavy clay soils. Although the rises are very low the habitat is probably much drier than the surrounding plains because of run-off.

The gilgai communities are Grasslands. Each gilgai depression occupies only a small area, but they are present in so many parts of the region that the community is worthy of separate description.

(i) Astrebla pectinata *Association.*—Barkly, Argadargada, Kallala, Moonah, Helen Springs, Georgina, Austral, Wonardo, Kilgour, Camilrock, Thorntonia, Tobermorey, and Gregory Land Systems. The association is a Grassland and is the commonest community on the heavy soil plains of the Barkly Tableland and extends down the plains of the Georgina River. It occurs only on the Heavy Grey and Brown Pedocal soils (heavy clays) and occupies most of the area on which these soils are developed.

The dominant, *Astrebla pectinata* (barley Mitchell grass), is a perennial tussock grass, the tussocks being 9-12 in. in diameter and 12-30 in. in height. The tussocks are generally 18-36 in. apart. Other tussock grasses which occur, but less frequently, are *Astrebla squarrosa* (bull Mitchell grass), *A. elymoides* (weeping Mitchell grass), *Aristida latifolia,* and *Chrysopogon fallax* (golden beard grass).

Additional grasses, which may grow to a height of about 30 in., are *Sorghum* sp., *Aristida inaequiglumis, Panicum decompositum, P. whitei,* and *Spathia nervosa.* These may occur quite commonly in restricted patches, especially in some seasons, but they are generally less important than the above-mentioned species. The spaces between the perennial tussocks are almost bare in adverse seasons, and are usually so at the end of the dry season. During and following a good wet season they are covered with a mid-dense layer of lower grasses and other herbaceous plants, 3-12 in. high. These are mostly annual species of which the most important and commonest are the *Iseilema* spp. (Flinders grasses) — *I. vaginiflorum, I. windersii, I. membranaceum, I. convexum, I. macratherum,* and *I. fragile* all occur. Other common associated grasses and herbs are *Brachyachne convergens* (native couch), *Sida spinosa, S. fibulifera, Malvastrum spicatum, Flaveria australasica, Polymeria* sp., *Boerhaavia diffusa* (tah-vine), and *Rhyncosia minima.* There are large numbers of less common grasses, legumes, and other herbaceous plants associated with the above.

The community is, in general, devoid of trees and shrubs, but there are patches where trees of *Eucalyptus microtheca* (coolibah) or shrubs such as *Acacia victoriae* or *Atalaya hemiglauca* (whitewood) occur very sparsely.

The *Astrebla pectinata* association is economically the most important community in the Barkly region as it provides good grazing during the wet season and fair grazing throughout the long dry season. Grazing has altered the community in some places, but in general the dominant withstands grazing very well, apart from a reduction in size and sometimes in density. Under conditions of concentrated grazing and trampling such as occur near stock-watering points and on stock routes the vegetation is reduced to annual species which give a cover for part of the year only. *Brachyachne convergens* and *Salsola kali* (roly poly) commonly occur in these heavily grazed areas.

(ii) Astrebla elymoides *Association.*—Barkly, Creswell, Wonardo, Austral, Kallala, Moonah, and Georgina Land Systems. The *Astrebla elymoides* association is very similar in structure to the *Astrebla pectinata* association but has a somewhat different appearance. The long leaves and flowering stalks of *Astrebla elymoides* curve over to form rounded hummocks in contrast to the upright nature of *A. pectinata.* The association occurs in slightly wetter habitats such as broad shallow depressions and shallow drainage lines on the Barkly Tableland and in the Georgina Basin. The associated tussock grasses are *Aristida latifolia, Astrebla squarrosa* (bull Mitchell grass), *Eriachne nervosa, Panicum whitei,* and *P. decompositum.*

The lower storey of annual grasses and other herbs is generally denser than in the *Astrebla pectinata* association, probably because of more favourable moisture conditions. The commonest of these plants are *Iseilema vaginiflorum* (red Flinders grass), *I. convexum, I. membranaceum* (small Flinders grass), *Cyperus retzii, Psoralea cinerea, Boerhaavia diffusa* (tah-vine), *Tribulus terrestris* (caltrop), *Chionachne hubbardiana, Alysicarpus rugosus, Alternanthera nodiflora* (common joy-weed), *Rhyncosia minima, Sporobolus mitchellii,* and *S. actinocladus.*

In some parts *Sesbania benthamiana* (sesbania pea, also known as pea bush), an annual plant which grows to 6 ft. high, grows densely in some seasons when these areas are referred to as pea-bush swamps. *Chenopodium auricomum* (bluebush), a shrub 2-3 ft. in height, occurs sparsely along some of the drainage lines, i.e. the wettest of the *Astrebla elymoides* association habitats. Scattered trees of *Eucalyptus microtheca* (coolibah) occur in some parts.

This community has a higher grazing value than the *Astrebla pectinata* association because of the better associated herbaceous plants. These remain green well into the dry period and at this time this community is grazed in preference to the *Astrebla pectinata* association. However, the area of the *Astrebla elymoides* association is small compared with that of the *Astrebla pectinata* association.

(iii) Eulalia fulva — Dichanthium fecundum *Alliance.*—Creswell, Kilgour, Balbirini, and Mitchiebo Land Systems. The *Eulalia fulva — Dichanthium fecundum* alliance is a Grassland. It is taller (3-5 ft.) and denser than the *Astrebla* associations and is dominated by a varying mixture of perennial tussock grasses of which *Eulalia fulva* (browntop) and *Dichanthium fecundum* (blue grass) are the commonest. Other tussock grasses which may be dominant or co-dominant are *Aristida latifolia, Astrebla squarrosa* (bull Mitchell grass), *Astrebla elymoides* (weeping Mitchell grass), *Chrysopogon fallax* (golden beard grass), *Dichanthium superciliatum* (tassel blue grass), *Sehima nervosum* (white grass), and *Bothriochloa* spp. (blue grass).

The community occurs only on the Northern Heavy Grey Pedocal soils (heavy clays), which occur in a higher rainfall area than the Heavy Grey and Brown Pedocals on which the *Astrebla pectinata* association is developed. Other plants which grow to approximately the same height as the dominants, but are less common, are an annual *Sorghum* sp., *Panicum decompositum, P. whitei, Astrebla pectinata* (barley Mitchell grass), *Themeda australis* (kangaroo grass), *Sesbania benthamiana* (sesbania pea), *Cassia sophera,* and *Trichodesma zeylanicum.*

The spaces between the tussocks of the dominant grasses are not as large and the ground layer is usually denser and taller (12-18 in.) than in the *Astrebla* communities. The commonest plants occurring are *Iseilema vaginiflorum* (red Flinders grass), *Moghania pauciflora, Boerhaavia diffusa* (tah-vine), *Cyperus retzii, Rhyncosia minima, Brachyachne convergens* (native couch grass), *Crotalaria crassipes* (rattle pod), *Pterigeron odorus* (stink weed), *Eragrostis japonica* (delicate love grass), *Gomphrena brownii, Wedelia asperrima, Flaveria australasica,* and *Alysicarpus rugosus.*

Trees and shrubs are generally absent but in restricted areas some of the following occur very sparsely: *Eucalyptus microtheca* (coolibah), *Bauhinia cunninghamii, Atalaya hemiglauca* (whitewood), *Acacia farnesiana, A. victoriae, Terminalia volucris* (rosewood), *Carissa lanceolata* (konkerberry), and *Capparis lasiantha.*

(iv) Eucalyptus microtheca — Astrebla pectinata *Association.*—This association occurs within the *Astrebla pectinata* association where extra water is available by run-off from nearby areas, or slightly to the north of the *Astrebla pectinata* association area where rainfall is slightly higher. The association is a Woodland with *E. microtheca* occurring as widely spaced trees growing to a height of 15-25 ft. Like the *Astrebla pectinata* association, it always occurs on Heavy Grey Pedocals or Heavy Brown Pedocals (heavy clay soils).

The grass storey is similar to the *Astrebla pectinata* association. Thus the *Eucalyptus microtheca* — *Astrebla pectinata* association can be regarded as the *Astrebla pectinata* association with *E. microtheca* as a sparse low tree layer.

(v) Eucalyptus microtheca — Astrebla elymoides *Association.*—Barkly, Creswell, Joanundah, and Austral Land Systems. This community can be regarded as the *Astrebla elymoides* (weeping Mitchell grass) association with a sparse low tree layer of *E. microtheca.* It is a Woodland and grows in similar habitats to the *Astrebla elymoides* association but more especially toward the northern edge of the latter community.

(vi) Eucalyptus microtheca—Eulalia fulva—Dichanthium fecundum *Association.*—Joanundah and Mitchiebo Land Systems. This community may be regarded as the *Eulalia fulva* — *Dichanthium fecundum* alliance with a low tree layer of *E. microtheca* (coolibah). It grows in similar habitats and under similar conditions to the *Eulalia fulva* — *Dichanthium fecundum* alliance but only in small patches.

(vii) Eucalyptus microtheca *Association.*—Characteristic of Drylake Land System, on which it is the only community. This community occurs on Drylake Heavy Grey Pedocals (heavy clay soils) in the lowest parts of the Barkly internal drainage basin. The country is nearly flat but slightly lower than the surrounding land systems and the surface is very rough.

E. microtheca (coolibah) occurs as widely spaced, straggly trees 10-20 ft. high. Scattered trees of *Acacia stenophylla* also occur. The ground flora is sparse. *Chenopodium auricomum* (bluebush), a shrub about 3 ft. high, occurs irregularly, particularly in hollows.

Mid-height grasses and other plants occur in small patches several yards across (mainly in the hollows with *C. auricomum*). They include *Eulalia fulva* (brown top), *Dichanthium fecundum* (blue grass), *Aristida latifolia, Panicum decompositum, P. whitei, Astrebla elymoides* (weeping Mitchell grass), *Chrysopogon fallax, Salsola kali* (roly poly), and *Hibiscus radiatus.* Smaller grasses and other herbs occur sparsely throughout the community. The rises tend to have only this lower vegetation layer. Commonest of these plants are *Polymeria* sp., *Iseilema vaginiflorum* (Flinders grass), *Eragrostis setifolia, Enneapogon* spp. (whiteheads), *Dactyloctenium radulans* (button grass), *Boerhaavia diffusa* (tah-vine), *Crotalaria crassipes, Pterigeron odorus,* and *Goodenia* spp.

(viii) Acacia georginae — Astrebla pectinata *Association.*—Argadargada, Kallala, Moonah, Austral, Wonardo, and Tobermorey Land Systems. Like the *Eucalyptus microtheca* — *Astrebla pectinata* association, this association is a Woodland. It occurs on some of the Heavy Grey Pedocals and Brown Pedocals (heavy clay soils) in the area near the Georgina River.

The trees of *Acacia georginae* (gidgee) are fairly widely spaced and between 10 and 20 ft. high. The community can be considered as the *Astrebla pectinata* association with a sparse low tree layer of *Acacia georginae,* although in some parts the grasses are not so dense as in the *Astrebla pectinata* association.

(ix) Bauhinia cunninghamii — Eulalia fulva — Dichanthium fecundum *Alliance.*—Balbirini Land System. This community is similar to the *Eucalyptus microtheca — Eulalia fulva — Dichanthium fecundum* association but has a tree layer composed of *Bauhinia cunninghamii* instead of *E. microtheca.* Like this association the grass layer is similar to the *Eulalia fulva — Dichanthium fecundum* alliance.

The *Bauhinia cunninghamii—Eulalia fulva—Dichanthium fecundum* alliance occurs only on Northern Heavy Grey Pedocals (heavy clay soils) under a higher rainfall than the *Eulalia fulva — Dichanthium fecundum* alliance.

(x) Chenopodium auricomum *Association.*—On most of Sylvester Land System and on the flats fringing the streamlines in the Georgina Land System. This is a Shrubland occurring on the seasonally flooded swamps of the Barkly internal drainage basin and to a lesser extent on the flats fringing the streamlines of the Georgina River. The soils are Heavy Grey Pedocals (heavy clays).

Chenopodium auricomum (bluebush) is a shrub growing to a height of 3-4 ft. and spreading to a diameter of 3-4 ft. It has slightly succulent leaves which are palatable to stock. The seasonal flooding of the community provides plenty of water for plants, which consequently remain green and succulent for some months after those in the surrounding *Astrebla pectinata* association have dried off. The following perennial tussock grasses occur sparsely throughout the community: *Astrebla elymoides* (weeping Mitchell grass), *A. squarrosa* (bull Mitchell grass), *Aristida latifolia, Dichanthium* spp. (blue grass), *Eriachne nervosum,* and *Eulalia fulva* (brown top). Other plants of similar height (2-4 ft.) are: *Sesbania benthamiana, Cyperus retzii, Panicum decompositum, P. whitei,* and *Salsola kali.*

As the water recedes during the dry season a dense mass of smaller grasses and herbaceous plants germinates and for a time provides succulent and nutritious stock pastures. Probably the commonest of these smaller plants are *Psoralea cinerea* and *P. patens.* Other common plants are: *Iseilema* spp., *Alternanthera nodiflora, Sida* spp., *Halorrhagis glabrescens, Sporobolus actinocladus, S. mitchellii,* and *Tribulus terrestris.*

Less common plants include *Malvastrum spicatum, Portulaca* sp., *Gomphrena brownii, Marsilea brownii, Brachiaria* sp., *Alysicarpus rugosus, Brachyachne convergens* (native couch grass), *Boerhaavia diffusa* (tah-vine), *Polanisia viscosa, Dactyloctenium radulans* (button grass), *Rhyncosia minima, Calotis hispidula, Crotalaria crassipes, Stackhousia viminea,* *Pterigeron odorus* (stinkweed), *Eragrostis japonica, Elytrophorus spicatus, Cyperus pygmaeus,* and *Fimbristylis* spp.

There is a well-defined zonation of plants around the edge of the swamps. The centre and wettest parts of the swamp have a fairly dense stand of *Chenopodium auricomum* with few associated plants. Nearer the edge there is a zone which dries up more rapidly and has a sparser stand of *Chenopodium,* generally a fairly dense annual ground cover and few perennial grasses. This zone is probably flooded for a sufficient period to prevent the perennials growing but is dry for long enough to allow the cattle to graze the *Chenopodium,* thus giving a sparser stand. Outside this zone there is a third zone that is flooded less frequently, on which *Chenopodium* is only of sparse occurrence and perennial grasses constitute the bulk of the herbage.

The community is generally treeless, but in some parts *Eucalyptus microtheca* (coolibah) occurs at about Woodland density. The more permanent channels and distributaries are often fringed by *Muehlenbeckia cunninghamii* (lignum).

This Shrubland community provides the best fattening pastures of the Barkly region. It is preferentially grazed by stock and the area over which it grows has probably been reduced for this reason. Many of the associated herbaceous plants are legumes which provide much more nutritious fodder during the dry season than the dry grasses of the *Astrebla* associations.

(xi) Sporobolus australasicus — Enneapogon *spp. Association.*— Barkly, Creswell, and Drylake Land Systems. This is a low Grassland dominated by short annual grasses which seldom grow higher than 6 in. It occurs on low gravelly rises within the Heavy Grey Pedocal area (heavy clays). The rises are probably relatively dry habitats because much of the rain water runs away to gilgai depressions and the surrounding heavy soil areas. The community is never very dense and much bare ground is exposed.

The *Enneapogon* spp. (whiteheads) which occur as dominants are *E. pallidus, E. avenaceus,* and *E. polyphyllus.* Other associated plants are: *Dactyloctenium radulans* (button grass), *Tragus australianus, Aristida arenaria, A. inaequiglumis, Brachyachne convergens* (native couch grass), *Chloris pectinata, Evolvulus alsynoides, Polycarpaea* sp., *Indigofera enneaphylla,* and *Neptunia* spp. Gilgai depressions containing the gilgai community are common on these low rises, particularly on the gentle slopes. Some of these rises have scattered, low, straggly trees of *Grevillea striata, Ventilago viminalis,* or *Atalaya hemiglauca* or scattered bushes of *Carissa lanceolata.* These may be transitions to the *Ventilago viminalis* association.

(xii) *Gilgai Communities.*—In many parts of the region gilgai depressions containing heavy clay soils are common. These depressions constitute a wetter habitat than the surrounding country, due to local run-off. They may hold water for several months. Throughout the region these depressions have a characteristic vegetation but the species present vary somewhat over the wide rainfall range.

The vegetation is always a Grassland, the most common plants being mid-height grasses such as *Eulalia fulva* (brown top), *Astrebla squarrosa* (bull Mitchell grass), *Dichanthium* spp. (blue grass), *Bothriochloa ewartiana, Panicum decompositum,* and *Chrysopogon fallax.* Other plants of similar height which occur are *Astrebla pectinata, Sorghum* sp., *Cyperus* spp. (especially *C. retzii*), and *Eriachne nervosum.* These mid-height grasses tend to occur around the edge of the depressions, the centre (the deepest and wettest part) containing short grasses and herbs such as *Marsilea* sp., *Brachyachne convergens, Wedelia asperrima, Rhyncosia minima, Alternanthera nodiflora, Malvastrum spicatum, Corchorus* spp., *Psoralea cinerea, Echinochloa* spp., and *Iseilema* spp. The species present at any time depend upon the stage of wetting or drying of the depression. Some of these shorter plants also form an understorey to the mid-height plants around the edge of the depressions. In addition to the plants already mentioned, *Sesbania benthamiana* and *Aeschynomene indica,* tall herbs growing to 4-6 ft. high, sometimes occur.

In the southern parts (low rainfall) *Astrebla pectinata* and *A. squarrosa* tend to be dominant, but further north (medium rainfall) *Eulalia fulva* is dominant, and in the high-rainfall areas *Dichanthium* spp. and *Sorghum* spp. are dominant.

(*b*) *Communities on Fairly- to Excessively-drained Areas (not Heavy Clay Soils) Mainly under Low Rainfall*

The 15 communities which have been described in this group are set out in Table 10. The first 12 communities are Woodlands or Shrub Woodlands with trees about 15-25 ft. high and a ground layer which is very different from the Woodlands described in Section II(*a*) and shown in Table 9. The Woodlands on the heavy clay soils (Table 9) all have a grass understorey similar to the Grasslands which occur on the heavy clay soils. In this group (Table 10), the Woodlands and Shrub Woodlands have a sparser ground layer dominated by either *Triodia* spp., *Aristida* spp., or short annual grasses.

The last three communities shown in Table 10 are respectively Shrub Grassland, Shrubland, and Scrub.

(xiii) Eucalyptus pruinosa — E. microtheca *Sub-alliance.*—Joanundah Land System. This community is a Shrub Woodland occupying small areas of Northern Heavy Grey Pedocals or transitions to Tertiary Lateritic Flat soils in the Joanundah Land System.

The two dominants are low, straggly trees about 20 ft. high. Associated with them are scattered lower (10-15 ft.) trees of *Bauhinia cunninghamii, Terminalia volucris, Ventilago viminalis,* and *Capparis umbonata.*

The sparse shrub layer is 4-6 ft. high and includes *Carissa lanceolata, Capparis lasiantha,* and *Phyllanthus* sp. The ground layer is variable, partly due to the microtopography. In the gilgai depressions there is a dense, mid-height grass layer dominated by *Eulalia fulva* and including *Bothriochloa intermedia* and *Panicum decompositum.* Lower plants such as *Rhyncosia minima* and *Malvastrum spicatum* are also common. On small, gravelly rises between the gilgai depressions there are no mid-height grasses, but short grasses and forbs such as *Enneapogon* sp., *Sporobolus australasicus, Indigofera enneaphylla, Evolvulus alsynoides,* and *Brachyachne convergens* occur.

Areas intermediate between the gilgai depressions and rises carry a fairly dense mid-height (3-4 ft.) grass layer dominated by *Sehima nervosum* and containing *Dichanthium fecundum, Themeda australis, Chrysopogon pallidus,* and *Aristida pruinosa.* In these positions many of the short grasses and forbs of the gilgai rises also occur.

(xiv) Eucalyptus pruinosa *Association.*—Wonorah, Waverley, Mt. Isa, Yelvertoft, Kilgour, Mitchiebo, Tennant Creek, Ashburton, and Gosse Land Systems. In the southern half of the region (i.e. the lower-rainfall portion) this community occurs on the lower parts of the topography. Farther north it occupies lower slopes, and north-west of the region, where rainfall is higher, it occurs on better-drained parts of the topography. In the region surveyed it occurs particularly on Red-brown Desert Alluvial soils (deep, well-drained, medium-textured soils) and on the less well-drained lateritic soils. It is developed on deeper, less well-drained soils than the *Eucalyptus brevifolia* association.

E. pruinosa (silver box) is a straggly low tree 15-25 ft. high and is widely spaced in this community. A few lower trees (10-15 ft. high), including *Hakea arborescens, H. lorea, Ventilago viminalis* (vine tree), *Acacia aneura* (mulga), *Grevillea striata* (beefwood), and *Atalaya hemiglauca* (whitewood), are associated with it. Generally the shrub layer (4-6 ft. high) is sparse but patches may be fairly dense. The following shrubs occur: *Acacia lysiphloia* (turpentine), *A. leursenii, A. drepanocarpa, Grevillea wickhamii, Dodonaea oxyptera, Carissa lanceolata* (konkerberry), *Eremophila latrobei,* and *Dodonaea lanceolatum.*

The grass layer (2-3 ft. high) is mid-dense. It is dominated by *Aristida pruinosa,* with which are associated *Themeda australis* (kangaroo grass), *Chrysopogon pallidus, Panicum decompositum, Sehima nervosum,* and *Cymbopogon bombycinus.* There is a well-developed layer of short annual grasses and other herbs about 6-12 in. high. These include *Enneapogon* spp. (whiteheads), *Aristida browniana, Schizachyrium obliquiberbe, Sporobolus australasicus, Eriachne ciliaris, Polycarpaea* spp., *Evolvulus alsynoides, Gomphrena* spp., *Trichinium* spp., *Indigofera* spp., and *Trianthema pilosa.* Although *Aristida pruinosa* is generally the dominant in the grass layer, there are small parts in which *Triodia pungens* becomes dominant.

(xv) Eucalyptus microtheca — Tristania grandiflora *Association.* — Restricted to a small part of Elliott Land System. The community is a Woodland and occupies only a small area of Sandy Tertiary Lateritic Flat soil (poorly-drained soils with sandy surface) in the Elliott Land System.

The two tree dominants, 15-20 ft. high, are widely spaced. Shrubs and lower trees are almost absent although *Hakea arborescens, Acacia cunninghamii,* and a shrubby *Indigofera* sp. occur sparsely. *Themeda australis, T. avenacea* (kangaroo grasses), *Chrysopogon* sp., *Panicum decompositum, Sehima nervosum, Aristida pruinosa, Sorghum plumosum,* and, in some parts, *Triodia pungens* form a mid-dense grass layer of mid-height (2-4 ft.).

Shorter grasses such as *Aristida* spp., *Enneapogon* spp. (whiteheads), *Brachyachne convergens* (native couch grass), and *Dactyloctenium radulans* (button grass) and other herbaceous species including *Neptunia* spp. and *Boerhaavia diffusa* (tah-vine) are common.

(xvi) Eucalyptus brevifolia *Association.*—Wonorah, Elliott, Beetaloo, Pollyarra, Westmoreland, Waverley, Mt. Isa, Redbank, Yelvertoft, Kilgour, Mitchiebo, Tennant Creek, Helen Springs, Ashburton, and Robinson Land Systems. This community is a Woodland and although widespread throughout the region, it is best developed in the lower rainfall parts. It occurs on lateritic soils and skeletal soils on "acid" rocks.

E. brevifolia (snappy gum) is a straggly tree 15-25 ft. high and in this community the trees are widely spaced. A shrub storey 4-6 ft. high which may be sparse or dense is present in some parts. Shrubs which occur are *Acacia lysiphloia* (turpentine), *A. hilliana, A. monticola, A. cunninghamii, A. leursenii, A. retivenia, A. gonoclada, A. hammondi, A. wickhamii, A. phlebocarpa, Petalostylis labicheoides, Dodonaea oxyptera, Petalostigma quadriloculare* (quinine bush), *Distichostemon filamentosus, Cassia venusta, Calytrix microphylla, Eucalyptus odontocarpa,* and *E. pachyphylla.*

The ground storey is generally dominated by the sclerophyllous tussock grass, *Triodia pungens* (spinifex), which grows to a height of 2-3 ft. and a width of several feet. *Cymbopogon bombycinus* and *Aristida pruinosa* occur sparsely. In some parts *Triodia pungens* is replaced as ground storey dominant by *Aristida pruinosa* and a mixture of grasses 2-3 ft. high. These include *Chrysopogon pallidus* (golden beard grass), *Heteropogon contortus* (bunch spear grass), *Bothriochloa intermedia, Sehima nervosum,* and *Themeda australis* (kangaroo grass).

The associated lower ground storey (6-12 in. high) is similar in both the *Triodia pungens* and the *Aristida pruinosa* dominant areas. The following plants occur in this lower layer: *Trichinium* spp. (including *T. alopecuroides*), *Gomphena* spp. (including *G. canescens*), *Eriachne* *ciliaris, E. obtusa, Enneapogon* spp., *Schizachyrium obliquiberbe, Neurachne muelleri, Eragrostis desertorum, Aristida arenaria, A. hygrometrica, A. jerichoensis, A. browniana, Evolvulus alsynoides, Polycarpaea* spp., and *Indigofera* spp. (including *I. trita*).

(xvii) Eucalyptus argillacea — E. terminalis *Sub-alliance*.—Wonorah, Westmoreland, Prentice, Waverley, Mt. Isa, Thorntonia, Rolyat, Redbank, Kilgour, Mitchiebo, Tennant Creek, Bundella, and Gosse Land Systems. This community extends over a wide north-south range and a correspondingly wide rainfall range. Although one or both of the dominant trees occur throughout, they vary in height, and the associated plants vary also. In the southern (low-rainfall) parts and in better-drained parts of higher-rainfall areas a sparse shrub layer is present but under wetter conditions this is replaced by a sparse low tree layer. Similarly there is a general correlation between the ground storey dominants and the moisture status of the habitat. In the higher rainfall parts there is a dense, mid-height grass layer, but under a lower rainfall or in well-drained sites in higher-rainfall areas short annual grasses are more common. In the driest habitats *Triodia* spp. may be dominant in the ground storey.

In the southern (lower-rainfall) parts of the region the community is a Shrub Woodland similar in structure and appearance to the *Eucalyptus pruinosa* association and occurring in similar habitats. In these parts it occurs on Red-brown Desert Alluvial soils (deep, well-drained, medium-textured soils), on the deeper, less well-drained lateritic soils, and on Granitic Desert Loams. The two dominants occur as widely spaced, low trees, 15-25 ft. high. *Eucalyptus papuana* and other lower trees, including *Ventilago viminalis* (vine tree), *Hakea lorea, Grevillea striata* (beefwood), *Bauhinia cunninghamii, Atalaya hemiglauca* (whitewood), and *Acacia aneura* (mulga), are present in some parts.

A shrub layer is generally present, but it varies from sparse to mid-dense. Shrubs which occur are *Acacia lysiphloia, A. stipuligera, A. chisholmi, A. leursenii, A. translucens, Santalum lanceolatum, Cassia* spp., and *Carissa lanceolata*. The lower ground layer (6-12 in. high) is well developed and includes *Enneapogon* spp., *Aristida* spp., *Eriachne* spp., *Polycarpaea* spp., and *Trichinium* spp.

In the northern (higher-rainfall) parts the community is a Woodland. It occurs mainly on shallow limestone soils but also on deep, yellow, podzolic soils, brown alluvial soils, and Podzolized Truncated Lateritic soils. The dominants occur as widely spaced trees 20-35 ft. high. There is a sparse, low tree layer 10-15 ft. high in which *Erythrophleum chlorostachys* (ironwood), *Terminalia canescens, Bauhinia cunninghamii,* and *Brachychiton* sp. are common. The ground storey includes a dense mid-height grass layer in which *Sehima nervosum* and *Sorghum plumosum* are the commonest plants. *Themeda australis* (kangaroo grass), *Heteropogon contortus* (bunch spear grass) and *Chrysopogon* sp. also occur. Short herbs are not common but *Enneapogon* spp., *Brachyachne convergens, Polycarpaea* spp., and *Evolvulus alsynoides* are generally present.

In some northern parts there are apparent transitions to the *Terminalia* spp. — *Bauhinia cunninghamii* — *Cochlospermum* sp. community, but this is probably due to the fact that very small areas of this latter community are restricted to rock outcrops within the *Eucalyptus argillacea* — *E. terminalis* sub-alliance. Where large numbers of these small areas of rock outcrops occur there is a complex of the two communities.

(xviii) Eucalyptus terminalis — Cassia *spp. Association.*—Austral, Tobermorey, and Prentice Land Systems. The community is a Shrub Woodland and occurs in the southern (lower-rainfall) part of the region on some shallow calcareous soils, mostly formed directly on limestone.

The dominant tree, *Eucalyptus terminalis* (bloodwood), occurs sparsely and grows to a height of 15-25 ft. In some parts *E. argillacea* (box) is also present. In others, trees are absent and the community becomes a *Cassia* spp. Shrub Grassland. Lower trees (10 ft. high) such as *Atalaya hemiglauca* (whitewood), *Ventilago viminalis* (vine tree), *Grevillea striata* (beefwood), *Capparis umbonata,* and *Hakea lorea* occur sparsely in some parts of the community.

The shrub layer (3-4 ft. high) is characteristic but sparse, and is dominated by *Cassia* spp. (including *C. oligophylla* and *C. sturtii*). *Eremophila latrobei, Cassia sophera, Acacia chisholmi,* and *A. translucens* also occur.

The ground vegetation is characterized by sparse, short (6-12 in.) annual grasses of which the most prominant are *Enneapogon* spp. (including *E. polyphyllus, E. glaber, E. lindleyanus, E. purpurescens,* and *E. avenaceus*). Other plants in this lower layer are *Aristida avenacea, A. inaequiglumis, A. browniana, Eragrostis xerophila, Brachyachne convergens, Tragus australianus, Fimbristylis dichotoma, Indigofera linifolia, I. enneaphylla, Evolvulus alsynoides,* and *Sida fibulifera.* In some small scattered parts *Triodia* spp. are the ground-storey dominants. Gilgai depressions occur in some places and contain mid-height grasses such as *Eulalia fulva, Chrysopogon fallax, Aristida latifolia,* and *Astrebla squarrosa.*

(xix) Terminalia grandiflora *Association.*—Helen Springs Land System. On some of the Igneous Calcareous Desert soils (shallow loamy soils) of the Helen Springs Land System *Terminalia grandiflora* becomes the dominant tree in a community structurally very similar to some parts of the *Eucalyptus terminalis* — *Cassia* spp. association.

Terminalia grandiflora is a rather graceful tree 15-25 ft. high and widely scattered. There are no shrubs or mid-height grasses in the community. The ground layer of short annual grasses and other herbs is mid-dense and dominated by *Aristida browniana, A. arenaria,* and *Enneapogon* spp. Associated plants are *Eragrostis setifolia, Brachyachne convergens, Evolvulus alsynoides, Indigofera linifolia, I. enneaphylla, Borreria* spp., and *Sida fibulifera.*

(xx) Acacia aneura *Association.*—Camil and Tennant Creek Land Systems. The *Acacia aneura* (mulga) community is a Woodland occurring near the southern edge of the area (i.e. in the lowest rainfall parts) on Red-brown Desert Alluvial soils (deep, well-drained, medium-textured soils) and on truncated Tertiary non-lateritic soils (well-drained loamy soils).

The dominant occurs fairly densely as a tree 15-25 ft. high. A number of shrubs including *Eremophila latrobei, Cassia pruinosa, C. sturtii, C. oligophylla, Acacia lysiphloia, A. chisholmi, A. bivenosa, A. translucens,* and *Santalum lanceolatum* form a sparse layer 4-6 ft. high. *Eremophila gilesii,* a shrub 1-2 ft. high, occurs sparsely.

The ground layers are sparse. There are scattered mid-height grasses 2-3 ft. high, such as *Aristida pruinosa, A. inaequiglumis,* and *A. jerichoensis,* and short grasses and other herbs including *Enneapogon* spp., *Aristida arenaria, A. hygrometrica, Kochia cornishiana,* and *Evolvulus alsynoides.*

(xxi) Acacia cambagei *Association.*—Waverley, Moonah, Mt. Isa, and Bundella Land Systems. This is a Shrub Woodland community occurring in the south-eastern corner of the region on Georgina Alluvial Red-brown Earth soils (deep, well-drained, medium-textured soils).

The dominant is a small tree, 10-20 ft. high. Other small trees which occur less frequently are *Eucalyptus terminalis, Acacia aneura* (mulga), *Ventilago viminalis* (vine tree), *Atalaya hemiglauca* (whitewood), *Grevillea striata* (beefwood), and *Hakea lorea.* Shrubs (3-5 ft. high) are fairly common and may include *Acacia* spp., *Eremophila latrobei, Cassia sturtii,* and *Carissa lanceolata.*

The ground flora is generally sparse and the ground may be bare in patches. Mid-height grasses are not common but *Aristida pruinosa* and *Triodia* sp. occur. Short grasses less than 1 ft. high are much more numerous and include *Aristida browniana, A. inaequiglumis, A. jerichoensis, A. arenaria, Eragrostis* spp., and *Enneapogon* spp.

(xxii) Acacia georginae — Cassia *spp. Association.*—Camil, Camilrock, Tobermorey, and Wonardo Land Systems. The *Acacia georginae — Cassia* spp. association is a Shrub Woodland similar, in structure and associated plants, to the *E. terminalis — Cassia* spp. association. It occurs only in the south-eastern part of the region (i.e. near the Georgina River) on Calcareous or Alluvial Desert soils (well-drained, medium-textured soils).

The dominant is a low tree, 10-20 ft. high, which may be sparse to mid-dense in occurrence. *Grevillea striata* (beefwood) and *Hakea lorea* are low trees which occur sparsely throughout the community. The sparse shrub layer includes *Cassia oligophylla, C. sturtii, Eremophila latrobei,* and *Carissa lanceolata.*

The ground storey is characterized by low (6-12 in. high) annual grasses and other herbs, but *Triodia pungens* (spinifex) occurs in small areas. The most prominent of the low plants are *Enneapogon* spp., *Chloris scariosa, C. pectinata, Aristida* spp., *Sporobolus actinocladus, S. australasicus, Tripogon loliiformis,* and *Evolvulus alsynoides.* Scattered gilgai depressions containing the gilgai communities occur.

(xxiii) Ventilago viminalis *Alliance.*—On small rises in Barkly Land System, as fringing slopes in Wonorah, Elliott, Yelvertoft, and Mitchiebo Land Systems, and in valley bottoms in Ashburton Land System. This low Shrub Woodland is widespread, but generally occupies only small areas. It occurs typically as a narrow fringe on variable transition soils between the Grasslands on the Heavy Grey Pedocal soils and the various communities on the "deserts". It also occurs on some Red-brown Desert Alluvial soils.

The community is a very variable one but *Ventilago viminalis* (vine tree) is generally the dominant tree. *Grevillea striata* (beefwood), *Atalaya hemiglauca* (whitewood), *Hakea arborescens,* and *H. lorea* are co-dominant or dominant in some small parts. All of these are low, straggly trees 10-20 ft. high and, in this community, are widely spaced. Other small trees which occur sparsely in some parts include *Eucalyptus* spp. (*E. papuana, E. pruinosa, E. terminalis,* and *E. argillacea*), *Capparis umbonata, Celastrus cunninghamii, Bauhinia cunninghamii, Erythrina vespertilio,* and *Acacia aneura* (mulga).

The shrub layer is also variable in floristic composition and density. It is 3-5 ft. high and varies from sparse to fairly dense, or may be sparse with small dense patches. Common shrub species are *Acacia lysiphloia, A. monticola, A. cunninghamii, A. leursenii, Carissa lanceolata,* and *Cassia* spp. Smaller, more herbaceous shrubs 2-3 ft. in height such as *Eremophila gilesii, Notoxylinon australe, Cassia sophera,* and *Psoralea pustulata* occur sparsely.

The grass-dominant layers tend to be irregular with patches of fairly dense mid-height (2-3 ft.) grass and patches of short (6-12 in.) grass. The mid-height patches include *Aristida pruinosa, Themeda australis, T. avenacea, Chrysopogon pallidus, Cymbopogon bombycinus, Sehima nervosum, Panicum decompositum, Trichodesma zeylanicum,* and, in some parts, *Triodia pungens.* The lower layer includes a large number of species of which the most prominent are *Enneapogon* spp., *Tragus australianus, Sporobolus australasicus, Aristida* spp., *Neurachne muelleri, Dactyloctenium radulans, Brachyachne convergens, Eragrostis* spp., *Indigofera* spp., *Polycarpaea* spp., *Evolvulus alsynoides,* and *Schizachyrium obliquiberbe.* In addition to these variations in the ground flora there are scattered gilgai depressions in which gilgai communities occur.

(xxiv) Bauhinia cunninghamii — Gyrocarpus americanus *Association.*—Elliott Land System. On a small area of Tertiary Lateritic Red Sands (deep sands) near Elliott, there is a Woodland community dominated by *Bauhinia cunninghamii* and *Gyrocarpus americanus.* These trees occur fairly widely spaced and grow to about 20 ft. high. *Ventilago viminalis* (vine tree), *Acacia torulosa,* and *Atalaya hemiglauca* (whitewood) are associated with the dominants.

There is a mid-height grass layer about 2-4 ft. high in which the commonest plants are *Chrysopogon pallidus, Aristida pruinosa, Eragrostis xerophila,* and *Triodia pungens.* Smaller plants (6-12 in. high) are fairly common and include *Enneapogon* spp., *Polycarpaea* spp., *Trianthema pilosa, Breweria* sp., *Gomphrena canescens,* and *Indigofera enneaphylla.*

(xxv) Triodia pungens *Association.*—Camil and Camilrock Land Systems. The community is a Shrub Grassland restricted to Tertiary Non-lateritic soils (well-drained, loamy soils) on nearly flat plains or gentle slopes in the south-eastern portion of the region.

The dominant, *Triodia pungens,* is a sclerophyllous tussock grass, the tussocks growing to about 2 ft. high and 3-6 ft. wide. The inflorescences may grow as high as 4 ft. Associated with *Triodia pungens* are scattered, very low, straggly trees (less than 6 ft. high) such as *Eucalyptus papuana, E. terminalis, E. microtheca, Hakea lorea,* and *Grevillea striata* and some scattered shrubs such as *Eremophila latrobei, Santalum lanceolatum, Cassia oligophylla, C. eremophila, Acacia adsurgens,* and *A. dictyophleba. Cymbopogon bombycinus,* a grass about 3 ft. high, occurs sparsely and a few smaller grasses and herbs such as *Aristida browniana, A. arenaria, Fimbristylis dichotoma, Trianthema pilosa,* and *Pterocaulon glandulosum* are present.

(xxvi) Eucalyptus *spp. (Low Mallees)* — Acacia *spp. Alliance.*—Wonorah and Waverley Land Systems. This Shrubland occurs on gravelly lateritic and skeletal soils (stony, well-drained soils) in the low-rainfall parts of the region, e.g. near Tennant Creek.

The dominants are shrubs or shrubby low trees 5-8 ft. high and include *Eucalyptus odontocarpa, E. pachyphylla, Acacia lysiphloia* (turpentine), *A. chisholmi, A. stipuligera, A. translucens, A. monticola,* and *A. hilliana.* Other shrubs scattered throughout the community are: *Cassia* spp., *Petalostylis labichioides, Grevillea wickhamii, Eremophila latrobei,* and *Melaleuca lasiandra.*

The ground layer is dominated by the sclerophyllous tussock grass, *Triodia pungens* (spinifex), with which are associated scattered plants of *Aristida pruinosa* and *Cymbopogon bombycinus.* Scattered short grasses and other small plants occur. These include *Aristida arenaria, Enneapogon* spp., *Eragrostis* spp., *Neurachne muelleri, Evolvulus alsynoides, Polycarpaea* spp., and *Trichinium exaltatum.*

(xxvii) Jacksonia odontoclada — Acacia *spp. Alliance.*—Elliott, Beetaloo, and Ashburton Land Systems. This community is a Scrub and occurs on three land systems always on gently undulating to nearly flat areas with deep sandy soils and mostly within the lower rainfall parts of the region.

The dominant plants are shrubs varying from 4 to 8 ft. high and including *Jacksonia odontoclada* and *Acacia* spp. (*A. lysiphloia, A. stipuligera, A. drepanocarpa, A. plectocarpa, A. leursenii, A. monticola,* and *A. hilliana*). These form a dense layer. Other shrubs present in this layer are *Grevillea wickhamii, G. dryandri, Oxylobium aphylla, Petalostylis labicheoides, Distichostemon filamentosis, Bossiaea phylloclada, Petalostigma quadriloculare,* and *Cassia venusta.* This community is generally treeless but in some parts, particularly in the higher-rainfall parts of the community, one or more of the following occur as scattered, straggly, low trees 10-20 ft. high: *Eucalyptus ferruginea, E. setosa, E. odontocarpa,* and *E. pachyphylla. Newcastlia spodiotricha* and *Cassia pumila* occur sparsely as low shrubs 1-3 ft. high.

The tall (6 ft.) grass *Sorghum plumosum* occurs sparsely in some parts. The ground layer is fairly sparse and dominated by *Triodia pungens,* with which *Aristida pruinosa* and *Cymbopogon bombycinus* are associated. Short (less than 1 ft. high) grasses and other herbs occur sparsely throughout the community. The commonest of these are: *Eragrostis xerophila, E. eriopoda, Aristida hygrometrica, Enneapogon* spp., *Polycarpaea* spp., *Breweria* sp., *Trianthema pilosa, Scaevola parvifolia, Goodenia* sp., *Hibanthus aurantiacum, Crotalaria dissitiflora, Fimbristylis dichotoma, Trichinium exaltatum,* and *Pimelia* sp.

(*c*) *Communities on Well- to Excessively-drained Areas (not Heavy Clay Soils) under Medium to High Rainfall*

There are five communities in this group, which is summarized in Table 11. Of these five communities, four occur on Pedalfers and one (*Terminalia* spp. — *Bauhinia cunninghamii* — *Cochlospermum* spp.) on outcrops of "basic" rocks. Four of the communities are Woodlands with a ground storey dominated by *Triodia* spp. and the fifth (*Acacia shirleyi* association) is a Forest with a very sparse ground storey.

(xxviii) Eucalyptus dichromophloia *Association.*—Pollyarra, Beetaloo, Westmoreland, Wonorah, Robinson, Redbank, Kilgour, Yelvertoft, Mitchiebo, Ashburton, and Gosse Land Systems. This association is a Woodland similar in structure and associated plants to the *Eucalyptus brevifolia* association but requiring better moisture conditions. It is developed further to the north (higher rainfall) and where it occurs in the southern parts it is on deeper, less well-drained soils than the *Eucalyptus brevifolia* association. As with the *Eucalyptus brevifolia* community, it occurs on skeletal soils on "acid" rocks and on lateritic soils.

In this community *E. dichromophloia* occurs as widely spaced, straggly trees 20-25 ft. high. *E. ferruginea* occurs sparsely as a low tree 10-20 ft. high. As with the *Eucalyptus brevifolia* association, there may or may not be a shrub layer 4-8 ft. high, and if present it may be dense or sparse. Shrubs which occur are *Acacia lysiphloia, A. translucens, A. monticola, A. xylocarpa, A. stipuligera, A. wickhamii, Petalostylis labicheoides, Jacksonia odontoclada, Grevillea wickhamii, G. dryandri, Distichostemon filamentosis,* and *Cassia venusta.* Low shrubs about 1-2 ft. high are not common, but *Cassia pumila* occurs fairly constantly.

The ground storey is dominated by the sclerophyllous tussock grass *Triodia pungens* (2-3 ft. high), with which several other species of *Triodia* and *Plectrachne* are associated in some parts. On deeper, less well-drained soils, *Aristida pruinosa* may replace *Triodia pungens* as dominant. *Chrysopogon pallidus* and *Cymbopogon bombycinus* also occur in the mid-height grass layer. There is a layer of short annual grasses and other herbaceous plants 6-12 in. high. These include *Enneapogon* spp., *Eriachne ciliaris, Schizachyrium obliquiberbe, Aristida* spp., *Gomphrena* spp. (including *G. canescens*), *Trichinium* spp. (including *T. alopecuroides*), *Polycarpaea* spp., and *Evolvulus alsynoides.*

(xxix) Eucalyptus aspera *Association.*—Minor areas in Robinson, Yelvertoft, and Ashburton Land Systems. This Shrub Woodland community occurs only in small patches on almost bare rock outcrops in the northern half of the region.

E. aspera occurs as widely spaced, low (10-15 ft.) straggly trees. Scattered shrubs (3-6 ft.) of *Calytrix microphylla* and *C. brachychaeta* occur throughout the association. The ground storeys are very sparse with bare rock occupying most of the area. However, *Triodia pungens* and *Cymbopogon bombycinus* occur sparsely and grow to 2-3 ft. high. *Polycarpaea* spp. (6 in. high) also occur. Although fairly widespread, the actual area occupied by the *E. aspera* association is very small.

(xxx) Terminalia *spp.* — Bauhinia cunninghamii — Cochlospermum *sp. Alliance.*—Mt. Isa, Thorntonia, Rolyat, Redbank, and Balbirini Land Systems. On limestone outcrops and on shallow skeletal soils on limestone in the northern parts of the region the vegetation is variable but is dominated by a mixture of deciduous species.

The community is very variable in floristic composition and density and often occurs in scattered small areas only a chain or so in diameter. In such cases only a few of the tree and shrub species may occur in any one patch and the species present vary from patch to patch. The following small trees occur in the community: *Terminalia volucris, T. hirsuta, T. aridicola, Bauhinia cunninghamii, Cochlospermum* sp., *Ventilago viminalis, Atalaya hemiglauca, Hakea arborescens, Erythrophleum chlorostachys, Gyrocarpus americanus, Brachychiton* sp., *Capparis umbonata, Dolichandrone heterophylla, Wrightia saligna,* and *Ficus* spp.

There is a sparse shrub layer, 4-6 ft. high, in which the following are the commonest: *Carissa lanceolata, Dodonaea oxyptera, D. lanceolata, Phyllanthus* sp., *Capparis lasiantha, Acacia chisholmi, A. farnesiana, A. lysiphloia,* and *Pavetta* sp. *Grewia retusifolia* and *Cassia sophera,* shrubby plants 2-3 ft. high, also occur sparsely.

The mid-height (2-4 ft.) grass layer varies from sparse to dense and includes *Triodia* sp. and/or *Themeda australis, Cymbopogon* sp., *Chrysopogon* sp., *Heteropogon contortus, Aristida* sp., and an annual *Sorghum* sp. The short grass layer (6-12 in. high) contains *Enneapogon* spp., *Brachyachne convergens, Neurachne muelleri, Sporobolus australasicus, Dactyloctenium radulans, Tragus australianus, Schizachyrium obliquiberbe, Evolvulus alsynoides, Polycarpaea* spp., *Borreria* spp., and *Indigofera linofolia. Abrus precatorius,* a trailing plant, is fairly common in some parts.

(xxxi) Terminalia canescens — Eucalyptus setosa *Association.*—One small part of Westmoreland Land System. The community is a Shrub Woodland growing on skeletal soils and stony slopes. It is dominated by a mixture of low straggly trees 10-15 ft. high including *Terminalia canescens, Eucalyptus setosa, E. argillacea, Erythrophleum chlorostachys, Ventilago viminalis,* and *Cochlospermum gregori.* Other low trees which may be associated with these are *Eucalyptus confertiflora, E. grandifolia, Hakea arborescens, Dolichandrone heterophylla,* and *Melaleuca leucadendron.* Shrubs 6 ft. high are fairly common and include *Acacia* spp. and *Dodonaea oxyptera.*

The ground layer is dominated by the sclerophyllous tussock grass, *Triodia pungens.* Associated with *Triodia pungens* are scattered plants of *Aristida pruinosa* and *Cymbopogon bombycinus.* Shorter herbs and grasses include *Aristida* spp., *Enneapogon* spp., *Eriachne* spp., and *Polycarpaea* spp.

(xxxii) Acacia shirleyi *Association.*—On small areas of steep slopes, breakaways, and stony rises in Pollyarra and Kilgour Land Systems and on gently sloping to almost flat country in Beetaloo Land System. This is one of the few Forest communities in northern Australia. It occurs in small patches on steep slopes and breakaways over most of the region but extends on to Tertiary Lateritic soils (leached medium-textured soils) in the north-western part of the region.

The trees of *Acacia shirleyi* (lancewood) have straight trunks about 6-9 in. in diameter and grow to a height of 20-30 ft. They are closely spaced and form a dense community. Shrubs and grasses are sparse or absent. A few scattered plants of *Aristida pruinosa* and *Heteropogon contortus* represent a mid-height grass layer and a few low plants such as *Chloris dichanthioides, Aristida browniana, Enneapogon* sp., *Eriachne* sp., *Schizachyrium* sp., *Gomphrena canescens,* and *Trichinium exaltatum* form a sparse lower layer.

Acacia shirleyi timber is extensively used for posts and rails in construction of fences and yards. The association is probably less extensive than before settlement because of this. In some parts *Macropteranthes kekwickii* (bullwaddi) forms small dense thickets under the lancewood.

(*d*) *Communities of High-rainfall Areas Other than Those with Excessive Drainage*

A summary of the eight communities in this group is shown in Table 12. The more important of these communities in regard to area occupied are the *Eucalyptus tetrodonta* — *E. miniata* alliance of sandy soils, the *Eucalyptus papuana* — *E. tectifica* alliance on river levees, and the *Eucalyptus argillacea* — *E. terminalis* — *E. tectifica* alliance of medium-textured podzolized soils. The first is an Open Forest with a sparse grass layer. The last two are Woodlands with a denser layer of mid-height to tall grasses. The remaining communities are restricted to small areas.

(xxxiii) Eucalyptus tetrodonta — E. miniata *Alliance.* — Well developed in Westmoreland and less important in Redbank, Robinson, and Keighran Land Systems. On sandy soils (often lateritic) in the higher rainfall parts of the region, *E. tetrodonta* and *E. miniata* are dominant in a Shrub or Shrubland Open Forest. These two trees are fairly closely spaced and average 30-40 ft. in height although in some parts they grow to 60 ft. In some parts *E. dichromophloia* and *Callitris intratropica* are associated with them. *E. ferruginea* occurs sparsely as a tree about 20-30 ft. high.

Low trees 10-20 ft. high are fairly common and include *Terminalia canescens, Erythrophleum chlorostachys, Planchonia careya, Petalostigma banksii, P. quadriloculare, Gardenia* sp., *Alphitonia excelsa, Grevillea chrysodendron, G. pteridifolia, Canarium australianum,* and *Pandanus* sp.

There is generally a sparse to mid-dense shrub layer 4-6 ft. high in which *Calytrix microphylla, Jacksonia odontoclada, Distichostemon filamentosis,* and *Bossiaea phylloclada* are common. Lower shrubs 2-3 ft. high are not so common, but the following occur in some parts: *Acacia galioides, Cassia pumila, Triumfetta* sp., and *Tephrosia stuartii.*

Although not general, the tall (5-6 ft.) grass *Sorghum plumosum* occurs in some parts. The grass layer is generally 2-3 ft. high and dominated by *Triodia* sp. and/or *Plectrachne* sp., associated with which are *Heteropogon contortus, Chrysopogon* sp., *Cymbopogon* sp., and *Eriachne* sp. Short grasses and forbs less than one foot high are common and include *Aristida browniana, A. hygrometrica, Schizachyrium obliquiberbe, Polycarpaea* spp., *Gomphrena canescens, Borreria* spp., *Crotalaria dissitiflora,* and *Evolvulus alsynoides.*

(xxxiv) Callitris intratropica *Association.*—Westmoreland Land System. In some parts of the sandy soil area on which the *Eucalyptus* *tetrodonta* — *E. miniata* alliance is the major community, *Callitris intratropica* (cypress pine) is the dominant tree in a Forest or Shrub Forest community. This community also occurs to a lesser extent on some skeletal soils. *C. intratropica* occurs in fairly dense stands as a straight-trunked tree 40-50 ft. high. Scattered trees of *E. tetrodonta* are associated with it in some parts. Low trees, 10-15 ft. high, such as *Terminalia canescens, Petalostigma banksii, P. quadriloculare, Alphitonia excelsa, Erythrophleum chlorostachys,* and *Acacia* spp. are fairly common.

There is generally a shrub layer 4-6 ft. high in which *Bossiaea phylloclada, Calytrix microphylla, Jacksonia odontoclada, Dodonaea oxyptera, Acacia* spp., and *Grevillea dryandri* occur. Low shrubs such as *Cassia pumila* and *Acacia galioides* occur sparsely throughout the community.

Sorghum plumosum, a grass about 6 ft. high, occurs in some parts. The sparse grass layer is generally about 3 ft. high and dominated by *Plectrachne* sp., with which are associated *Heteropogon contortus, Chrysopogon pallidus,* and *Cymbopogon bombycinus.* Small grasses and other herbs such as *Aristida browniana, Schizachyrium obliquiberbe, Neurachne muelleri, Eriachne* spp., *Borreria* spp., and *Evolvulus alsynoides* are common.

(xxxv) Eucalyptus papuana — E. tectifica *Alliance.*—Mainly on Keighran and to a lesser extent on Balbirini and Gregory Land Systems. The tall (40-50 ft.) Woodland community which occurs on the levees of the major rivers is dominated by *E. papuana* and *E. tectifica.* This community is best developed on the levees of rivers flowing into the Gulf of Carpentaria. *E. foelscheana, E. terminalis,* and *E. polycarpa* are associated with the dominants in some parts. Lower trees (30 ft. high) such as *E. confertiflora, E. grandiflora,* and, more rarely, *Acacia sutherlandii* form a sparse layer. Smaller trees, 15 ft. high, are common, but do not form a dense layer. Included on this layer are *Erythrophleum chlorostachys, Alphitonia excelsa, Planchonia careya, Bauhinia cunninghamii, Owenia vernicosa, Celastrus cunninghamii, Canarium australianum, Pandanus* sp., *Hakea arborescens, Ventilago viminalis, Atalaya hemiglauca, Ficus* sp., and *Gyrocarpus americanus.*

Shrubs are not common but *Acacia farnesiana* and *Carissa lanceolata* and a few lower shrubs such as *Cassia sophera, Acacia galioides, Phyllanthus* sp., and *Grewia retusifolia* occur sparsely in parts.

Mid-height (3-4 ft.) grasses are very prominent and generally form a dense layer. *Themeda australis* and *Heteropogon contortus* are the grass dominants and associated with them are *Eulalia fulva, Cymbopogon* sp., *Aristida pruinosa, Chrysopogon pallidus, Sehima nervosum,* and *Panicum decompositum.* Other plants of similar height are *Crotalaria novaehollandiae, C. trifoliastrum, Melhania oblongifolia,* and *Achyranthes aspera.* Shorter grasses and herbs are not very common, but the following occur: *Aristida hygrometrica, Chloris* spp., *Enneapogon* spp., *Schizachyrium obliquiberbe, Fimbristylis* spp. (including *F. dichotoma*), *Evolvulus alsynoides,* and *Trianthema pilosa.*

On the Gregory Land System *Eucalyptus papuana* and *E. tectifica* are dominant on levees, but they are much lower than in the typical form of the community. The associated small trees are also lower and not all the species mentioned above are present. The grass layers are essentially similar but not so dense.

On the Balbirini Land System the community is intermediate in appearance between the typical form on Keighran Land System and the variant on the Gregory Land System.

(xxxvi) Eucalyptus argillacea — E. terminalis — E. tectifica *Alliance.*—Pollyarra, Robinson, Redbank, and Keighran Land Systems. This community is a Woodland occurring on Tertiary Lateritic Flats or Deep Yellow Podzolic soils in the higher-rainfall parts of the region.

E. argillacea, E. terminalis, E. tectifica, E. papuana, E. polycarpa, E. grandifolia, and *E. confertiflora* all occur as dominants or co-dominants but the first three are dominant more commonly than the others. All these trees are 25-50 ft. high. There may or may not be a lower tree layer (10-20 ft.), the floristic composition of which varies from place to place. Some of these lower trees are *Erythrophleum chlorostachys, Bauhinia cunninghamii, Planchonia careya, Brachychiton* spp., *Celastrus cunninghamii, Hakea arborescens, Melaleuca leucadendron, Alphitonia excelsa,* and *Grevillea parallela.*

A sparse shrub layer, about 4-6 ft. high, containing *Acacia lysiphloia, A. cunninghamii, Distichostemon filamentosis,* and *Carissa lanceolata* is present in many parts. In addition, *Grewia retusifolia* and *Notoxylinon australe,* smaller shrubby plants 2-3 ft. high, are present in some parts.

The medium-height grass layer is fairly dense and about 3-4 ft. high. The most prominent plants are *Heteropogon contortus, Chrysopogon pallidus, Sehima nervosum, Bothriochloa intermedia, Themeda australis, Aristida pruinosa, Trichodesma zeylanicum, Achyranthes aspera,* and *Crotalaria novae-hollandiae.* There is a layer of shorter grasses and forbs (about 6-12 in. high) which includes *Enneapogon* spp., *Brachyachne convergens, Polycarpaea* spp., *Borreria* spp., *Glycine falcata, Indigofera trita, Evolvulus alsynoides, Phyllanthus* spp., and *Gomphrena canescens.*

(xxxvii) Melaleuca acacioides *Association.*—Restricted to a small part of Redbank Land System. On Shallow Yellow Podzolic soils on gentle slopes in the Redbank Land System there is a Woodland community dominated by *Melaleuca acacioides,* a low tree 10-20 ft. high. Other trees of similar height such as *Terminalia canescens, Erythrophleum chlorostachys,* and *Eucalyptus pruinosa* occur sparsely. *Petalostigma banksii* and *Hakea arborescens,* trees about 10 ft. high, also occur sparsely.

A few shrubs, about 4-6 ft. high, such as *Carissa lanceolata, Dodonaea oxyptera, Calytrix microphylla,* and *Acacia hammondii* form a sparse shrub layer and *Grewia retusifolia,* a shrubby plant about 2 ft. high, occurs scattered throughout the community.

The mid-height (2-3 ft.) grass layer is rather sparse and is dominated by *Triodia pungens* or a mixture of the following: *Themeda australis, Sehima nervosum, Heteropogon contortus, Chrysopogon* sp., *Bothriochloa intermedia, Aristida pruinosa,* and an annual *Sorghum* sp. Smaller plants 6-12 in. high are fairly common. These include *Sporobolus australasicus, Enneapogon avenaceus, Eriachne ciliaris, Schizachyrium obliquiberbe, Aristida browniana, Polycarpaea* spp., *Gomphrena canescens,* and *Trichinium exaltatum.*

(xxxviii) Melaleuca leucadendron *Association.*—Redbank and Westmoreland Land Systems. On Tertiary Lateritic Flat and Deep Yellow Podzolic soils in Redbank and Westmoreland Land Systems *Melaleuca leucadendron* is dominant in a low Open Forest community about 20 ft. high. These habitats are poorly drained and are probably flooded for parts of the year. In the dry season there is a very shallow water table. In much of the community the dominant occurs in almost pure stands, but in some parts *Alphitonia excelsa, Erythrophleum chlorostachys, Grevillea parallela, G. pteridifolia, Petalostigma banksii, Bauhinia cunninghamii,* and more rarely *Eucalyptus pruinosa, E. argillacea,* and *E. confertiflora* also occur. Shrubs are almost absent but *Carissa lanceolata* and *Grewia retusifolia* occur sparsely. The ground flora is dominated by a sparse mixture of mid-height (2-3 ft.) grasses including *Bothriochloa intermedia, Chrysopogon* sp., *Aristida pruinosa, Themeda australis,* and *Heteropogon contortus.* Short grasses and other herbs are very common, the most prominent being *Pseudopogonatherum contortum, Perotis rara, Schizachyrium* spp., *Borreria* sp., *Drosera* spp., and *Stylidium* spp.

(xxxix) Eucalyptus microtheca — Sorghum *sp. Association.*—Keighran Land System. On Heavy-textured Deep Yellow Podzolic soils in broad depression areas in Keighran Land System (near Gulf of Carpentaria), *E. microtheca* dominates a Woodland community. The habitat is flooded for part of the year and surface water is present in pools most of the time. In this community, *E. microtheca* is a tree 30 ft. high. Scattered trees of *Melaleuca leucadendron* and *Excoecaria parvifolia* form a sparse low tree layer.

The tall (6 ft.) grass layer is fairly dense and includes *Sorghum* sp., *Oryza australis,* and *Coelorachis rottboellioides.* Mid-height grasses such as *Eulalia fulva, Aristida latifolia, Leptochloa brownii, Chrysopogon* sp., *Dichanthium superciliatum, Panicum decompositum,* and sedges such as *Cyperus* spp. form a dense layer 3 ft. high. There are few lower plants present, but *Brachyachne convergens, Fimbristylis* spp., and *Psoralea cinerea* occur sparsely.

(xl) Eucalyptus ptychocarpa *Association.*—Small patches in Robinson Land System. This community occurs only in the northern part (higher rainfall) of the region in habitats where extra water is available, e.g. near springs and along the edge of large rock outcrops where run-off contributes the extra water. The soil is generally sandy. *E. ptychocarpa* occurs fairly densely and may have *E. camaldulensis* associated with it. There is a dense layer of trees 18-20 ft. high in which *Banksia dentata, Pandanus* sp., *Melaleuca leucadendron, Grevillea pteridifolia, Acacia torulosa, A. mangium* var. *holosericea, Erythrophleum chlorostachys,* and *Brachychiton* sp. occur. *Acacia mangium* var. *holosericea* also occurs as a shrub 6-8 ft. high and *A. hammondii* is usually associated with it.

The ground layers vary considerably. Generally there are a few scattered plants of *Coelorachis rottboellioides* growing to a height of 5-6 ft., a fairly dense layer of mid-height grasses in which *Eriachne triseta, Aristida exserta,* and *Eragrostis* spp. are prominent, and a lower layer of small grasses and other herbs such as *Rhyncosia minima, Drosera* spp., and *Stylidium* spp. *Passiflora foetida* commonly occurs scrambling over the shrubs and lower trees.

III. Description of the Minor Plant Communities Occurring in Miscellaneous Habitats

These communities can be classified into four main groups:

(*a*) Fringing communities — those communities which occur along streamlines and around lagoons, etc.

(*b*) Communities of saline areas.

(*c*) Communities of sand dunes near the coast.

(*d*) Communities of lagoons and areas subject to long periods of flooding each year.

(*a*) *Fringing Communities*

(i) *Mangrove Community.*—Littoral Land System. Mangroves occur along the muddy shores of the Gulf of Carpentaria near stream estuaries and extend along the banks of the streams for some miles inland. The following mangroves occur: *Rhizophora mucronata, Avicennia* sp., *Ceriops tagal, Lumnitzera racemosa, Bruguiera gymnorrhiza, B. parvifolia, Xylocarpus moluccanus, Aegiceras corniculatum,* and *Aegialitus annulatis.*

(ii) *Tall Fringing Forest.*—This forest occurs along the banks of the perennial streams flowing into the Gulf of Carpentaria. There is a large number of species, the commonest of which are listed below.

Tall trees, 50-70 ft. high: *Eucalyptus camaldulensis, Nauclea orientalis, Casuarina cunninghamiana, Melaleuca saligna, M. mimosoides, Terminalia platyphylla, T. erythrocarpa.*

Mid-height trees 30-50 ft. high: *Ficus* spp., *Tristania grandiflora, Brachychiton* spp., *Pithecolobium monoliferum, Melaleuca bracteata, Terminalia bursarina, Barringtonia acutangula.*

Small trees 15-30 ft. high: *Melaleuca leucadendron, M. symphyocarpa, Pandanus aquaticus, Excoecaria parvifolia, Bauhinia cunninghamii, Acacia mangium* var. *holosericea, A. salicina, Caesalpinia bonduc, Livistona* sp.

Tall grasses and herbs 5-6 ft. high: *Vetiveria elongata, Arundinella nepalensis, Ophiuros exaltatus, Chionachne cyathopoda, Dichanthium superciliatum, Sesbania benthamiana.*

Mid-height grasses, etc., 3-4 ft. high: *Eulalia fulva, Dichanthium fecundum, D. annulatum, Bothriochloa intermedia, B. ewartiana, B. decipiens, Panicum decompositum, Chrysopogon* sp., *Themeda australis, T. avenacea, Cyperus vaginatus.*

Small plants ½-2 ft. high: *Eragrostis japonica, E. tenax, Paspalidium jubiflorum, Enneapogon lindleyanus, Cynodon dactylon, Brachiaria reptans, Dactyloctenium radulans, Chloris acicularis, Melochia pyramidata, Alternanthera nodiflora, Indigofera trita.*

(iii) Eucalyptus microtheca *Fringing Community.*—This community occurs along streams flowing through heavy soils such as those flowing into the Barkly internal drainage basin, the Georgina River, and many of its tributaries. These streams generally have a very low gradient and are non-perennial. In the dry season they consist of chains of water-holes. The following is a list of the commonest species present:

Trees 30 ft. high: *E. microtheca.*

Trees 10-20 ft. high: *Bauhinia cunninghamii, Acacia stenophylla, Eremophila bignoniflora, Atalaya hemiglauca.*

Shrubs 4-6 ft. high: *Acacia farnesiana, Carissa lanceolata, Muehlenbeckia cunninghamii.*

Shrubs 2-4 ft. high: *Chenopodium auricomum.*

Tall herbs 6 ft. high: *Sesbania benthamiana, Aeschynomine indica.*

Grasses and herbs 2-4 ft. high: *Astrebla pectinata, A. elymoides, A. squarrosa, Chrysopogon fallax, Dichanthium fecundum, D. superciliatum, Aristida latifolia, Panicum whitei, Eriachne nervosa, Cyperus retzii.*

Small grasses and herbs 6-12 in. high: *Iseilema* spp., *Paspalidium jubiflorum, Sporobolus mitchellii, S. actinocladus, Elytrophorus spicatus, Eragrostis japonica, Malvastrum spicatum, Psoralea cinerea, Boerhaavia diffusa, Neptunia* spp., *Gomphrena brownii, Euphorbia drummondii, Corchorus pascuorum, Marsilea* sp., *Alternanthera nodiflora, Cyperus pygmaeus.*

In some areas near Newcastle Waters *Excoecaria parvifolia* (gutta percha) is common on flats near streams. These flats are flooded for short periods.

(iv) *Fringing Communities of Small Non-perennial Streams in Areas of Dissection.*—The commonest species are listed below:

Trees 20-40 ft. high: *Terminalia bursarina.*

Trees 10-20 ft. high: *Grevillea striata, Hakea arborescens, Ventilago viminalis, Melaleuca leucadendron.*

Shrubs 4-8 ft. high: *Acacia lysiphloia, A. chisholmi, A. mangium* var. *holosericea, A. cunninghamii, A. dictyophleba, A. stipuligera, A. farnesiana, Carissa lanceolata.*

Mid-height grasses 2-4 ft. high: *Themeda australis, Chrysopogon* sp., *Aristida pruinosa, Sehima nervosum, Heteropogon contortus, Panicum decompositum.*

Small herbs and grasses 6-12 in. high: *Chloris acicularis, Enneapogon* spp.

(*b*) *Communities of Saline Areas*

(i) Xerochloa barbata *Association.* Littoral Land System. A narrow band of this community occurs on the inland edge of the salt flats along the coast. The soils are solonetzic. The dominant grows to a height of 1-2 ft. and usually occurs fairly densely. Other grasses of similar height such as *Chrysopogon* sp., *Panicum decompositum,* and *Eriachne* sp. occur sparsely. A few shorter (6-12 in.) grasses and herbs also occur. The commonest of these are *Digitaria* sp., *Brachyachne tenella, Sporobolus actinocladus, Chloris scariosa, Bassia* spp., *Enchylaena* sp., and *Gomphrena* sp. In some places scattered straggly low trees of *Grevillea striata* (beef-wood), *Excoecaria parvifolia* (gutta percha), *Pandanus* sp., and *Eucalyptus papuana* occur, but generally the community is treeless.

(ii) *Salt Marsh.*—On the salt flats most of the ground is bare, but patches of *Arthrocnemum* spp., *Salicornia* sp., and *Sueda* sp. occur. *Sporobolus virginicus* also occurs sparsely. The salt flats occur only in the Littoral Land System.

(*c*) *Communities of Sand Dunes*

(i) *Foredunes.*—These have a low vegetation dominated by *Spinifex longifolius* and *Ipomoea pes-caprae.* Scattered trees of *Casuarina equisetifolia* and *Hibiscus tiliaceus* occur almost on the beach.

(ii) *Older Dunes.*—These have a more stable vegetation with small trees and shrubs, such as *Acacia tanumbirinense, Terminalia* sp., and *Clerodendron floribundum. Passiflora foetida* is common and creeps over these shrubs and small trees.

The following is a list of the grasses and herbaceous plants:

Tall grass 6 ft. high: *Sorghum plumosum.*

Mid-height plants 2-4 ft. high: *Elyonurus citreus, Panicum leurostachyum, Xerochloa barbata, Xyris camplanata,* and *Triumfetta appendicularis.*

Small plants 6-12 in. high and scattered: *Chloris scariosa, Chamaeraphis hordeacea, Brachiaria muliiformis, Eriachne obtusa, Setaria brownii, Dactyloctenium radulans, Scleria brownii, Fimbristylis caespitosa, Desmodium biarticulatum, Pterocaulon glandulosa,* and *Tribulus terrestris.*

(*d*) *Communities of Lagoons and Areas Subject to a Long Period of Flooding Each Year*

(i) Where the water is several feet deep, waterlilies such as *Nelumbium nelumbo* and *Nymphaea* sp. are found.

(ii) In shallow water *Pseudoraphis spinescens* and *Leersia hexandra* become dominant.

(iii) In very shallow, swampy areas an almost pure community dominated by *Eleocharis* spp. occurs. *Pseudoraphis spinescens, Leersia hexandra,* and *Oryza australis* occur sparsely in the *Eleocharis* community. Dense clumps of *Melaleuca leucadendron* (paperbark) may occur on these swampy areas. These lagoons and flooded areas are found only in the Keighran Land System.

PART VIII. THE LAND SYSTEMS OF THE BARKLY REGION

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I. INTRODUCTION

The soils and vegetation units of this region occur in complex patterns that cannot be mapped over very large areas without a considerable amount of field work. The composite unit used for describing and mapping the nature of country is the *Land System* as developed and used by Christian and Stewart (1953)† for the Katherine-Darwin region, Northern Territory. This concept was subsequently used by Stewart and Perry (1953)‡ in the Townsville-Bowen region, north Queensland. A *Land System* is "an area or group of areas throughout which there is a recurring pattern of topography, soils, and vegetation". These inherent land characteristics are dependent on the nature of the underlying rocks (i.e. geology), the erosional and depositional forces that have produced the present topography (i.e. geomorphology), and the climate under which these processes have operated. That is, the land system is a scientific unit for the description and mapping of types of country, classified according to their origin.

In this region 38 land systems have been described, and their distribution is shown on the map accompanying this report. In general, a land system occurs only within one geomorphological unit (an area of country of the same origin — see Part IV). However, under some circumstances similar types of country may be formed in different ways and may be included in one compound land system. For example, the Tobermorey Land System is a compound land system in which a similar type of country has developed on portions of three geomorphological units. In each case similar residual soils have developed on limestone, but in different circumstances. In the Mitchiebo, Mt. Isa, Yelvertoft, and Redbank Land Systems portions occur in different geomorphological units but in each land system similar rocks and processes are involved.

The land systems have been grouped according to their origin into their respective geomorphological units. The latter have been grouped into the three geomorphological subdivisions — Stable Tertiary Land Surface, Erosional Land Surface, and Depositional Land Surface. In the following text and tables the characteristics and differentiating factors of the land systems of each geomorphological unit are summarized. Table 13 is an alphabetical index to the land system tables.

* Land Research and Regional Survey Section, C.S.I.R.O., Canberra, A.C.T.

† Christian, C. S., and Stewart, G. A. (1953).—General report on survey of Katherine-Darwin region, 1946. C.S.I.R.O. Aust. Land Res. Ser. No. 1.

‡ Stewart, G. A., and Perry, R. A. (1953).—The land systems of the Townsville-Bowen region. C.S.I.R.O. Aust. Land Res. Ser. No. 2: 55-68.

The land systems and their land units are described and illustrated by diagrammatic cross sections in Tables 15-29, 31-43, 45-54. The cross sections are not drawn to scale but the relative areas are shown below each land unit of the cross section.

In order to give as much information on vegetation communities as possible in the limited space available on the land system tables, the notation has been simplified by listing together the community name and its formation, e.g. the *Astrebla pectinata* association is a Grassland and is referred to as *A. pectinata* Grassland. In order to save space in the tables the name *Eucalyptus* has always been abbreviated to *E.*

TABLE 13

ALPHABETICAL INDEX TO THE LAND SYSTEMS

Land System	Table No. of Key	Table No. of Description	Land System	Table No. of Key	Table No. of Description
Argadargada	14	23	Kilgour	30	38
Ashburton	30	41	Littoral	44	45
Austral	14	28	Mitchiebo	30	39
Balbirini	44	48	Moonah	44	50
Barkly	14	24	Mt. Isa	30	33
Beetaloo	14	17	Pollyarra	14	16
Bundella	44	51	Prentice	14	22
Camil	14	20	Redbank	30	37
Camilrock	14	21	Robinson	30	36
Creswell	14	25	Rolyat	30	35
Drylake	14	27	Sylvester	44	53
Elliott	14	18	Tennant Creek	30	42
Georgina	44	54	Thorntonia	30	34
Gosse	44	52	Tobermorey	14	29
Gregory	44	47	Waverley	30	32
Helen Springs	30	43	Westmoreland	14	19
Joanundah	14	26	Wonardo	30	31
Kallala	44	49	Wonorah	14	15
Keighran	44	46	Yelvertoft	30	40

As well as summarizing the inherent land characteristics, the tables have notes on drainage and distribution of the constituent land units, and brief descriptions of geology, geomorphology, and climate of the land system. Data given for climate are average figures for different parts of the land system and are not the variations from year to year at a particular station.

In some land systems, small areas of other land systems, too small to be mapped, are included. Where these are of any importance they are listed as main inclusions, in a footnote to the tables.

II. Stable Tertiary Land Surface

The Stable Tertiary Land Surface in this region includes large areas of Tertiary swamps and lake alluvia in the central portion, lateritic plains throughout the region, and non-lateritic plains in the southern part of the region. The topography is nearly flat to undulating and, in general, there has been little or no post-Tertiary dissection. The seven geomorphological units within this subdivision are shown in Table 14 together with their constituent land systems. Table 14 also summarizes the major characteristics of these land systems and their differentiating factors.

(i) *Land Systems of the Tertiary Lateritic Plain* (*Wonorah, Pollyarra, Beetaloo, Elliott*).—These four land systems have deep lateritic soils which have been only slightly modified since the Tertiary Period. However, differences in the nature of the parent rock have resulted in the formation of different Tertiary lateritic soils, e.g. the highly arenaceous parent material of the Ashburton sandstones gave rise to Lateritic Red Sands (Elliott Land System), whereas the less arenaceous Carpentaria complex, Warramunga and Mullaman Groups, and Pilpah sandstones generally gave rise to Lateritic Red Earths and Lateritic Podzolic soils (Wonorah, Pollyarra, and Beetaloo Land Systems).

The Wonorah Land System occurs in lower-rainfall areas (mostly less than 17 in. per annum). The vegetation is mainly *E. brevifolia* Woodland or *Eucalyptus* spp. (low mallees) — *Acacia* spp. Shrubland.

The Pollyarra and Beetaloo Land Systems both have mean annual rainfalls of 17-25 in. The Pollyarra Land System carries predominantly *E. dichromophloia* Woodland whereas the Beetaloo Land System is characterized by *Acacia shirleyi* (lancewood) Forest.

(ii) *Land System of the Low-level Tertiary Lateritic Plain* (*Westmoreland*).—The deep lateritic soils of the Westmoreland Land System, the only one in this geomorphological unit, have been less modified since the Tertiary Period than those of the Tertiary Lateritic Plain, and Tertiary Lateritic Podzolic soils are dominant. Tertiary Lateritic Red Earths do not occur. The rainfall (22-30 in. per annum) is higher than for the first geomorphological unit and the vegetation is mostly *E. tetrodonta* — *E. miniata* Shrubland Open Forest.

(iii) *Land Systems of the Tertiary Non-lateritic Plain* (*Camil, Camilrock*).—This unit, formed on calcareous sediments, occurs only in the southern part of the region where the mean annual rainfall is less than 12 in. Both land systems are characterized by leached Tertiary Non-lateritic soils carrying *Triodia pungens* Shrub Grassland. In the Camil Land System there is a fairly uniform soil cover which, in the extreme south, has been weakly eroded with redeposition in narrow depressions within the land system. The Camilrock Land System is similar in the gently undulating topography, but there are many limestone outcrops in

TABLE 14

LAND SYSTEMS OF THE STABLE TERTIARY LAND SURFACE WITH THEIR MAJOR CHARACTERISTICS AND DIFFERENTIATING FACTORS

Geomorphological Unit	Differentiating Factors	Land System	Most Common Topography, Soil, and Vegetation
Tertiary Lateritic Plain	(1) Parent material not highly arenaceous		
	(*a*) Lower rainfall ($<$17 in. per annum)	Wonorah (Table 15)	Gently undulating; Lateritic Red Earths; *E. brevifolia* Woodland or *E.* spp. (low mallees) — *Acacia* spp. Shrubland
	(*b*) Higher rainfall (17-25 in. per annum)		
	(i) Mostly *E. dichromophloia* Woodland	Pollyarra (Table 16)	Gently undulating; Lateritic Red Earth and Lateritic Podzolic soils; *E. dichromophloia* Woodland and *E. brevifolia* Woodland
	(ii) Mostly *Acacia shirleyi* Forest	Beetaloo (Table 17)	Gently undulating; Lateritic Red Earth and Lateritic Podzolic soils; *Acacia shirleyi* Forest
	(2) Parent material highly arenaceous	Elliott (Table 18)	Gently undulating; Lateritic Red Sands; *Jacksonia odontoclada* — *Acacia* spp. Scrub
Low-level Tertiary Lateritic Plain	Low-lying, downwarped part of the lateritic land surface near the Gulf of Carpentaria	Westmoreland (Table 19)	Gently undulating; Tertiary Lateritic Podzolic soils; *E. tetrodonta* — *E. miniata* Shrubland Open Forest
Non-lateritic Tertiary Plain	(1) Uniform non-lateritic soil cover formed during Tertiary weathering cycle	Camil (Table 20)	Gently undulating; Tertiary Non-lateritic soils; *Triodia pungens* Shrub Grassland
	(2) Many limestone outcrops at end of Tertiary weathering cycle	Camilrock (Table 21)	Gently undulating; Tertiary Non-lateritic soils and many limestone outcrops; *Triodia pungens* Shrub Grassland

TABLE 14 (*Continued*)

Geomorphological Unit	Differentiating Factors	Land System	Most Common Topography, Soil, and Vegetation
Tertiary Plain with Aeolian Limestone	Lateritic soils modified by deposits of aeolian limestone derived from Tertiary lakes	Prentice (Table 22)	Gently undulating with low limestone rises; Calcified Lateritic soils; *E. argillacea* — *E. terminalis* Shrub Woodland
Tertiary Swamp	(1) Low rainfall (10 in. per annum)	Argadargada (Table 23)	Very gently undulating; Southern Heavy Grey Pedocals; *Astrebla pectinata* Grassland and *Acacia georginae* — *Astrebla pectinata* Woodland
	(2) Medium rainfall (10-18 in. per annum) (3) Higher rainfall (15-20 in. per annum)	Barkly (Table 24)	Very gently undulating; Heavy Grey Pedocals; *Astrebla pectinata* Grassland
	(a) Better drained areas	Cresswell (Table 25)	Very gently undulating; Northern Heavy Grey Pedocals; *Eulalia fulva* — *Dichanthium fecundum* Grassland
	(b) Wetter areas	Joanundah (Table 26)	Very gently undulating; Northern Heavy Grey Pedocals; *E. microtheca* — *Eulalia fulva* — *Dichanthium fecundum* Woodland
Tertiary Lake Alluvia	Not regularly flooded, extremely cracked soil	Drylake (Table 27)	Very gently undulating; Drylake Heavy Grey Pedocals; *E. microtheca* Shrub Woodland
Tertiary Lake Limestone	(1) Higher rainfall or poorer drainage	Austral (Table 28)	Very gently undulating; Heavy Grey Pedocals and Heavy Brown Pedocals; *Astrebla pectinata* Grassland and *Acacia georginae* — *Astrebla pectinata* Woodland
	(2) Lower rainfall or better drainage	Tobermorey (part) (Table 29)	Undulating; Limestone Calcareous Desert soils; *Acacia georginae* — *Cassia* spp. or *E. terminalis* — *Cassia* spp. Shrub Woodland

the Tertiary Non-lateritic soils and shallow Limestone Calcareous Desert soils have formed on one of these since the Tertiary Period.

(iv) *Land System of the Tertiary Plain with Aeolian Limestone* (*Prentice*).—The only land system in this unit is characterized by low parallel rises of aeolian limestone which have been deposited on the Tertiary Lateritic plain. Some of the lateritic soils between the rises have been heavily impregnated with lime.

(v) *Land Systems of the Tertiary Swamp* (*Barkly, Creswell, Joanundah, Argadargada*).—These four land systems all have heavy "black soils" mostly with grassland vegetation and a very gently sloping topography. The unit occurs over a wide climatic range, the mean annual rainfall ranging from 10 in. in the southern part of the region to 22 in. to the east of Anthony Lagoon Homestead. There are gradual changes in the vegetation and soils over this range and thus transition areas between the land systems are broad.

The Barkly Land System, which is the most extensive in the region, occupies most of the area of "black-soil" plains commonly referred to as the Barkly Tableland. It has a mean annual rainfall ranging from 10 to 18 in., the soils are Heavy Grey Pedocals and the vegetation is *Astrebla pectinata* Grassland. Low, gravelly rises with gilgais in some parts are characteristic of the land system. On the map the proportions of gravelly and stony rises are indicated by B_1 (few or no rises), B_2 (intermediate), and B_3 (rises comprise one-third to one-half the area).

The Creswell Land System is the northern portion of the Barkly Tableland "black-soil" plains and adjoins the Barkly Land System. The mean annual rainfall is 15-20 in. The soils are Northern Heavy Grey Pedocals and the typical vegetation *Eulalia fulva* — *Dichanthium fecundum* Grassland.

The Joanundah Land System also has a mean annual rainfall of 15-20 in. but it occurs on wetter areas near streams or receives run-off from higher, neighbouring country. The soils are Northern Heavy Grey Pedocals which carry *E. microtheca* — *Eulalia fulva* — *Dichanthium fecundum* Woodland.

Argadargada Land System in the southern part of the region has a mean annual rainfall of less than 10 in., but receives some run-off and eroded material from neighbouring higher country. The soils are Southern Heavy Grey Pedocals and the vegetation is *Astrebla pectinata* Grassland or *Acacia georginae* (gidgee) — *Astrebla pectinata* Woodland.

(vi) *Land System of the Tertiary Lake Alluvia* (*Drylake*).—The only land system of this unit is characterized by the extremely "ashy" or friable, extremely cracked Drylake Heavy Grey Pedocals which carry *E. microtheca* Shrub Woodland.

TABLE 15

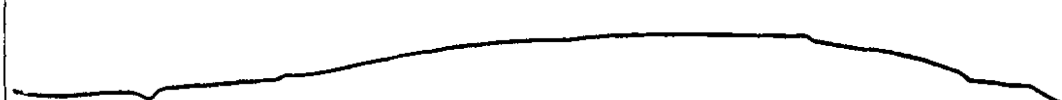
WONORAH LAND SYSTEM (9,700 SQ. MILES)

Location and general description	Gently undulating country with deep lateritic soil and low, scrubby vegetation. There is one large area in the south-west and numerous scattered areas in the central and eastern portions				
Climate	Wettest locality: av. ann. rainfall 20 in.; estimated growing periods: agricultural exceeds 12 weeks in 30%, 16 weeks in 10% of years; pastoral exceeds 12 weeks in 75%, 16 weeks in 50% of years. Corresponding values for driest locality: 12 in.; 10%, nil, 30%, 10%				
Geology and geomorphology	Part of the Tertiary Lateritic Plain formed on parent materials which were not highly arenaceous (rocks of the Carpentaria complex, Barkly, Warramunga, and Mullaman Groups). In some places the Tertiary surface soils have been truncated and the eroded material redeposited in the shallow depressions within the land system				
Topography	Very shallow, linear depressions	Long, gentle slopes and very low rises	Low gravelly rises	Fringing slopes	Nearly flat adjacent land systems
Cross section and relative areas					
	Small	Large	Large	Very small	
Distribution of units	Principally long, gentle slopes and very low rises broken by irregular areas of gravelly rises and linear, shallow depressions; the fringing slope occurs as a band 2–6 chains wide at the edge of the heavy soil land systems				
Vegetation	*E. pruinosa* Shrub Woodland or *E. argillacea*—*E. terminalis* Shrub Woodland	*E. brevifolia* Woodland or *E. dichromophloia* Woodland	*E.* spp. (low mallees)—*Acacia* spp. Shrubland or *E. brevifolia* Woodland	*Ventilago viminalis* Shrub Woodland	Grasslands and Woodlands
Soils	Red-brown Desert Alluvial soils	Lateritic Red Earths with small areas of Lateritic Red Sands	Gravelly Lateritic Red Earths	Variable transition soils of medium texture	Heavy pedocal soils
Drainage	No streamlines, but run-off drains into shallow depressions within the land system				

Main inclusions: Tennant Creek, Yelvertoft, Prentice.

TABLE 16

POLLYARRA LAND SYSTEM (4,100 SQ. MILES)

Location and general description	A discontinuous strip of gently undulating, sparsely timbered country with lateritic soils extending E. from Newcastle Waters to the Queensland border			
Climate	Wettest locality: av. ann. rainfall 25 in.; estimated growing periods: agricultural exceeds 12 weeks in 40%, 16 weeks in 20% of years; pastoral exceeds 12 weeks in 85%, 16 weeks in 65% of years. Corresponding values for driest locality: 17 in., 20%, 5%, 60%, 40%			
Geology and geomorphology	Part of the Tertiary Lateritic Plain formed on parent materials which were not highly arenaceous (rocks of the Mullaman Group, Robinson Beds, and Carpentaria complex). In some places the Tertiary lateritic formations have been weakly truncated and the headwaters of Gulf streams have dissected the northern and eastern edge			
Topography	Linear flats with or without streamlines	Gentle slopes	Gentle slopes	Moderate to steep dissection slopes
Cross section and relative areas				
	Small	Large	Large	Very small
Distribution of units	The two gently undulating units are greatly intermixed and are intersected by the linear flats; the dissection slopes occur mostly at the northern edge of the land system at the heads of the Gulf streams			
Vegetation	Variable, mostly *E. argillacea*—*E. terminalis*—*E. tectifica* Woodland; also fringing communities	*E. dichromophloia* Woodland	*E. brevifolia* Woodland	*Acacia shirleyi* Forest or *E. brevifolia* Woodland
Soils	Tertiary Lateritic Flat soils	Tertiary Lateritic Red Earths	Gravelly Tertiary Lateritic Podzolic soils	Skeletal soils on exposed lateritic horizons
Drainage	Widely spaced, senile streamlines which follow the drainage lines of the Tertiary Period			

Main inclusions: Creswell, Joanundah, Beetaloo, Kilgour.

TABLE 17

BEETALOO LAND SYSTEM (3,600 SQ. MILES)

Location and general description	Gently undulating country with various lateritic soils, mostly with lancewood Forest, in the NW. corner of the region			
Climate	Wettest locality: av. ann. rainfall 20 in.; estimated growing periods: agricultural exceeds 12 weeks in 35%, 16 weeks in 20% of years; pastoral exceeds 12 weeks in 80%, 16 weeks in 65% of years. Corresponding values for driest locality: 17 in., 20%, 5%, 65%, 40%			
Geology and geomorphology	Part of the Tertiary Lateritic Plain formed on parent materials which were not highly arenaceous (rocks of the Mullaman Group, Robinson Beds, and Carpentaria complex). In some places the Tertiary lateritic formations have been weakly truncated			
Topography	Flats with or without streamlines	Gentle Slopes	Gentle slopes	Moderate slopes
Cross section and relative areas				
	Very small	Medium	Medium	Medium
Distribution of units	The two units with gentle slopes are intermixed and are cut by linear flats; the moderate dissection slopes occur adjacent to streamlines			
Vegetation	*Acacia shirleyi* Forest with fringing communities along streams	*Acacia shirleyi* Forest	*E. dichromophloia* Woodland with *Jacksonia odontoclada*—*Acacia* spp. Scrub on sandy parts	*Acacia shirleyi* Forest or *E. brevifolia* Woodland
Soils	Tertiary Lateritic Flat soils	Tertiary Lateritic Red Earths	Tertiary Lateritic Podzolic soils; sandy or gravelly	Skeletal soils on exposed lateritic horizons
Drainage	Widely spaced, senile streamlines which follow the drainage pattern of the Tertiary Period			

Main inclusions: Pollyarra, Creswell, Joanundah.

TABLE 18

ELLIOTT LAND SYSTEM (4,000 SQ. MILES)

Location and general description	Deep sandy, gently undulating, scrubby or sparsely timbered country with poorly developed dune formations in some parts. It occurs mainly in the W. part of the region				
Climate	Wettest locality: av. ann. rainfall 18 in.; estimated growing periods: agricultural exceeds 12 weeks in 25%, 16 weeks in 5% of years: pastoral exceeds 12 weeks in 70%, 16 weeks in 45% of years. Corresponding values for driest locality: 12 in., 15%, nil, 50%, 15%				
Geology and geomorphology	Parts of the Tertiary Lateritic Plain formed on the highly arenaceous Ashburton Sandstones. The lower parts have received accessions of sandy material from higher, stony areas of the Ashburton Land System in which the sandy Tertiary soils have been truncated and dissected				
Topography	Gently sloping upland	Ashburton Land System	Stony, moderate to gentle slopes	Gentle slopes with weak dune formations	Low, flat areas adjacent to heavy soils
Cross section and relative areas					
	Medium		Small	Large	Very small
Distribution of units	The first unit occurs at higher altitudes within, or adjacent to, the Ashburton Land System, the second and third units at lower altitudes to the east and west of the Ashburton Land System, and the fourth unit adjacent to heavy-soil land systems				
Vegetation	*Bauhinia cunninghamii*—*Gyrocarpus americanus* Woodland or *Jacksonia odontoclada* —*Acacia* spp. Scrub		*E. brevifolia* Woodland	*Jacksonia odontoclada* —*Acacia* spp. Scrub	*E. microtheca*—*Tristania grandiflora* Woodland on sandy Tertiary Lateritic Flat soils and *Ventilago viminalis* Shrub Woodland on variable transition soils
Soils	Tertiary Lateritic Red Sands		Shallow, very stony, sandy soils	Tertiary Lateritic Red Sands	
Drainage	No development of a surface drainage pattern but streamlines arising in Ashburton Land System traverse this land system				

Main inclusion: Ashburton.

TABLE 19

WESTMORELAND LAND SYSTEM (7,000 SQ. MILES)

Location and general description	Gently undulating, timbered country between the coastal plains of the Gulf of Carpentaria and the inland, hilly country				
Climate	Wettest locality: av. ann. rainfall 30 in.; estimated growing periods: agricultural exceeds 12 weeks in 70%, 16 weeks in 35% of years; pastoral exceeds 12 weeks in 95%, 16 weeks in 85% of years. Corresponding values for driest locality: 20 in., 25%, 5%, 85%, 65%				
Geology and geomorphology	The only land system on the Low-level Tertiary Lateritic Plain, which resulted from post-Tertiary downwarping of the Gulf of Carpentaria. It is formed on rocks of the Carpentaria complex and Robinson Beds (non-calcareous except for some limestone and basic igneous intrusions). Dissection of the lateritic formations is confined to the inland edges of the land system				
Topography	Steep to moderate dissection slopes	Gentle slopes (N. section)	Depressions and flats along streamlines	Gentle slopes (S. section)	Very gentle slopes near edge of Keighran Land System
Cross section and relative areas					
	Small	Large	Small	Medium	Very small
Distribution of units	The second and fourth units dominate the higher-rainfall and the lower-rainfall areas respectively and are both traversed by bands of the third unit; the first unit occurs only along the inland edges and the fifth along the coastal edge				
Vegetation	*E. brevifolia* Woodland or *Terminalia canescens—E. setosa* Woodland	*E. tetrodonta—E. miniata* Shrubland Open Forest or *Callitris intratropica* Shrub Open Forest	*Melaleuca leucadendron* Woodland (N.), *E. argillacea —E. terminalis* Shrub Woodland (S.)	*E. dichromophloia* Woodland or *E. brevifolia* Woodland	*Melaleuca leucadendron* Woodland
Soils	Skeletal soils	Tertiary Lateritic Podzolic soils	Tertiary Lateritic Flat soils	Tertiary Lateritic Podzolic soils	Poorly drained Tertiary Lateritic Podzolic soils
Drainage	Moderately drained by senile, widely-spaced, small creeks which flow into the major coastal streams traversing the Keighran Land System				

Main inclusions: Keighran, Redbank, Robinson.

TABLE 20

CAMIL LAND SYSTEM (3,700 SQ. MILES)

Location and general description	This gently undulating country with spinifex and low shrubs has leached limestone soils; it occurs as one large and a number of small areas W. of Lake Nash Homestead			
Climate	Wettest locality: av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 10% of years, never exceeds 16 weeks; pastoral exceeds 12 weeks in 35%, 16 weeks in 10% of years. Corresponding values for driest locality: 10 in., 5%, nil, 25%, nil			
Geology and geomorphology	Part of the Tertiary Non-lateritic Plain formed on highly calcareous sediments of the Barkly Group. In some places the Tertiary surface soils have been eroded and redeposited on lower slopes and in depressions within the land system			
Topography	Nearly flat plains	Very gentle lower slopes and depressions at foot of gravelly hills	Gravelly and stony, rounded, low hills	Very gentle lower slopes adjoining heavy-soil areas
Cross section and relative areas				
	Large	Small (in S. only)	Medium (in S. only)	Very small
Distribution of units	The N. part of the land system is almost exclusively of the first unit; the S. part contains considerable areas of the third and second units, which are always associated; the fourth unit occurs only at the edge of adjacent heavy-soil land systems			
Vegetation	*Triodia pungens* Shrub Grassland	*Acacia georginae—Cassia* spp. Shrub Woodland	*Acacia aneura* Woodland	*Acacia georginae—Cassia* spp. Shrub Woodland
Soils	Tertiary Non-lateritic soils	Red-brown Desert Alluvial soils	Gravelly, weakly truncated, Tertiary Non-lateritic soils	Red-brown Desert Alluvial soils
Drainage	The N. parts have no evidence of drainage but the S. parts have weakly developed drainage lines which rise in the gravelly low hills and terminate in depressions within the land system			

Main inclusions: Camilrock, Argadargada.

TABLE 21

CAMILROCK LAND SYSTEM (400 SQ. MILES)

Location and general description	Several small areas of gently undulating country with numerous limestone outcrops, and carrying spinifex and low shrubs to the W. and NW. of Lake Nash Homestead		
Climate	Wettest locality: av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 10% of years, never exceeds 16 weeks; pastoral exceeds 12 weeks in 35%, 16 weeks in 10% of years. Corresponding values for driest locality: 10 in., 5%, nil, 30%, nil		
Geology and geomorphology	Part of the Tertiary Non-lateritic Plain formed on the highly calcareous sediments of the Barkly Group. The Tertiary soils have not been truncated		
Topography	Very gently sloping plains	Very low, stony rises	Very shallow depressions
Cross section and relative areas			
	Large	Medium	Very small
Distribution of units	The units occur as a complex mixture of small areas		
Vegetation	*Triodia pungens* Shrub Grassland	*Triodia pungens* Shrub Grassland; *Acacia georginae*—*Cassia* spp. Shrub Woodland	*Astrebla pectinata* Grassland
Soils	Tertiary Non-lateritic soils	Limestone outcrops; Limestone Calcareous Desert soils	Heavy Brown Pedocals
Drainage	The only drainage is in poorly defined gutters which rise on the low stony rises and terminate in the shallow depressions		

Main inclusion: Camil.

TABLE 22

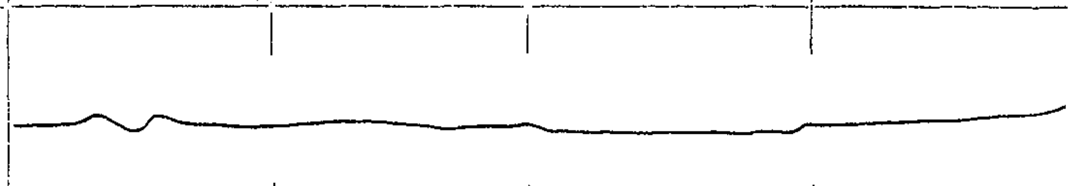
PRENTICE LAND SYSTEM (1,100 SQ. MILES)

Location and general description	Gently undulating country carrying scrubby vegetation and occurring between Wonorah and Frewina on the Barkly Highway		
Climate	Av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 15% of years, never exceeds 16 weeks; pastoral exceeds 12 weeks in 45%, 16 weeks in 10% of years		
Geology and geomorphology	Part of the Tertiary Lateritic Plain on which wind-blown calcareous material from the Tertiary lakes to the N. has been deposited in low, parallel (NW.-SE.) rises		
Topography	Low, parallel limestone rises up to 12 ft. high	Gently sloping plain	Very low rises
Cross section and relative areas			
	Medium	Large	Medium
Distribution of units	The low rises are irregularly distributed in the gently sloping plain; the parallel limestone rises are spaced 5–40 ch. apart		
Vegetation	*E. terminalis*—*Cassia* spp. Shrub Woodland	*E. argillacea*—*E. terminalis* Shrub Woodland	
Soils	Limestone boulders and Limestone Calcareous Desert soils	Tertiary Lateritic Red Earths	Calcified Lateritic soils
Drainage	Drainage lines are absent but there may be some run-off from the limestone rises onto the neighbouring plains		

Main inclusions: Tobermorey, Wonorah.

TABLE 23

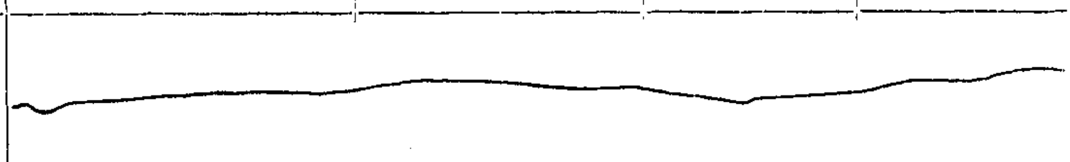
ARGADARGADA LAND SYSTEM (400 SQ. MILES)

Location and general description	Irregular areas of nearly flat Mitchell grass plains SW. of Lake Nash Homestead with low trees (gidgee) in some areas			
Climate	Av. ann. rainfall 10 in.; estimated growing periods: agricultural exceeds 12 weeks in 5% of years, never exceeds 16 weeks; pastoral exceeds 12 weeks in 30%, never exceeds 16 weeks			
Geology and geomorphology	Parts of the Tertiary Swamp, formed on calcareous rocks of the Barkly Group, surrounded by Tertiary Non-lateritic Plains from which they have received alluvial material			
Topography	Creek with levee and adjacent narrow depressions	Nearly flat plains	Very shallow depressions	Very gentle slopes adjoining Camil Land System
Cross section and relative areas				
	Very small	Large	Small	Medium
Distribution of units	The fourth unit occurs adjacent to Camil Land System; the second unit in the central portions of the larger plains; the first and third occur as narrow bands through the two previous units			
Vegetation	*Acacia georginae*—*Astrebla pectinata* Woodland with *E. microtheca* fringing community along streams	*Astrebla pectinata* Grassland	*Acacia georginae*—*Astrebla pectinata* Woodland	*Acacia georginae*—*Astrebla pectinata* Woodland
Soils	Heavy-textured alluvial soils	Southern Heavy Grey Pedocals (with heavier textured surface)	Southern Heavy Grey Pedocals (with heavier textured surface)	Southern Heavy Grey Pedocals
Drainage	In general, this land system has no drainage; it may be flooded for short periods by run-off from neighbouring higher country or from the Sandover River			

Main inclusion: Camil.

TABLE 24

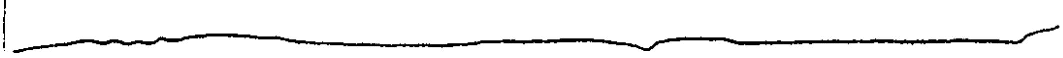
BARKLY LAND SYSTEM (15,800 SQ. MILES)

Location and general description	Very gently undulating to nearly flat Mitchell grass plains covering much of the area commonly referred to as the Barkly Tableland			
Climate	Wettest locality: av. ann. rainfall 20 in.; estimated growing periods: agricultural exceeds 12 weeks in 25%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 65%, 16 weeks in 40% of years. Corresponding values for driest locality: 10 in., 5%, nil, 30%, nil			
Geology and geomorphology	This is one of the land systems of the Tertiary Swamp which is composed of material derived from calcareous rocks of the Barkly and Mullaman Groups overlain by, or intermixed with, fine-textured swamp alluvia			
Topography	Extensive gently sloping plains with widely-spaced small streamlines	Low, gravelly rises with varying degrees of gilgai development	Shallow depressions which may have minor drainage lines	Stony rises
Cross section and relative areas				
	Large	Medium	Small	Small
Distribution of units	The depressions occur as widely-spaced, linear bands and the gravelly and stony rises are irregularly distributed in extensive areas of the gently undulating plain; on the map the proportions of gravelly and stony rises are indicated by B_1 (few or no rises), B_2 (intermediate), and B_3 (rises comprise one-third to one-half of the area)			
Vegetation	*Astrebla pectinata* Grassland or *E. microtheca*—*Astrebla pectinata* Woodland, with *E. microtheca* fringing community along streams	*Sporobolus australasicus*—*Enneapogon* spp. Grassland	*Astrebla elymoides* Grassland or *E. microtheca*—*Astrebla elymoides* Woodland	*Ventilago viminalis* Shrub Woodland and some dense patches of *Acacia georginae*
Soils	Heavy Grey Pedocals	Heavy Grey Pedocals with much chert gravel on surface	Heavy Grey Pedocals	Heavy Grey Pedocals with gravel or stone
Drainage	The weakly-developed drainage system of widely-spaced small streams drains either into the Barkly internal drainage basin or into tributaries of the Georgina and Gregory Rivers			

Main inclusions: Wonorah, Creswell, Sylvester.

TABLE 25

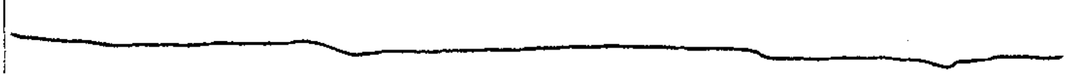
CRESWELL LAND SYSTEM (2,500 SQ. MILES)

Location and general description	Discontinuous areas of very gently undulating to nearly flat black-soil grasslands extending from Newcastle Waters to E. and SE. of Creswell Homestead		
Climate	Wettest locality: av. ann. rainfall 20 in; estimated growing periods: agricultural exceeds 12 weeks in 35%, 16 weeks in 10% of years; pastoral exceeds 12 weeks in 70%, 16 weeks in 45% of years. Corresponding values for driest locality: 15 in., 20%, 5%, 65%, 20%		
Geology and geomorphology	One of the land systems of the Tertiary Swamp which is composed of material derived from calcareous rocks of the Barkly and Mullaman Groups overlain by, or intermixed with, fine-textured swamp alluvia		
Topography	Low rises with gilgais	Nearly flat plain with widely-spaced small streams	Very shallow depressions
Cross-section and relative areas			
	Small	Large	Very small
Distribution of units	The depressions occur as widely-spaced linear bands; the low rises occur irregularly within the nearly flat plain		
Vegetation	*Sporobolus australasicus*—*Enneapogon* spp. Grassland with some scattered low trees and shrubs	*Eulalia fulva*—*Dichanthium fecundum* Grassland with *E. microtheca* fringing community along streamlines	*Astrebla elymoides* Grassland or *E. microtheca*—*Astrebla elymoides* Woodland
Soils	Northern Heavy Grey Pedocals with gilgais	Northern Heavy Grey Pedocals	Northern Heavy Grey Pedocals
Drainage	Weakly-developed drainage system of widely-spaced small streams which drain into the Barkly internal drainage basin		

Main inclusions: Joanundah, Barkly, Pollyarra, Beetaloo, Sylvester.

TABLE 26

JOANUNDAH LAND SYSTEM (1,400 SQ. MILES)

Location and general description	Several small areas of very gently undulating black-soil plains carrying coolibah occurring E. of Newcastle Waters and N. and E. of Creswell Homestead		
Climate	Wettest locality: av. ann. rainfall 20 in.; estimated growing periods: agricultural exceeds 12 weeks in 35%, 16 weeks in 10% of years; pastoral exceeds 12 weeks in 70%, 16 weeks in 45% of years. Corresponding values for driest locality: 15 in., 20%, 5%, 65%, 20%		
Geology and geomorphology	One of the land systems of the Tertiary Swamp, composed of material derived from calcareous rocks of the Barkly and Mullaman Groups overlain by, or intermixed with, fine-textured swamp alluvia		
Topography	Very gentle slopes fringing desert areas or very low islands in the heavy-soil plains	Nearly flat plains with rough surface	Shallow depressions with or without small stream channels
Cross section and relative areas			
	Small	Large	Small
Distribution of units	The second unit occurs over large areas which are intersected by narrow bands of the third unit; the first unit always occurs as an irregular band adjacent to neighbouring "desert" land systems		
Vegetation	*E. pruinosa*—*E. microtheca* Shrub Woodland	*E. microtheca*—*Eulalia fulva*—*Dichanthium fecundum* Woodland	*E. microtheca*—*Astrebla elymoides* Woodland
Soils	Northern Heavy Grey Pedocals or transition to Tertiary Lateritic Flat soils	Northern Heavy Grey Pedocals	Northern Heavy Grey Pedocals
Drainage	Run-off from neighbouring higher country may produce temporary flooding before the waters are removed by the widely-spaced small streams which flow into the Barkly internal drainage basin		

Main inclusions: Creswell, some Wonorah, Pollyarra, Beetaloo.

TABLE 27

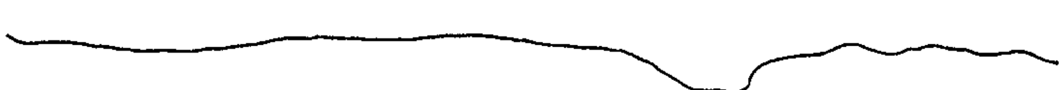
DRYLAKE LAND SYSTEM (2,200 SQ. MILES)

Location and general description	These very gently undulating lightly timbered plains, which occupy the lowest parts of the local topography, occur in irregular areas between Elliott and Brunette Downs Homestead. The fluffy soils are locally called drybog	
Climate	Wettest locality: av. ann. rainfall 17 in.; estimated growing periods: agricultural exceeds 12 weeks in 25%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 65%, 16 weeks in 40% of years. Corresponding values for driest locality: 14 in., 15%, 5%, 55%, 10%	
Geology and geomorphology	The only land system of the Tertiary Lake Alluvia which consist of fine-textured calcareous sediments. They were deposited in the Tertiary Lakes of the Barkly internal drainage basin which have dried up as a result of the low present-day rainfall. According to local information they may be flooded for short periods in very wet years	
Topography	Nearly flat plains, lower than the surrounding land systems, irregular surface with very wide cracks, sink-holes, and gilgais	Very cherty, low, parallel rises, 2 ch. wide, 6 ft. high
Cross section and relative areas	 Large	Very small
Distribution of units	The low, narrow rises occur widely scattered within, or at the edge of, the nearly flat areas	
Vegetation	*E. microtheca* Shrub Woodland	*Sporobolus australasicus*—*Enneapogon* spp. Grassland
Soils	Drylake Heavy Grey Pedocals	Very cherty, grey, medium-textured soils with gilgais
Drainage	No external drainage; may be partially flooded by run-off from surrounding higher land systems in very wet years	

Main inclusions: Sylvester, Barkly, Cresswell.

TABLE 28

AUSTRAL LAND SYSTEM (2,400 SQ. MILES)

Location and general description	A number of small areas of gently undulating Mitchell grass plains near Brunette Downs Homestead in the Barkly Basin and between Austral Downs and Carandotta Homesteads in the Georgina Basin			
Climate	Wettest locality: av. ann. rainfall 15 in; estimated growing periods: agricultural exceeds 12 weeks in 15%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 60%, 16 weeks in 20% of years. Corresponding values for driest locality: 10 in., 5%, nil, 25%, nil			
Geology and geomorphology	Portions of the exposed Tertiary Lake Limestones on which mostly heavy clay soils have formed. These sediments have not been dissected except by stream bed entrenchment of the Georgina River and its major tributaries			
Topography	Shallow depression lines	Very gentle slopes	Stream channel	Low stony rises with gentle to moderate slopes
Cross section and relative areas	 Small	Large	Very small	Small
Distribution of units	The first and third units occur as linear bands, the fourth unit as irregular small areas within the second unit			
Vegetation	*Astrebla elymoides* Grassland or *E. microtheca*—*Astrebla elymoides* Woodland	*Astrebla pectinata* Grassland or *Acacia cambagei*—*Astrebla pectinata* Woodland	*E. microtheca* fringing community	*E. terminalis*—*Cassia* spp. Shrub Woodland
Soils	Heavy Grey Pedocals	Heavy Grey Pedocals or Heavy Brown Pedocals	—	Limestone Calcareous Desert soils and skeletal soils
Drainage	Widely-spaced small streamlines of irregular pattern			

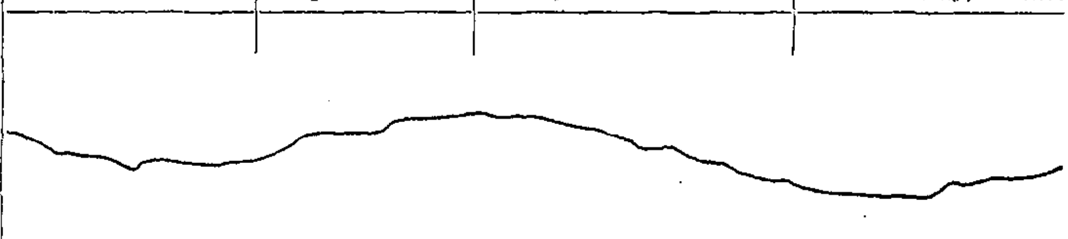
Main inclusions: Tobermorey, Kallala.

(vii) *Land Systems of the Tertiary Lake Limestones* (*Austral, Tobermorey* (*part*)).—On these limestones Heavy Grey Pedocals or Heavy Brown Pedocals with *Astrebla pectinata* Grassland have formed in the more poorly-drained or the higher-rainfall areas and Limestone Calcareous Desert soils on well-drained areas and those with lower rainfall.

The Austral Land System consists primarily of heavy soil grassland areas with small inclusions of the Limestone Calcareous Desert soils.

TABLE 29

TOBERMOREY LAND SYSTEM (2,300 SQ. MILES)

Location and general description	This sparsely timbered undulating to gently undulating country with some low hills occurs S. of Lake Nash Homestead and in a number of small areas between Alroy Downs and Eva Downs Homesteads			
Climate	Wettest locality: av. ann. rainfall 17 in.; estimated growing periods: agricultural exceeds 12 weeks in 20%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 60%, 16 weeks in 30% of years. Corresponding values for driest locality: 10 in., 5%, nil, 25%, nil			
Geology and geomorphology	Part of the Tertiary Lake Limestones and other limestones exposed in the Dissected Tertiary Non-lateritic Plain and Dissected Tertiary Swamp. The low rainfall and good external drainage are responsible for the low rate of weathering in these shallow soils			
Topography	Streamlines with narrow flats	Stepped moderate slopes	Irregular moderate slopes	Narrow depressions between stony, low rises
Cross section and relative areas				
	Small	Medium	Large	Very small
Distribution of units	The first unit occurs as narrow bands and the fourth unit as irregular small areas within the two major units; the second unit occurs only in the S. portion of the land system			
Vegetation	*Acacia georginae—Astrebla pectinata* Woodland with *E. microtheca* fringing community along streams	*Acacia georginae—Cassia* spp. Shrub Woodland or *E. terminalis—Cassia* spp. Shrub Woodland		*Astrebla pectinata* Grassland or *Acacia georginae—Astrebla pectinata* Woodland
Soils	Deep forms of Limestone Calcareous Desert soils	Limestone Calcareous Desert soils and skeletal soils with small patches of Heavy Brown Pedocals		Heavy Brown Pedocals or Heavy Grey Pedocals
Drainage	The small areas do not have a defined drainage pattern but the large area in the S. portion of the land system has a well-defined, moderately intense, dendritic pattern of small drainage lines			

Main inclusions: Austral, Wonardo.

The Tobermorey Land System consists primarily of the areas of Limestone Calcareous Desert soils. Similar soils have formed on limestones exposed in the Dissected Tertiary Swamp and Dissected Non-lateritic Tertiary Plain of the Erosional Land Surface Subdivision and these areas have been included in the Tobermorey Land System.

III. EROSIONAL LAND SURFACES

In these areas the Tertiary peneplain has been dissected and the present land surface has been formed mainly on the underlying pre-Tertiary rocks. The topography varies from undulating plains to low hills and rugged ridges cut by narrow, steep-sided valleys and gorges. On

TABLE 30

LAND SYSTEMS OF THE EROSIONAL LAND SURFACE WITH THEIR MAJOR CHARACTERISTICS AND DIFFERENTIATING FACTORS

Geomorphological Unit	Differentiating Factors	Land System	Most Common Topography, Soil, and Vegetation
Dissected Non-lateritic Tertiary Plain	Limestones exposed by erosion of Tertiary Non-lateritic soils	Tobermorey (part) (Table 29)	Undulating to low hilly; Limestone Calcareous Desert soils; *Acacia georginae* — *Cassia* spp. or *E. terminalis* — *Cassia* spp. Shrub Woodlands
Dissected Tertiary Swamp	(1) Lower rainfall or better drainage	Tobermorey (part)	As above
	(2) Higher rainfall or poorer drainage	Wonardo (Table 31)	"Black-soil" plains; Heavy Grey Pedocals or Heavy Brown Pedocals; *Astrebla pectinata* Grassland
Dissected Country of Georgina Basin without Lateritic Remnants	(1) Parent material granitic	Waverley (Table 32)	Undulating to low hilly country; mostly skeletal soils; *E. brevifolia* Woodland
	(2) Parent material steeply folded sedimentary and igneous rocks	Mt. Isa (part) (Table 33)	Rugged, hilly country with N.-S. ridges; mostly rock outcrops or skeletal soils; *E. brevifolia* Woodland
Dissected Country of Gulf Fall without Lateritic Remnants	(1) Lower rainfall (15-20 in. per annum)		
	(*a*) Parent material steeply folded sedimentary and igneous rocks	Mt. Isa (part)	As above
	(*b*) Parent material highly calcareous	Thorntonia (Table 34)	Rough, rounded hills or stepped slopes; skeletal soils and rock outcrops; *E. argillacea* — *E. terminalis* Shrub Woodland or *Terminalia* spp. — *Bauhinia cunninghamii* — *Cochlospermum* sp. Shrub Woodland

Table 30 (*Continued*)

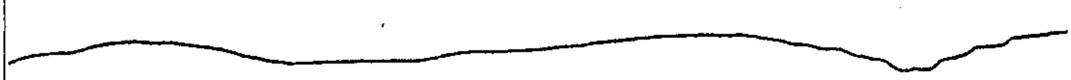
Geomorphological Unit	Differentiating Factors	Land System	Most Common Topography, Soil, and Vegetation
	(2) Higher rainfall (20-30 in. per annum)		
	(*a*) Parent material highly calcareous	Rolyat (Table 35)	Gently undulating country; mostly limestone outcrops with some Limestone Red Soils; *Terminalia* spp. — *Bauhinia cunninghamii* — *Cochlospermum* sp. Shrub Woodland or *E. argillacea* — *E. terminalis* Woodland
	(*b*) Parent material mostly strongly jointed sandstones and quartzites	Robinson (Table 36)	Rough topography with large rock masses separated by steep-sided gorges; skeletal soils and rock outcrops; *E. brevifolia*, *E. dichromophloia*, or *E. aspera* Woodlands
	(*c*) Parent material broadly folded sedimentary, metamorphic, and igneous rocks	Redbank (part) (Table 37)	Hilly country; mostly skeletal soils with *E. brevifolia* or *E. dichromophloia* Woodlands on "acid" rocks and *E. argillacea* — *E. terminalis* Woodland on limestones
Dissected Country of Gulf Fall with Lateritic Remnants	(1) Higher rainfall (20-30 in. per annum)		
	(*a*) Parent material broadly folded sedimentary, metamorphic, and igneous rocks	Redbank (part)	As above
	(*b*) Parent material mostly calcareous shales	Kilgour (Table 38)	Steeply to gently undulating country; mostly Podzolic Truncated Lateritic soils and Kilgour Heavy Grey Pedocals; *E. brevifolia* Woodland and *Astrebla pectinata* Grassland respectively

TABLE 30 (*Continued*)

Geomorphological Unit	Differentiating Factors	Land System	Most Common Topography, Soil, and Vegetation
	(2) Lower rainfall (15-20 in. per annum)		
	(*a*) Parent material steeply folded rocks, extensive alluvial valleys	Mitchiebo (part) (Table 39)	Undulating to low hilly country; skeletal or Podzolized Desert Alluvial soils; *E. brevifolia* Woodland or *E. pruinosa* and *E. argillacea*—*E. terminalis* Shrub Woodland
	(*b*) Parent material steeply folded or subhorizontal rocks, small alluvial valleys	Yelvertoft (part) (Table 40)	Hilly to undulating country; mostly skeletal soils or truncated gravelly Lateritic Red Earths; *E. brevifolia* or *E. dichromophloia* Woodland
Dissected Country of Georgina Basin with Lateritic Remnants	Parent material steeply folded or subhorizontal rocks, small alluvial valleys	Yelvertoft (part)	As above
Dissected Country of Barkly Basin with Lateritic Remnants	(1) Dissection has not exposed underlying steeply folded or subhorizontal rocks, small alluvial valleys	Yelvertoft (part)	See above
	(2) Dissection has exposed some of the underlying subhorizontal sandstones	Ashburton (Table 41)	Hilly country; skeletal soils; *E. brevifolia* or *E. dichromophloia* Woodland
	(3) Dissection has exposed some of the underlying metamorphic rocks	Tennant Creek (Table 42)	Flat-topped hills and broad valleys; skeletal and alluvial soils; *E. brevifolia* Woodland
	(4) Dissection has exposed some of the underlying volcanic rocks	Helen Springs (Table 43)	Gently undulating to low hilly country; skeletal soils, Igneous Calcareous Desert and Heavy Pedocal soils; *E. brevifolia* Woodland, *Terminalia grandifolia* Woodland, and *Astrebla pectinata* Grassland respectively
	(5) Dissection has not exposed underlying steeply folded rocks, extensive alluvial valleys	Mitchiebo (part)	As for Dissected Country of Gulf Fall with Lateritic Remnants

TABLE 31

WONARDO LAND SYSTEM (5,200 SQ. MILES)

Location and general description	Irregular areas of gently undulating to nearly flat Mitchell grass plains confined to the Georgina valley in the SE. portion of the region			
Climate	Wettest locality: av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 15%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 60%, 16 weeks in 25% of years. Corresponding values for driest locality: 10 in., 5%, nil, 30%, nil			
Geology and geomorphology	Dissected Tertiary Swamp with deep heavy soils formed on the exposed calcareous rocks of the Barkly Group			
Topography	Moderate to gentle slopes with gilgais	Narrow depressions	Moderate to gentle slopes	Streamlines with adjacent stony slopes
Cross section and relative areas				
	Large	Small	Large	Very small
Distribution of units	The first and third units are greatly intermixed and are traversed by narrow bands of the second and fourth units			
Vegetation	*Astrebla pectinata* Grassland or *Acacia georginae—Astrebla pectinata* Woodland	*Astrebla elymoides* Grassland	*Astrebla pectinata* Grassland	*E. microtheca* fringing community along creeks and *Acacia georginae—Cassia* spp. Woodland on slopes
Soils	Heavy Grey Pedocals or Heavy Brown Pedocals	Heavy Grey Pedocals	Heavy Grey Pedocals or Heavy Brown Pedocals	Heavy Grey Pedocals or Heavy Brown Pedocals with limestone boulders
Drainage	Moderately intense, dendritic drainage pattern of small streams which flow into the Georgina River and its tributaries			

Main inclusions: Georgina, Tobermorey.

TABLE 32

WAVERLEY LAND SYSTEM (1,200 SQ. MILES)

Location and general description	A broken strip of hilly lightly-timbered granite country with mostly steep to moderate slopes which extends from the SE. corner of the region to N. of Mt. Isa			
Climate	Wettest locality: av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 10% of years, never exceeds 16 weeks; pastoral exceeds 12 weeks in 50%, 16 weeks in 30% of years. Corresponding values for driest locality: 10 in., 5%, nil, 25%, nil			
Geology and geomorphology	Maturely dissected granitic rocks which are exposed in the Dissected Country of the Georgina Basin without Lateritic Remnants			
Topography	Hills with moderate to steep slopes	Gentle to moderate slopes	Gentle slopes frequently on the bottom of valleys between hills	Creeks, very narrow levees, and associated flats in the broader valleys
Cross section and relative areas				
	Medium	Medium	Medium	Small
Distribution of units	The first three units are intermixed and the fourth occurs as narrow bands along some streamlines			
Vegetation	*E. brevifolia* Woodland or *E.* spp. (low mallees)—*Acacia* spp. Shrubland	*E. pruinosa* Shrub Woodland	*E. argillacea—E. terminalis* Shrub Woodland	*Acacia cambagei* Shrub Woodland with fringing communities along creeks
Soils	Skeletal soils with rounded granite boulders	Very gritty, shallow soils	Granitic Desert Loams	Brown alluvial soils
Drainage	Well-developed drainage system of many small streamlines forming a dendritic pattern			

Main inclusions: Mt. Isa, Bundella, Yelvertoft.

the steeply sloping country there are large areas with rock outcrops and skeletal soils.

The geomorphological units within the Erosional Land Surface are listed in Table 30, together with the constituent land systems and the major characteristics and differentiating factors of those land systems.

TABLE 33

MT. ISA LAND SYSTEM (8,400 SQ. MILES)

Location and general description	This lightly-timbered, rugged, hilly country with N.–S. ridges extends from the SE. corner of the area to about 120 miles N. and W. of Lawn Hill Homestead			
Climate	Wettest locality: av. ann. rainfall 22 in.; estimated growing periods: agricultural exceeds 12 weeks in 30%, 16 weeks in 10% of years; pastoral exceeds 12 weeks in 80%, 16 weeks in 65% of years. Corresponding values for driest locality: 10 in., 5%, nil, 25%, nil			
Geology and geomorphology	Portions of the Dissected Country of the Georgina Basin and Gulf Fall with Lateritic Remnants where rocks of the Carpentaria complex have been exposed. These are steeply-dipping, interbedded sandstones, quartzites, shales, limestones, and greenstones			
Topography	Rugged steep slopes	Rugged steep slopes	Lower moderate slopes	Alluvial valley floors with streamlines
Cross section and relative areas				
	Medium	Large	Medium	Small
Distribution of units	The first and second units are intermixed and form parallel sharp ridges in the S. where the rocks dip most steeply; the third unit occurs as an irregular fringe to the steep slopes and the fourth as narrow bands along streamlines			
Vegetation	*Terminalia* spp.—*Bauhinia cunninghamii*—*Cochlospermum* sp. Shrub Woodland	*E. brevifolia* Woodland	*E. pruinosa* Shrub Woodland	*E. argillacea*—*E. terminalis* Woodland on Deep Yellow, Podzolic soils in N., *Acacia cambagei* Shrub Woodland on Georgina Alluvial Red-brown Earths in S.
Soils	Rock outcrops or skeletal soils on basic rocks such as limestones and greenstones	Rock outcrops or skeletal soils on acidic rocks such as sandstones, quartzites, and shales	Colluvial stony slopes, some Shallow Yellow Podzolic soils in N., formed from acidic rocks	
Drainage	Intense drainage system of irregular pattern			

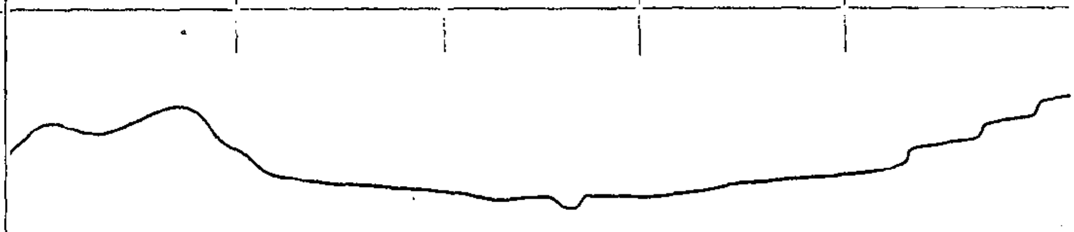
Small patches of heavy pedocal soils with *Astrebla pectinata* Grassland occur on basic rocks.
Main inclusions: Yelvertoft, Waverley.

(i) *Land Systems of Dissected Non-lateritic Plain* (*Tobermorey* (*part*)).—In these portions of the Tobermorey Land System post-Tertiary erosion of the leached Tertiary Non-lateritic soils has exposed limestones of the Barkly Group on which shallow Calcareous Desert soils have since been formed. The topography is undulating to low hilly.

(ii) *Land Systems of Dissected Tertiary Swamp* (*Tobermorey* (*part*) *and Wonardo*).—In the Georgina Basin the Tertiary Swamp has been weakly dissected to an undulating topography and the calcareous sediments of the Barkly Group have been exposed. In the lower-rainfall areas, or on some of the steeper slopes where drainage is good, Limestone Calcareous Desert soils have formed and these are included in the Tobermorey Land System. On the other hand, the Wonardo Land System has Heavy Grey or Heavy Brown Pedocal soils which have formed in higher rainfall or more poorly-drained situations.

TABLE 34

THORNTONIA LAND SYSTEM (2,700 SQ. MILES)

Location and general description	Several areas of rough, rounded, limestone hills or stepped slopes with sparse timber in the headwaters of the Gregory and O'Shannessy Rivers, i.e. between Lawn Hill Homestead and Undilla Homestead				
Climate	Wettest locality: av. ann. rainfall 21 in.; estimated growing periods: agricultural exceeds 12 weeks in 25%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 75%, 16 weeks in 55% of years. Corresponding values for driest locality: 17 in., 15%, 5%, 65%, 30%				
Geology and geomorphology	Dissected Country of the Gulf Fall without Lateritic Remnants where the nearly horizontal calcareous sediments of the Barkly Group (Cambrian) have been exposed				
Topography	Rocky, rounded hills	Gentle slopes	Flats with streamlines	Gentle slopes	Stepped slopes with limestone exposed at breaks
Cross section and relative areas					
	Large	Very small	Very small	Very small	Medium
Distribution of units	In the S. part of the land system the fifth unit occurs with small areas of the third and fourth, but the central and N. portions are dominated by the first unit with small areas of the second, third, and fourth units				
Vegetation	*E. argillacea—E. terminalis* Shrub Woodland and *Terminalia* spp.—*Bauhinia cunninghamii—Cochlospermum* sp. Shrub Woodland	*E. argillacea—E. terminalis* Woodland	*E. argillacea—E. terminalis* Woodland	*Astrebla pectinata* Grassland	*E. argillacea—E. terminalis* Woodland and Shrub Woodland
Soils	Skeletal soils and rock outcrops	Limestone Calcareous Desert Soils	Brown alluvial soils	Heavy Grey Pedocals	Limestone Calcareous Desert Soils and skeletal soils
Drainage	Well drained by an intensive, somewhat dendritic pattern of streamlines; the larger streams are spring fed and flow throughout the dry season				

Main inclusion: Yelvertoft.

(iii) *Land Systems of Dissected Country of the Georgina Basin without Lateritic Remnants (Waverley, Mt. Isa (part))*.—Tributaries of the Georgina River which rise in the south-east corner of the region have maturely-dissected Pre-Cambrian rocks in their head-water sections. These rocks include granites and gneisses and the Carpentaria complex of steeply folded metamorphic and sedimentary rocks.

The Waverley Land System is formed on the granites and gneisses and has undulating to low hilly topography. It has bare rounded boulders, or skeletal soils and some small areas of Desert Loam and brown alluvial soils.

TABLE 35
ROLYAT LAND SYSTEM (300 SQ. MILES)

Location and general description	Gently undulating timbered country with many outcrops of platy limestone in the headwaters of the McArthur River	
Climate	Av. ann. rainfall 21 in.; estimated growing periods: agricultural exceeds 12 weeks in 35%, 16 weeks in 15% of years; pastoral exceeds 12 weeks in 75%, 16 weeks in 55% of years	
Geology and geomorphology	Formed on limestones of the Barkly Group which are exposed in the Dissected Country of the Gulf Fall without Lateritic Remnants	
Topography	Gentle slopes	Low rises of boulders
Cross section and relative areas	 Medium	Medium
Distribution of units	The two units are intimately intermixed	
Vegetation	*E. argillacea—E. terminalis* Woodland	*Terminalia* spp.—*Bauhinia cunninghamii—Cochlospermum* sp. Shrub Woodland
Soils	Shallow Limestone Red soils with boulders and outcrops	Surface of boulders with pockets of red soils between
Drainage	Well drained by moderately intense, dendritic drainage pattern	

TABLE 36
ROBINSON LAND SYSTEM (3,600 SQ. MILES)

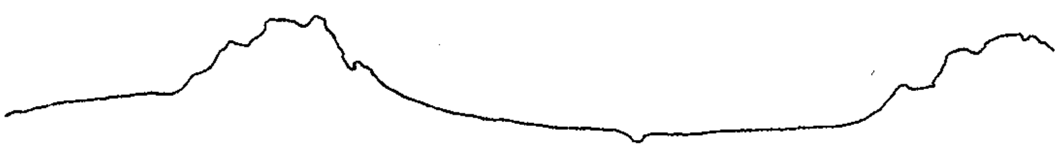
Location and general description	These irregular areas of timbered, rugged country, which have large rock slopes separated by steep-sided gorges, occur between Lawn Hill Homestead and O.T. Homestead				
Climate	Wettest locality: av. ann. rainfall 30 in.; estimated growing periods: agricultural exceeds 12 weeks in 70%, 16 weeks in 35% of years; pastoral exceeds 12 weeks in 95%, 16 weeks in 85% of years. Corresponding values for driest locality: 20 in., 25%, 10%, 75%, 50%				
Geology and geomorphology	Part of the Dissected Country of the Gulf Fall in which almost complete removal of the Tertiary lateritic land surface has exposed the underlying sandstones and quartzites of the Robinson Beds and Carpentaria complex				
Topography	Nearly level stony truncated lateritic areas	Nearly level areas with irregular sandstone masses	Steep-sided gorges	Very rocky, steep slopes	Colluvial lower slopes, springs, and streams
Cross section and relative areas	 Small	Large	Small	Large	Small
Distribution of units	The first, second, and fourth units are intermixed and are cut by narrow bands of the third and fifth units				
Vegetation	*E. tetrodonta—E. miniata* Shrubland Open Forest	*E. dichromophloia, E. brevifolia*, or *E. aspera* Woodlands	*E. aspera* Woodland	*E. brevifolia* or *E. aspera* Woodland	*E. argillacea—E. terminalis—E. tectifica* Woodland with fringing forest along streams and *E. ptychocarpa* Forest near springs
Soils	Shallow gravelly soils	Rock outcrops and some sandy skeletal soils	Bare rock and skeletal soils	Bare rock and some sandy skeletal soils	Sandy Deep Yellow Podzolic soils
Drainage	Intensely developed drainage system of irregular pattern with some spring-fed streams				

Main inclusions: Redbank, Mt. Isa, Pollyarra.

The Mt. Isa Land System, formed on rocks of the Carpentaria complex, is rugged, hilly country mostly with rock outcrops and skeletal soils. This land system extends into the next geomorphological unit.

TABLE 37

REDBANK LAND SYSTEM (7,300 SQ. MILES)

Location and general description	These discontinuous areas of timbered, hilly country cut by narrow valleys occur from Corinda Homestead to beyond the McArthur River					
Climate	Wettest locality: av. ann. rainfall 30 in.; estimated growing periods: agricultural exceeds 12 weeks in 70%, 16 weeks in 35% of years; pastoral exceeds 12 weeks in 95%, 16 weeks in 85% of years. Corresponding values for driest locality: 22 in., 30%, 10%, 80%, 60%					
Geology and geomorphology	Part of the Dissected Country of the Gulf Fall with some remnants of the Tertiary lateritic land surface. The base rocks are interbedded, moderately dipping sandstones, limestones, acid volcanics, and shales of the Carpentaria complex					
Topography	Lower gentle slopes on shales	Steep slopes with rock outcrops	Lower gentle slopes on acidic volcanics or sandstones	Very gentle sloping valley floors	Lower gentle slopes on limestones	Rocky steep slopes
Cross section and relative areas						
	Small	Large	Small	Very small	Small	Large
Distribution of units	The second and sixth units are intermixed, with small irregular areas of the first, third, and fifth and narrow bands of the fourth units along some streamlines					
Vegetation	*Melaleuca acacioides* Woodland	*E. brevifolia* or *E. dichromophloia* Woodlands	*E. tetrodonta*—*E. miniata* Shrubland Open Forest	*Melaleuca leucadendron* low Open Forest	*E. argillacea*—*E. terminalis*—*E. tectifica* Woodland	*E. argillacea*—*E. terminalis* Woodland with *Terminalia* spp.—*Bauhinia cunninghamii*—*Cochlospermum* sp. Shrub Woodlands on outcrops
Soils	Shallow Yellow Podzolic soils	Skeletal soils on sandstones and acid volcanics	Deep Sandy Yellow Podzolic soils	Deep Yellow Podzolic soils on alluvium	Limestone Red soils	Skeletal soils on limestones
Drainage	Intensely developed drainage system of irregular pattern, some spring-fed streams					

Main inclusions: Keighran, Robinson, Westmoreland

(iv) *Land Systems of the Dissected Country of the Gulf Fall without Lateritic Remnants (Mt. Isa (part), Thorntonia, Rolyat, Robinson, Redbank (part))*.—As in the previous geomorphological unit, erosion has removed all evidence of the Tertiary land surface but in this unit dissection has been by streams flowing into the Gulf of Carpentaria.

The Thorntonia and Rolyat Land Systems are both formed on highly calcareous shales and limestones of the Barkly Group but they differ in topography, soils, and vegetation. The Thorntonia Land System, which has a mean annual rainfall of 17-21 in., consists of rough, rounded, limestone hills or stepped hills with mostly skeletal soils and some Limestone Calcareous Desert soils. The Rolyat Land System, with a mean annual

(v) *Land Systems of the Dissected Country of the Gulf Fall with Lateritic Remnants* (*Redbank* (*part*), *Kilgour, Yelvertoft* (*part*), *and Mitchiebo* (*part*)).—There are two sections in the Gulf Division where lateritic remnants occur as a result of dissection encroaching on the lateritic Tertiary land surface:

(1) In the head waters of the Gulf streams, and

(2) On the inland margin of the Low-level Tertiary Lateritic Plain.

TABLE 39

MITCHIEBO LAND SYSTEM (1,800 SQ. MILES)

Location and general description	A single area, N. of Alexandria Homestead, of undulating to low hilly country with leached soils and Woodland or Shrub Woodland vegetation				
Climate	Wettest locality: av. ann. rainfall 20 in.; estimated growing periods: agricultural exceeds 12 weeks in 30%, 16 weeks in 10% of years; pastoral exceeds 12 weeks in 70%, 16 weeks in 50% of years. Corresponding values for driest locality: 16 in., 20%, 5%, 65%, 25%				
Geology and geomorphology	Parts of the Dissected Country with Lateritic Remnants of the Gulf Fall and Barkly Basin in which dissection and truncation have rarely proceeded below the Tertiary lateritic formations. The underlying rocks are part of the Carpentaria complex. Limited drainage beyond the land system has resulted in considerable areas of local alluviation				
Topography	Upland, gently sloping areas	Stony, moderately sloping dissection areas	Very gentle slopes fringing flats	Nearly flat areas	Flats with streamlines
Cross section and relative areas					
	Medium	Medium	Very small	Small	Medium
Distribution of units	The first and second units occur together and are intermixed with the fifth unit; the fourth occurs as small, irregular areas in the lower parts of the topography and is surrounded by narrow bands of the third unit				
Vegetation	*E. brevifolia* or *E. dichromophloia* Woodlands or *E. pruinosa* Shrub Woodland	*E. brevifolia* Woodland	*Ventilago viminalis* Shrub Woodland	*Eulalia fulva—Dichanthium fecundum* Grassland or *E. microtheca—Eulalia fulva—Dichanthium fecundum* Woodland	*E. pruinosa* or *E. argillacea—E. terminalis* Shrub Woodlands
Soils	Slightly truncated Lateritic Red Earths or Lateritic Podzolic soils	Skeletal soils on lateritic horizons or underlying rocks	Variable transition soils of medium texture	Northern Heavy Grey Pedocals	Podzolized Desert Alluvial soils
Drainage	Drained by moderately intense, irregular pattern of small streamlines which mostly terminate within the land system				

In both areas remnants of the lateritic profile remain as features of the present-day land surface. The Kilgour Land System is the only one which is wholly within this geomorphological unit. It occurs along the northern edge of the Tertiary Lateritic Plain and has patches of "black soils" formed where the underlying sediments of the Mullaman Group have been exposed. In the Yelvertoft and Mitchiebo Land Systems dissection is mainly within the depth of the lateritic profile and these land systems are characterized by a variety of soils formed on various portions of the lateritic profile. Mitchiebo differs in that local alluviation has been more extensive than in

TABLE 40

YELVERTOFT LAND SYSTEM (2,300 SQ. MILES)

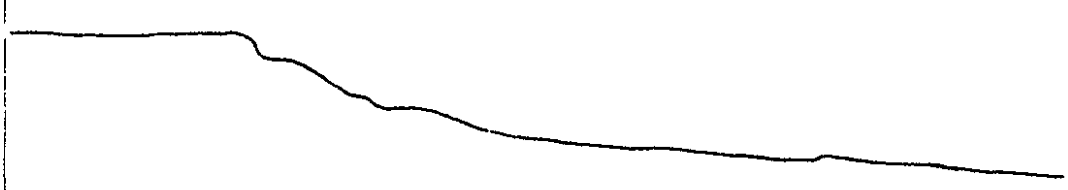
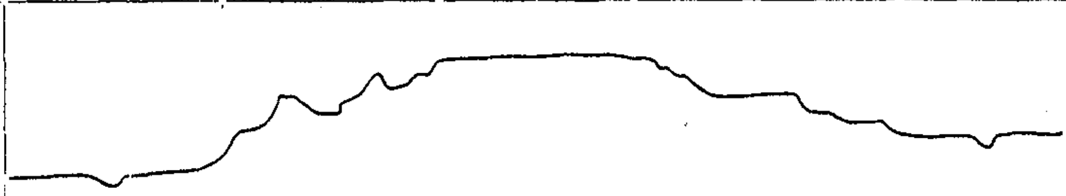
Location and general description	Numerous, widely separated areas of undulating timbered country in the S. half of the region with gravelly and stony lateritic soils			
Climate	Wettest locality: av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 20% of years, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 65%, 16 weeks in 25% of years. Corresponding values for driest locality: 13 in., 10%, nil, 40%, 10%			
Geology and geomorphology	Portions of the Dissected Country of the Gulf Fall with Lateritic Remnants of the Barkly Basin and Georgina Basin. Dissection has not exposed the rocks underlying the Tertiary lateritic formations			
Topography	Upland areas with gentle slopes	Stony dissection slopes	Nearly flat alluvial areas	Very gently sloping fringe to heavy soils
Cross section and relative areas				
	Large	Large	Small	Very small
Distribution of units	The first and second units are intermixed, the third unit occurs as bands at the foot of the second, and the fourth as narrow bands fringing adjacent heavy-soil land systems			
Vegetation	*E. brevifolia* or *E. dichromophloia* Woodlands or *E. pruinosa* Shrub Woodland	*E. brevifolia* or *E. aspera* Woodlands	*E. pruinosa* Shrub Woodland	*Ventilago viminalis* Shrub Woodland
Soils	Truncated gravelly Lateritic Red Earths	Skeletal soils on exposed lateritic horizons	Red-brown Desert Alluvial soils	Variable transition soils of medium texture
Drainage	Generally well drained by headwater tributaries which do not have a distinct drainage pattern			

TABLE 41

ASHBURTON LAND SYSTEM (1,500 SQ. MILES)

Location and general description	A strip of lightly timbered hilly country with many sandstone outcrops extending from Phillip Creek to Elliott in the W. part of the region				
Climate	Wettest locality: av. ann. rainfall 17 in.; estimated growing periods: agricultural exceeds 12 weeks in 25%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 70%, 16 weeks in 45% of years. Corresponding values for driest locality: 14 in., 15%, 5%, 45%, 10%				
Geology and geomorphology	Part of the Dissected Country of the Barkly Basin with Lateritic Remnants formed on sub-horizontally bedded Ashburton Sandstones with some exposures of these rocks and some alluvia				
Topography	Valley bottoms with streamlines (in S.)	Steep slopes with "billy" or sandstone outcrops	Nearly flat upland areas	Moderate slopes broken by irregular benches of sandstone or "billy"	Valley bottoms with streamlines (in N.)
Cross section and relative areas					
	Small	Small	Small	Large	Very small
Distribution of units	Small irregular areas of the second and third units occur within the fourth unit and first and fifth units occur along larger streamlines in the S. and N. respectively				
Vegetation	*Ventilago viminalis* or *E. pruinosa* Shrub Woodlands	*E. brevifolia* or *E. aspera* Woodlands	*Jacksonia odontoclada*—*Acacia* spp. Scrub	*E. brevifolia* or *E. dichromophloia* Woodlands	*E. pruinosa* Shrub Woodland
Soils	Red-brown Desert Alluvial soils, generally sandy	Skeletal soils	Tertiary Lateritic Red Sands	Skeletal soils	Podzolized Desert Alluvial soils
Drainage	An intense, irregular pattern of small streamlines but only the larger streamlines flow beyond the land system to terminate in the seasonal swamps of Gosse Land System				

Main inclusions: Elliott, Helen Springs.

Yelvertoft and Podzolized Desert Alluvial soils have developed on the alluvia. In the Yelvertoft Land System the areas of alluvia are small and have Red-brown Desert Alluvial soils. Both land systems extend beyond this geomorphological unit into areas being similarly dissected by inland-flowing streams.

TABLE 42

TENNANT CREEK LAND SYSTEM (900 SQ. MILES)

Location and general description	An area of lightly-timbered flat-topped hills and broad valleys in the SW. corner of the region				
Climate	Wettest locality: av. ann. rainfall 14 in.; estimated growing periods: agricultural exceeds 12 weeks in 15%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 45%, 16 weeks in 10% of years. Corresponding values for driest locality: 12 in., 10%, 5%, 35%, 10%				
Geology and geomorphology	Dissected Country of the Barkly Basin with Lateritic Remnants, formed on rocks of the Warramunga Group (slates, sandstones, quartzites, shales, and some granites), with some exposures of these rocks and some local alluvia				
Topography	Flat-topped hills	Steep and moderate dissection slopes with drainage lines	Gentle slopes	Very gently sloping valley bottoms	Steep-sided hills
Cross section and relative areas					
	Small	Large	Medium	Small	Small
Distribution of units	The second and third units are intermixed, with small areas of the first and fifth occurring irregularly within them; the fourth unit occurs as narrow bands along streamlines				
Vegetation	*E. brevifolia* Woodland		*E. pruinosa* Shrub Woodland or *Acacia aneura* Woodland	*E. argillacea*—*E. terminalis* Shrub Woodland	*E. brevifolia* Woodland
Soils	Truncated, gravelly or stony lateritic soils	Skeletal soils	Red-brown Desert Alluvial soils	Podzolized Desert Alluvial soils	Skeletal soils
Drainage	On the steeper topography the drainage pattern of small streamlines is intense, but many drainage lines terminate on the lower slopes and only the larger streams drain beyond the land system				

Main inclusion: Wonorah.

The area of dissected lateritic remnants at the inland margin of the Low-level Tertiary Lateritic Plain is not large. As the soils are skeletal and the vegetation is similar to that of the adjacent Redbank Land System, it has been included in that land system.

(vi) *Land Systems of Dissected Country of the Georgina Basin with Lateritic Remnants (Yelvertoft (part))*.—All of this unit is included in Yelvertoft Land System with similar country of the previous and following geomorphological units.

(vii) *Land Systems of Dissected Country of the Barkly Basin with Lateritic Remnants (Yelvertoft (part), Ashburton, Tennant Creek, Helen*

Springs, Mitchiebo (part)).—Streams of the Barkly Basin have dissected portions of the Tertiary lateritic land surface but the area dissected and the degree of dissection are much less than in the case of the Gulf Fall streams.

Portions of the Yelvertoft and Mitchiebo Land Systems occur in this geomorphological unit. The Mitchiebo Land System is being eroded by both Gulf Fall and Barkly Basin streams and the portion of the land system in this unit. The Yelvertoft Land System, which occurs in all three geomorphological divisions, is most extensive in the Barkly Basin where there are two large and several small areas.

TABLE 43

HELEN SPRINGS LAND SYSTEM (300 SQ. MILES)

Location and general description	Gently undulating to low hilly mixed grassland and lightly-timbered country occurring in small areas near Helen Springs Homestead in the W. part of the region					
Climate	Av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 15%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 55%, 16 weeks in 25% of years					
Geology and geomorphology	Part of the Dissected Country of the Barkly Basin with Lateritic Remnants, formed on Helen Springs volcanics with some exposures of these rocks and some local alluvia					
Topography	Gently sloping areas of Tertiary swamp at high levels	Moderately sloping Tertiary lateritic areas at high levels	Steep slopes on dissected Tertiary lateritic horizons	Moderate lower slopes on exposed volcanics	Gentle lower slopes on exposed volcanics	Flat areas of Recent alluvia at lowest levels
Cross section and relative areas						
	Medium	Small	Medium	Medium	Medium	Small
Distribution of units	The first and second units are intermixed at high levels, the third fringes the higher levels, and the fourth, fifth, and sixth units occur intermixed at lower levels					
Vegetation	*Astrebla pectinata* Grassland	*E. brevifolia* Woodland	*E. brevifolia* Woodland	*Terminalia grandiflora* Woodland	*Astrebla pectinata* Grassland	
Soils	Heavy Grey Pedocals or Heavy Brown Pedocals	Gravelly Lateritic Red Earths	Skeletal soils	Igneous Calcareous Desert soils	Heavy Grey Pedocals or Heavy Brown Pedocals	
Drainage	Well-defined, moderately intense, irregular pattern of small streamlines					

Main inclusion: Ashburton.

In the Tennant Creek, Helen Springs, and Ashburton Land Systems dissection has exposed the underlying non-lateritized rocks and the proportion of Tertiary lateritic land surface which remains is relatively small. These three land systems are distinguished by the nature of the parent rocks. The Ashburton Land System is formed on the highly siliceous rocks of the Ashburton sandstones, the Tennant Creek Land System on the metamorphics of the Warramunga Group, and Helen Springs Land System on the Helen Springs volcanics. Consequently there are differences in the soils formed on the exposed underlying rocks as well as differences in the lateritic soils.

IV. Post-Tertiary Depositional Land Surface

The streams which have dissected the country of the second geomorphological subdivision have provided a considerable amount of eroded material, part of which has been transported beyond the region into the Gulf of Carpentaria or down the Georgina River, and part of which has been deposited within the region over sufficiently large areas to map as land systems. Many of the land systems already described have small areas of alluvia which have been described as land units within these land systems. The more extensive areas of post-Tertiary deposits occur in the following places:

(1) In the shallow seas of the Gulf of Carpentaria, where sea recession has exposed the deposits at the margins.

(2) On river flood plains which, in general, are no longer subject to regular flooding.

(3) In internal drainage distributary systems, which now are only intermittent swamps; and

(4) In braided stream channels of the Georgina River system.

The geomorphological units of the Depositional Land Surface are listed in Table 44 along with the major characteristics and factors differentiating the constituent land systems.

(i) *Land Systems of the Post-Miocene Alluvia and Flood-plain Alluvia of Coastal Rivers (Littoral, Keighran, Gregory, Balbirini).*— These geomorphological units fringe the Gulf of Carpentaria and extend irregularly up in the valleys. Although flooding does occur infrequently, the maturity of soil profiles indicates that deposition is no longer active except in the littoral areas.

The origin of the alluvia has been a very important factor in determining the soils and vegetation.

The Littoral Land System is the low-lying, coastal part of the alluvia which is not completely removed from salt influence, and consists of sand dunes, salt flats, and salt meadows.

The Keighran Land System, which is formed on alluvia derived largely from non-calcareous rocks of the Robinson Beds and parts of the Carpentaria complex, has leached yellow podzolic soils with mostly *E. argillacea* — *E. terminalis* — *E. tectifica* Woodland.

The Gregory Land System is formed on alluvia derived mostly from calcareous rocks, namely, the Barkly Group and parts of the Carpentaria complex. It has Heavy Grey Pedocals with *Astrebla pectinata* Grassland

TABLE 44

LAND SYSTEMS OF THE DEPOSITIONAL LAND SURFACE WITH THEIR MAJOR CHARACTERISTICS AND DIFFERENTIATING FACTORS

Geomorphological Unit	Differentiating Factors	Land System	Most Common Topography, Soil, and Vegetation
Post-Miocene Coastal Alluvia and Flood Plain Alluvia of Coastal Rivers	(1) Subject to major salt influence	Littoral (Table 45)	Salt flats, salt meadows, and sand dunes with a variety of plant communities
	(2) Not subject to salt influence		
	(*a*) Derived mostly from non-calcareous rocks	Keighran (Table 46)	Gently undulating; Deep Yellow Podzolic soils; *E. argillacea* — *E. terminalis* — *E. tectifica* Woodland
	(*b*) Derived mostly from calcareous rocks		
	(i) Lower rainfall (19-23 in. per annum)	Gregory (Table 47)	Very gently undulating "black-soil" plains; Heavy grey Pedocals; *Astrebla pectinata* Grassland
	(ii) Higher rainfall (23-30 in. per annum)	Balbirini (Table 48)	Very gently undulating "black-soil" plains; Northern Heavy Grey Pedocals; *Eulalia fulva* — *Dichanthium fecundum* Grassland
Post-Miocene Fine-textured Alluvia of the Georgina Basin	(1) Only fine-textured alluvia	Kallala (Table 49)	Very gently undulating "black-soil" plains; Heavy Brown Pedocals; *Astrebla pectinata* Grassland or *Acacia georginae* — *Astrebla pectinata* Woodland
	(2) Fine- and medium-textured alluvia	Moonah (Table 50)	Gently undulating, mixed "black-soil" plains and "red-soil" rises; Heavy Brown Pedocals and Georgina Alluvial Red-brown Earths; *Astrebla pectinata* Grassland or *Acacia georginae* — *Astrebla pectinata* Woodland and *Acacia georginae* Shrub Woodland respectively

TABLE 44 (*Continued*)

Geomorphological Unit	Differentiating Factors	Land System	Most Common Topography, Soil, and Vegetation
Post-Miocene Coarse-textured Alluvia of the Georgina Basin	Coarse-textured alluvia, partly wind resorted	Bundella (Table 51)	Undulating; "Bundella" soils; *E. argillacea* — *E. terminalis* Shrub Woodland
Recent Coarse-textured Alluvia of the "Desert" Distributary Systems	Coarse-textured, non-calcareous alluvia, short seasonal flooding	Gosse (Table 52)	Flats; soils of the "Desert" Distributary Complex; *E. dichromophloia* Woodland, *E. pruinosa* or *E. argillacea* — *E. terminalis* Shrub Woodland
Recent Fine-textured Alluvia of the "Downs" Distributary Systems	Fine-textured, calcareous alluvia, seasonally flooded for long periods	Sylvester (Table 53)	"Bluebush swamps"; Distributary Heavy Grey Pedocals; *Chenopodium auricomum* Shrubland
Channel Alluvia of the Georgina River and Major Tributaries	Within braided stream channels, flooded for short periods	Georgina (Table 54)	Gently undulating "black-soil" plains cut by braided streamlines; Heavy Grey Pedocals; *Astrebla pectinata* Grassland

TABLE 45

LITTORAL LAND SYSTEM (1,200 SQ. MILES)

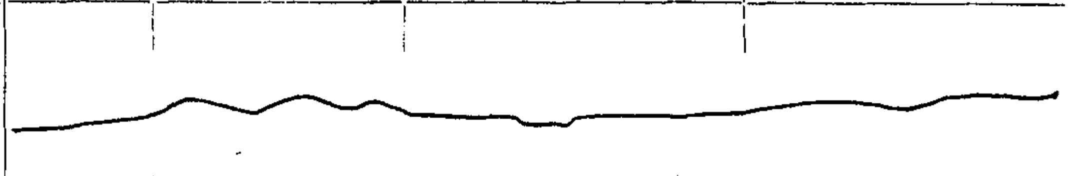
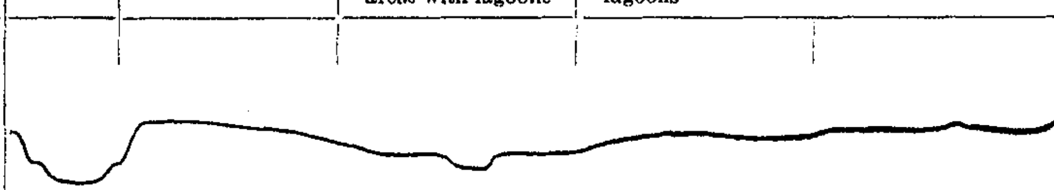
Location and general description	A continuous band of salt flats, salt meadows, and sand dunes along the coast of the Gulf of Carpentaria			
Climate	Wettest locality: av. ann. rainfall 30 in.; estimated growing periods: agricultural exceeds 12 weeks in 70%, 16 weeks in 35% of years; pastoral exceeds 12 weeks in 95%, 16 weeks in 85% of years. Corresponding values for driest locality: 27 in., 65%, 35%, 95%, 75%			
Geology and geomorphology	The portions of the Post-Miocene Alluvia that are still subject to a major salt influence			
Topography	Beach	Sand dunes	Salt flats with estuaries, frequently flooded with tidal waters	Gently undulating, slightly elevated areas; not subject to tidal flooding
Cross section and relative areas				
	Very small	Small	Large	Large
Distribution of units	The first and second units occur near the coast and generally parallel to it; the third occurs as an irregular large area behind these but extending to the coast near estuaries; the fourth occurs as irregular small areas within the third, and also as larger areas on the inland edge			
Vegetation	—	Sand dune communities	Salt flat community and mangrove fringing communities	*Xerochloa barbata* Grassland
Soils	—	Coastal Sand Dunes	Salt Marsh soils	Solonetzic soils
Drainage	By estuaries which traverse the land system, but the third unit is subject to tidal flooding and the fourth may be flooded when flood flow coincides with king tides			

TABLE 46

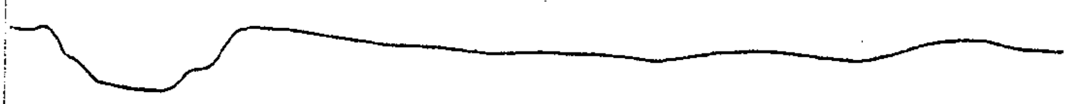
KEIGHRAN LAND SYSTEM (4,900 SQ. MILES)

Location and general description	Gently sloping, timbered plains adjoining the Littoral Land System and extending up the major river valleys				
Climate	Wettest locality: av. ann. rainfall 30 in.; estimated growing periods: agricultural exceeds 12 weeks in 70%, 16 weeks in 35% of years; pastoral exceeds 12 weeks in 95%, 16 weeks in 85% of years. Corresponding values for driest locality: 22 in., 30%, 10%, 85%, 65%				
Geology and geomorphology	Those areas of the Post-Miocene Coastal Alluvia and Flood-plain Alluvia of Coastal Rivers derived mostly from non-calcareous rocks. They are no longer subject to saline influence and are now above flood level following weak stream entrenchment due to Recent sea recession				
Topography	Rivers	Levees	Broad depression areas with lagoons	Nearly flat plains with old drainage lines and lagoons	
Cross section and relative areas					
	Very small	Small	Small	Large	Small
Distribution of units	The second and fifth units occur as parallel bands adjacent to the rivers; the broader inter-river areas are principally of the fourth unit with narrow irregular bands of the third unit				
Vegetation	Tall fringing forest communities	*E. papuana*—*E. tectifica* Woodland	*E. microtheca*—*Sorghum* sp. Woodland	*E. argillacea*—*E. terminalis*—*E. tectifica* Woodland	*E. tetrodonta*—*E. miniata* Shrubland Open Forest
Soils	—	Leached Brown Levee soils	Meadow Podzolic soils	Deep Yellow Podzolic soils	Deep Sandy Yellow Podzolic soils
Drainage	The land system is cut by many mature streams with deep channels running more or less parallel to one another and at right angles to the coast; these streams have no well-marked tributary or distributary systems				

Main Inclusions: Westmoreland, Redbank.

TABLE 47

GREGORY LAND SYSTEM (900 SQ. MILES)

Location and general description	Four areas of nearly treeless Mitchell grass plains associated with the Gregory River system in the NE. corner of the region			
Climate	Wettest locality: av. ann. rainfall 24 in.; estimated growing periods: agricultural exceeds 12 weeks in 40%, 16 weeks in 15% of years; pastoral exceeds 12 weeks in 85%, 16 weeks in 65% of years. Corresponding values for driest locality: 20 in., 20%, 5%, 75%, 50%			
Geology and geomorphology	One of the land systems of the Post-Miocene Coastal Alluvia and Post-Miocene Flood Plain Alluvia of Coastal Rivers derived mostly from calcareous rocks. As a result of stream entrenchment following Recent sea recession they are no longer subject to flooding			
Topography	Permanently flowing streamlines	Narrow levees	Slightly undulating plains with scattered gilgais	Slight rises of old levees
Cross section and relative areas				
	Very small	Very small	Large	Very small
Distribution of units	Large areas of the third unit are cut by narrow bands of the first, second, and fourth units			
Vegetation	Fringing forest	*E. papuana—E. tectifica* Woodland	*Astrebla pectinata* Grassland	Variant of *E. papuana —E. tectifica* Woodland
Soils	—	Brownish grey levee soils	Heavy Grey Pedocals	Alluvial Red-brown Earths of Gulf Fall
Drainage	Drained by a well-developed pattern of broadly anabranched streamlines of the Gregory River and Lawn Hill Creek drainage systems			

Main inclusions: Mt. Isa, Thorntonia.

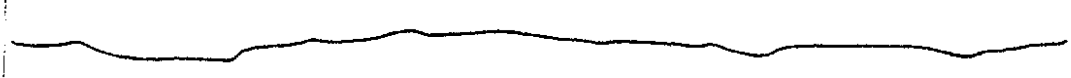
TABLE 48

BALBIRINI LAND SYSTEM (1,400 SQ. MILES)

Location and general description	Lightly timbered, "black-soil" plains occurring as small areas in river valleys in the NW. portion of the region with one larger area near Burketown in the east			
Climate	Wettest locality: av. ann. rainfall 30 in.; estimated growing periods: agricultural exceeds 12 weeks in 70%, 16 weeks in 35% of years; pastoral exceeds 12 weeks in 95%, 16 weeks in 85% of years. Corresponding values for driest locality: 23 in., 35%, 10%, 85%, 65%			
Geology and geomorphology	One of the land systems of the Post-Miocene Coastal Alluvia and Post-Miocene Flood Plain Alluvia derived mostly from calcareous rocks. They are no longer subject to saline influence and are above flood level owing to weak stream entrenchment following Recent sea recession or by lowering of base level of streams			
Topography	Slight rise of old levees	Slightly dissected sloping banks of major streams	Nearly flat plains	Nearly flat plains with limestone patches
Cross section and relative areas				
	Small	Small	Large	Small
Distribution of units	The third unit extends over large areas in all occurrences, but the first unit occurs as narrow, linear rises only near Borroloola, the second as linear bands along major rivers near Burketown, and the fourth as irregular areas near O.T. Downs			
Vegetation	*E. papuana— E. tectifica* Woodland	*E. microtheca* fringing community	*Eulalia fulva— Dichanthium fecundum* Grassland or *Bauhinia cunninghamii—Eulalia fulva—Dichanthium fecundum* Woodland	*Eulalia fulva— Dichanthium fecundum* Grassland, with patches *Terminalia* spp.— *Bauhinia cunninghamii— Cochlospermum* sp. Shrub Woodland
Soils	Gulf Alluvial Red-brown Earths	Northern Heavy Grey Pedocals	Northern Heavy Grey Pedocals	Northern Heavy Grey Pedocals with patches of skeletal soil
Drainage	In the E. section there is a well-developed pattern of braided stream channels associated with the Gregory River but in the NW. the areas are too small to have well-defined drainage patterns			

TABLE 49

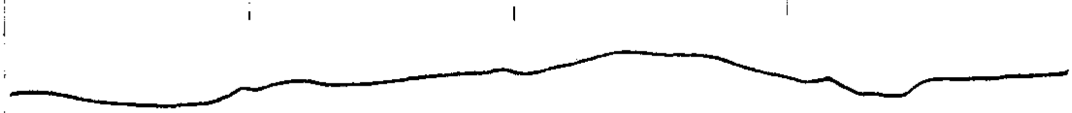
KALLALA LAND SYSTEM (3,900 SQ. MILES)

Location and general description	Numerous irregular areas of nearly flat Mitchell grass plains in the SE. portion of the region		
Climate	Wettest locality: av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 10% of years, never exceeds 16 weeks; pastoral exceeds 12 weeks in 50%, 16 weeks in 25% of years. Corresponding values for driest locality: 10 in., 5%, nil, 25%, nil		
Geology and geomorphology	The area of the Post-Miocene Fine-textured Alluvia of the Georgina Basin in which only fine-textured sediments occur. These alluvia are derived from the mixed rocks of the Carpentaria complex and granites which have been dissected by the eastern tributaries of the Georgina River		
Topography	Shallow linear depressions	Gently sloping plains with small areas of gilgais	Streamlines
Cross section and relative areas			
	Very small	Large	Very small
Distribution of units	The large areas of the second unit are cut by narrow bands of the first and third units		
Vegetation	*Astrebla elymoides* Grassland	*Astrebla pectinata* Grassland or *Acacia georginae—Astrebla pectinata* Woodland	*E. microtheca* fringing community
Soils	Heavy Grey Pedocals or Heavy Brown Pedocals	Heavy Brown Pedocals with some Heavy Grey Pedocals in N.	—
Drainage	Moderately drained by the shallow, linear depressions which empty into anabranched streams flowing from nearby hilly country through this land system and into the Georgina River		

Main inclusions: Moonah, Bundella.

TABLE 50

MOONAH LAND SYSTEM (400 SQ. MILES)

Location and general description	Mixed Mitchell grass plains and "red-soil" rises occurring as a number of small areas associated with streams in the SE. corner of the region			
Climate	Wettest locality: av. ann. rainfall 13 in.; estimated growing periods: agricultural exceeds 12 weeks in 5% of years, never exceeds 16 weeks; pastoral exceeds 12 weeks in 35%, 16 weeks in 10% of years. Corresponding values for driest locality: 10 in., 5%, nil, 25%, nil			
Geology and geomorphology	The area of the Post-Miocene Fine-textured Alluvia of the Georgina Basin in which both fine and medium-textured sediments occur. These alluvia have been deposited by tributaries of the Georgina River which rise in the mixed rocks of the Carpentaria complex and granites			
Topography	Shallow linear depressions	Gently sloping plains with small areas of gilgais	Low linear rises	Streamlines
Cross section and relative areas				
	Small	Large	Large	Very small
Distribution of units	The second and third units are intermixed and are cut by narrow bands of the first and fourth units			
Vegetation	*Astrebla elymoides* Grassland	*Astrebla pectinata* Grassland or *Acacia georginae—Astrebla pectinata* Woodland	*Acacia cambagei* Shrub Woodland	*E. microtheca* fringing community
Soils	Heavy Grey Pedocals or Heavy Brown Pedocals	Heavy Brown Pedocals	Georgina Alluvial Red-brown Earths	—
Drainage	Moderately well drained by the shallow, linear depressions which empty into anabranched streams flowing from nearby hilly country through this land system and into the Georgina River			

Main inclusions: Bundella, Kallala.

TABLE 51

BUNDELLA LAND SYSTEM (2,000 SQ. MILES)

Location and general description	Undulating, sandy, low-scrub country extending from Barkly Downs Homestead SE. and S. towards Ardmore Homestead	
Climate	Wettest locality: av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 10% of years, never exceeds 16 weeks; pastoral exceeds 12 weeks in 50%, 16 weeks in 25% of years. Corresponding values for driest locality: 10 in., 5%, nil, 30%, nil	
Geology and geomorphology	The Post-Miocene Coarse-textured Alluvia of the Georgina Basin which have been partly wind resorted. They are derived from metamorphics of the Carpentaria complex and granites	
Topography	Crests and upper slopes of undulations	Bottoms of undulations and lower slopes near the neighbouring heavy-soil plains
Cross section and relative areas	 Large	Medium
Distribution of units	The two units are generally intermixed but in some parts there are large areas of the first unit without the second	
Vegetation	*E. argillacea—E. terminalis* Shrub Woodland	*Acacia cambagei* Shrub Woodland
Soils	"Bundella" soils	Heavier-textured "Bundella" soils and some small areas of Georgina Alluvial Red-brown Earths
Drainage	There is no apparent drainage from this land system but it is traversed by widely-spaced streamlines which rise in nearby hilly country	

Main inclusions: Kallala, Yelvertoft.

TABLE 52

GOSSE LAND SYSTEM (300 SQ. MILES)

Location and general description	A number of small, scattered areas of sandy, seasonally flooded flats in the SW. "desert" portion of the region			
Climate	Wettest locality: av. ann. rainfall 16 in.; estimated growing periods: agricultural exceeds 12 weeks in 15%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 60%, 16 weeks in 35% of years. Corresponding values for driest locality: 12 in., 10%, nil. 35%, 10%			
Geology and geomorphology	Recent Coarse-textured Alluvia of the "Desert" Distributary Systems derived from dissection of lateritic profiles and the exposed underlying non-calcareous rocks			
Topography	Low, irregular, narrow hummocks of the distributary systems	Irregular, narrow, linear depressions of the distributary systems	Streamlines	Flats
Cross section and relative areas	 Medium	Medium	Small	Medium
Distribution of units	The first two units are very intimately intermixed; the fourth unit occurs as larger discrete areas; all are cut by narrow bands of the third unit			
Vegetation	*E. dichromophloia* Woodland	*E. pruinosa* Shrub Woodland	Fringing community	*E. argillacea—E. terminalis* or *E. pruinosa* Shrub Woodland
Soils	Sandy-rise soils of the Desert Distributary Complex	Depression soils of the Desert Distributary Complex	—	"Flat" soils of the Desert Distributary Complex
Drainage	These areas are the foci of internal drainage systems and are flooded for short periods each year, the flats being flooded for shorter periods than the distributary complex			

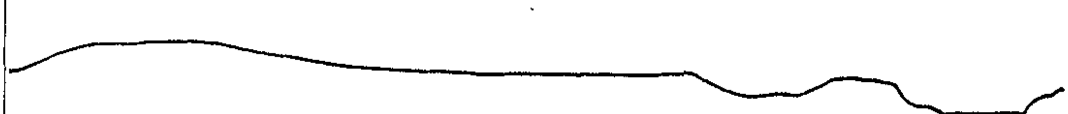
TABLE 53

SYLVESTER LAND SYSTEM (1,400 SQ. MILES)

Location and general description	Many small areas of bluebush swamp in the Barkly and Georgina Basins		
Climate	Wettest locality: av. ann. rainfall 17 in.; estimated growing periods: agricultural exceeds 12 weeks in 25%, 16 weeks in 5% of years; pastoral exceeds 12 weeks in 65%, 16 weeks in 45% of years. Corresponding values for driest locality: 10 in., 5%, nil, 25%, nil		
Geology and geomorphology	Recent Fine-textured Alluvia of the "Downs" Distributary Systems which are derived mainly from neighbouring "black-soil" plains. They are seasonally flooded swamps and many are the effluent areas of the streams of the internal drainage basin		
Topography	Very gentle slopes	Streamlines with some large waterholes	Distributary areas with a complex of low rises and shallow channels approximately 1 ch. apart
Cross section and relative areas			
	Small	Very small	Large
Distribution of units	The first unit occurs on the slightly higher edges of swamps and the third unit in the lower parts; both are cut by narrow bands of the second unit		
Vegetation	*Chenopodium auricomum* Shrubland	*E. microtheca* fringing community	*Chenopodium auricomum* Shrubland
Soils	Distributary Heavy Grey Pedocals	—	Distributary Heavy Grey Pedocals
Drainage	These swamps are the foci of internal drainage systems and are flooded for long periods of most years, the third unit being flooded more often and for longer periods than the first		

TABLE 54

GEORGINA LAND SYSTEM (600 SQ. MILES)

Location and general description	Narrow bands of Mitchell grass plains cut by the much-braided streamlines of the Georgina River and major tributaries		
Climate	Wettest locality: av. ann. rainfall 15 in.; estimated growing periods: agricultural exceeds 12 weeks in 10% of years, never exceeds 16 weeks; pastoral exceeds 12 weeks in 50%, 16 weeks in 25% of years. Corresponding values for driest locality: 10 in., 5%, nil, 25%, nil		
Geology and geomorphology	The Channel Alluvia of the Georgina River and Major Tributaries. These are fine-textured and are mostly derived from "black-soil" plains		
Topography	Long, narrow, low rises between streamlines	Flats fringing streamlines	Braided streamlines with large waterholes
Cross section and relative areas			
	Large	Small	Medium
Distribution of units	The streamlines form a braided pattern fringed by narrow flats and separated by long, narrow, low rises		
Vegetation	*Astrebla pectinata* Grassland	*Astrebla elymoides* Grassland or *Chenopodium auricomum* Shrubland	*E. microtheca* fringing community
Soils	Heavy Grey Pedocals	Heavy Grey Pedocals	—
Drainage	The intense pattern of subparallel, braided streamlines cannot carry peak flood flows and the flats are periodically flooded, but the long, narrow rises are flooded only in very wet seasons		

and is very similar to the Barkly Land System of the second geomorphological subdivision.

The Balbirini Land System is also formed on alluvia derived mostly from calcareous rocks but has Northern Heavy Grey Pedòcals with *Eulalia fulva — Dichanthium fecundum* Grassland. The mean annual rainfall of Balbirini Land System (23-30 in.) is higher than that of Gregory Land System (20-24 in.). In the Gregory River valley the two land systems merge into one another through a broad transition zone and the boundary on the map is rather arbitrary.

(ii) *Land Systems of the Post-Miocene Fine-textured Alluvia of the Georgina Basin (Kallala, Moonah).*—These alluvia, which are derived from the metamorphics of the Carpentaria complex and the granites, have been deposited by tributaries of the Georgina River. They are predominantly fine-textured with small areas of coarser sediments near streamlines. The Kallala Land System is formed on the finer material on which there are heavy pedocal soils carrying *Astrebla pectinata* Grassland or *Acacia georginae — Astrebla pectinata* Woodland. The Moonah Land System is formed on both fine and medium-textured sediments and has both heavy pedocal and red-brown earth soils carrying respectively *Astrebla pectinata* Grassland and *Acacia cambagei* Shrub Woodland.

(iii) *Land System of the Post-Miocene Coarse-textured Alluvia of the Georgina Basin (Bundella).*—The coarse sediments of this unit were probably deposited contemporaneously with the relatively lower fine-textured sediments of the previous unit. Weak wind resorting has given incipient dune development and there are no drainage lines. The soils are leached brown "Bundella" soils carrying *E. argillacea — E. terminalis* Shrub Woodland.

(iv) *Land System of Recent Coarse-textured Alluvia of "Desert" Distributary Systems (Gosse).*—The Gosse Land System is the only one in this geomorphological unit. It consists of areas of shallow non-calcareous alluvia deposited where streams rising in the western low hills effluent into swamps which are flooded for only short periods each year. The deposits, which are coarse- to medium-textured, are derived mostly from the dissection of lateritic formations.

(v) *Land System of the Recent Fine-textured Alluvia of the "Downs" Distributary Systems (Sylvester).*—The Sylvester Land System is the only one in this unit which occurs around the margins of the Tertiary Lake and in the Tertiary Swamp and the Georgina Basin. Each area is a distributary system for streams which flow mostly through fine-textured, "black-soil" plains and consequently the alluvia are fine-textured and calcareous. The soils are Distributary Heavy Grey Pedocals which carry *Chenopodium auricomum* Shrubland. The soils are impermeable and flooding is more prolonged than in Gosse Land System.

(vi) *Land System of the Channel Alluvia of the Georgina River and Major Tributaries* (*Georgina*).—The only land system in this unit consists of the braided stream channels and the inter-channel areas of the Georgina River and the major tributaries. As with Sylvester Land System, the alluvia are derived largely from "black-soil" plains. The inter-channel areas are flooded only for short periods during high flood-flow and probably receive very little deposition. The flats fringing the streamlines are flooded for longer periods and receive more deposition but the soils are still Heavy Grey Pedocals. This land system contains permanent waterholes and the resulting overgrazing has completely destroyed perennial grasses in many localities.

PART IX. THE LAND-USE GROUPS OF THE BARKLY REGION

By C. S. Christian* and G. A. Stewart*

The region, which covers 120,000 sq. miles, is sparsely populated. Apart from mining, important land-use development has been restricted to cattle-raising on the better pasture areas of the Barkly Tableland and the valleys of the Georgina and Gregory Rivers. Even there land use is still of an extensive nature and cattle properties are of large size. With the exception of one very large property of 11,000 sq. miles they mostly range from 1,000 to 6,000 sq. miles in area. There are a number of smaller properties in Queensland, where proximity to rail transport has obviously influenced the intensity of land use. Sheep are still carried on some of these smaller properties.

Parts II-VIII are concerned with the scientific description and classification of the inherent land characteristics of the region. The object of this section is to interpret their relationship to land use and land-use potential. Conclusions are drawn regarding possibilities of development, and recommendations are made concerning further investigations.

The lands of the region have been subdivided into 38 land systems, which have been described in Part VIII. Although these land systems are well differentiated on the basis of their inherent land characteristics, there are factors common to groups of land systems which have an overruling influence on land use. Such groups of land systems are called *land-use groups*. For regional land-use purposes it is adequate and simpler to consider these broader groupings rather than the larger numbers of individual land systems. For example, a very broad grouping shows that approximately one-third of the area (40,000 sq. miles) is fair to good cattle-grazing country, one-third is rough country or has inferior pastures, and one-third is poor, dry country locally described as "desert" country. A slightly more detailed grouping has been adopted for this discussion of land potential. The 38 land systems have been placed into 11 land-use groups. This grouping, with appropriate areas in square miles, is indicated in Table 55. Their distribution is shown on the land-use group map.

I. Climate in Relation to Land Use

In Part II, in which the climate of the region has been described and analysed, it has been shown that climate exerts a limiting influence on plant growth within the region and hence is of direct significance to present and potential land use. Rainfall is the most important factor.

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Over most of the region it occurs in adequate quantity, or falls during too short a period each year, to maintain any stable form of agriculture. The average annual rainfall varies from 10 in. in the interior to 30 in. at

TABLE 55

THE LAND-USE GROUPS AND THEIR CONSTITUENT LAND SYSTEMS

Land-use Group	Area (sq. miles)	Land Systems	Area (sq. miles)
(*a*) Mitchell Grass Country	28,700	Barkly	15,800
		Wonardo	5,200
		Austral	2,400
		Kallala	3,900
		Georgina	600
		Moonah	400
		Argadargada	400
(*b*) Northern Mitchell Grass Country	900	Gregory	900
(*c*) Inferior Mitchell Grass Country	3,900	Creswell	2,500
		Joanundah	1,400
(*d*) Northern Inferior Mitchell Grass Country	1,400	Balbirini	1,400
(*e*) Bluebush Swamp Country	1,400	Sylvester	1,400
(*f*) Drybog	2,200	Drylake	2,200
(*g*) Broken Mitchell Grass Country	7,000	Helen Springs	300
		Kilgour	1,400
		Mitchiebo	1,800
		Mixed areas	3,500
(*h*) Hilly Country	29,000	Robinson	5,600
		Redbank	7,300
		Mt. Isa	8,400
		Thorntonia	2,700
		Rolyat	300
		Ashburton	1,500
		Tennant Creek	900
		Yelvertoft	2,300
(*i*) Southern Desert Country	24,700	Wonorah	9,700
		Elliott	4,000
		Camil	3,700
		Camilrock	400
		Bundella	2,000
		Gosse	300
		Prentice	1,100
		Tobermorey	2,300
		Waverley	1,200
(*j*) Northern Desert Country	14,700	Beetaloo	3,600
		Polyarra	4,100
		Westmoreland	7,000
(*k*) Coastal Country	6,100	Littoral	1,200
		Keighran	4,900
Total area	120,000		120,000

points on the coast. As it is restricted almost entirely to the midsummer months, both evaporation and transpiration are high during the rainy period and in consequence the efficiency of the rainfall is low. The useful agricultural period, as estimated in Part II, has a mean value of only 3.1 weeks at the most inland centre and 13.3 weeks in the north. There is only a narrow strip of country near the coast with an average season sufficiently long to support any form of constant dry-land agriculture. Even there, rainfall conditions appear inadequate to maintain a stable agriculture based on export of crop products, although crops such as peanuts might be successfully grown in some years. At Burketown, for example, the average estimated growing period is 13.3 weeks. A period of 12 weeks is exceeded in only two-thirds of the years and one of 16 weeks in only one-third of the years. Any dry-land agricultural development is likely to be restricted to the production of fodder crops for use in association with the cattle industry. Apart from topographically favoured areas, the climatic limit for dry-land agriculture is expected to be no further inland than the 25 in. isohyet. The distribution of suitable soils will impose considerable restrictions on the development of agriculture even within this limit.

It is clear that most of the region is, and will remain, pastoral country. Over much of it rainfall is satisfactory to maintain a pastoral industry of an extensive nature, although nowhere is it sufficient for intensive pastoral development. In the south-western portion a combination of low rainfall and poor soils gives large areas of sparse vegetation unable to support a pastoral industry.

An estimate of the average period over which useful rain for pasture growth has been received was made for each year of record for various stations throughout the region (see Part II). These estimates show that the mean period ranges from approximately 7 weeks in the inland to 19 weeks at the coast. It is obvious, however, that although this portrays the general trend of rainfall incidence in the region, it does not indicate the relative pastoral productivity of the different parts of the region at the present time. The nature and growth of natural pastures are influenced to a large extent by soil and topography. For example, in areas of low rainfall, the additional water received in shallow depressions by run-off from adjacent land may equal or exceed the amount received from rainfall sources. Thus small areas of relatively high productivity occur within larger areas of practically useless country. Such factors, in addition to the rainfall characteristics, must be taken into account in assessing pastoral productivity.

It has been pointed out that the temperature depression during the wet season in this region is less than in other monsoonal areas. The occurrence of high temperatures during the growing period may be a factor in determining the low nutritive value of the pastures in higher-rainfall sections.

The reliability of the summer pastoral season decreases with distance from the coast. At Burketown a season of 8 weeks can be expected in all years, a season of 12 weeks in nine-tenths of the years and of 16 weeks in seven-tenths. At Alexandria, on the Barkly Tableland, an 8-weeks season occurs in about nine-tenths, 12 weeks in one-half, and a 16-weeks period in only one-tenth of the years. Extremely short seasons are also received in about one-tenth of the years. At Urandangi, in the Georgina basin, an 8-weeks season is recorded in three-fifths, and a 12-weeks season in one-third of the years. A 16-weeks summer season cannot be expected.

Winter rains are light and infrequent. They are of importance in that they can have a damaging effect on the standing pasturage produced by the summer rains, and in the most southern parts of the region they may induce useful growth of winter-active annuals. A fall exceeding 1 in. within a week occurs in about one-sixth of the years in the north-west and three-fifths of the years in the south-east. The occurrence on the central Mitchell grass pastures is about one-third. Such falls usually occur in May or June. There is rarely more than one such fall per year.

II. Vegetation in Relation to Land Use

Forest resources are not large and are mainly of local importance. *Acacia shirleyi* (lancewood) forests cover large areas in the Beetaloo Land System and are a useful source of poles. *Callitris intratropica* (cypress pine) is a more useful timber but occurs only sporadically in the Westmoreland Land System. There are extensive areas of sandy soils which might prove suitable for this species if satisfactory methods of reafforestation can be developed. Various useful *Eucalyptus* species occur in the open forest and woodland communities, but good timber is not concentrated in any abundance. Gidgee (*Acacia cambagei* and *A. georginae*), which is useful fencing timber, occurs on portions of the heavy-soil grassland plains, especially within the Georgina basin, but an important feature of many of these more productive plains is the complete absence of useful timbers. This is a factor contributing to the cost of fencing and of property management. The fringing forests of the larger northern streams can provide locally small amounts of various species including *Eucalyptus* spp., *Melaleuca leucadendron* (paperbark), and *Nauclea orientalis* (Leichhardt pine).

The main assets in the vegetation are the natural pastures, which are varied both in floristic composition and in economic value. They are the ground floras of the many plant communities (described in Part VII, where the species present are listed in more detail). In some instances several distinctive plant communities may have very similar lower storeys, alike in general pasture characteristics. Thus, the number of pasture types that need to be recognized for a general survey of the region is much fewer than the number of plant communities.

As rainfall is restricted to a short period each year the pasture species of the region are mostly adapted to making the bulk of their season's growth quickly, and stock depend upon mature pasturage for a large part of the year. The period of active growth varies for different pasture types. It may be as short as 2-3 weeks, or as long as 3-4 months. It rarely exceeds this period except in seasonally flooded areas or in particularly favourable seasons. In the latter case the increased bulk of mature pasture is offset to a large degree by its lower nutritive value. The proportion of winter-active pasture plants is greater in the southern half of the Georgina basin than in other parts of the region. In general, the better pastures are associated with the heavier soils and the lower parts of the topography. They are mainly restricted to the areas of low and medium rainfall (10-25 in. per annum).

The main pastures are as follows:

(i) *Barley Mitchell Grass Pastures.*—The most important pastures of the region are open tussock pastures, dominated by *Astrebla pectinata* (barley Mitchell grass), on the heavy-soil plains. These pastures occur as nearly treeless *Astrebla pectinata* Grasslands and in Woodlands dominated by *Eucalyptus microtheca* (coolibah) and *Acacia georginae* (gidgee). Absence of shade on the treeless areas is a factor that must influence the grazing habits of the animals.

In addition to the dominant, barley Mitchell grass, which is a very strong-rooted, large-crowned, perennial tussock grass, 2-3 ft. high at maturity, other perennials also occur. They are all widely spaced with bare areas between them, except during the wet season and for several months after, when summer-growing annual species are abundant. Of these, *Iseilema* spp. (Flinders grasses) and *Brachyachne convergens* (northern couch) are the most common. Many other herbaceous species are present but the variety is not nearly as great as in the Mitchell grass country in southern Queensland where sheep are the main grazing animals. The annual species rarely exceed 18 in. in height. In seasons of low rainfall they are much lower and in very dry years they are virtually absent. Several native legumes, such as *Rhyncosia minima, Alysicarpus rugosus, Neptunia gracilis,* and *N. monosperma* occur in these pastures, but rarely in any significant quantity. Following rains the annuals are the main source of feed. As the pastures mature the barley Mitchell seed heads become important and later still, when the annuals have disintegrated, the Mitchell grass clumps are heavily grazed throughout the dry season.

Approximately 2 in. of rain are required to produce a useful response in these pastures. Good growth will result from 4 in. but more is beneficial. Once sufficient rain is recorded, growth is rapid, and the bulk of the season's feed is usually produced in a period of 2-3 months. Winter rains may damage the standing mature grass and, because of the paucity of winter-active species, cause more harm than good. Thus, some years of high rainfall may actually be unfavourable years for these pastures. However, in the most southern sections there is a greater number of winter-active species and their growth may offset the damage to the mature summer species.

(ii) *Weeping Mitchell Grass Pastures*.—Pastures dominated by weeping Mitchell grass (*Astrebla elymoides*), rather than barley Mitchell, are characteristic of the broad, shallow depressions and narrow drainage lines of the heavy-soil plains of the Barkly Tableland and Georgina basin. These wetter habitats have a greater variety of lower-storey plants, which include not only several *Iseilema* spp. (Flinders grasses), but also many legumes and other herbs palatable to stock. These pastures are of much less extent than the barley Mitchell pastures, but their grazing value is better in some respects. The low herbaceous species are of high nutritive value and the pastures remain green for longer periods. Where grazing is intense the density of the weeping Mitchell grass is reduced. The two plant associations in which these pastures occur are the *Astrebla elymoides* Grassland and the *Eucalyptus microtheca—Astrebla elymoides* Woodland. The trees in the latter association provide valuable shade as the association often occurs as narrow strips in otherwise treeless, broad plains.

(iii) *Bluebush Pastures*.—This pasture type is the *Chenopodium auricomum* association of the Sylvester Land System and of small flats near streams. It occurs in areas where seasonal flood waters may lie for long periods, either as large, temporary, shallow lakes or as a dense network of distributary channels separated by narrow banks that are not inundated. In addition to the dominant succulent shrub, *Chenopodium auricomum*, commonly known as bluebush, the pasture contains many other useful plants. Several perennial tussock grasses, including the Mitchell grasses and several blue grasses (*Dichanthium* spp. and *Bothriochloa* spp.), occur, particularly where flooding is shallow or infrequent. *Sesbania benthamiana* (peabush) and the palatable reed *Cyperus retzii* are common, and as the waters recede a wide range of annual herbs becomes established. The botanical composition and value of the pastures vary according to the minor differences in the local topography. Such swamp pastures provide excellent fattening feed after the wet season and in some places are very intensively grazed, at rates exceeding that of the plains by 6-10 times. Overgrazing tends to eliminate the bluebush and this is particularly noticeable at the edges of the larger swamps and where small areas occur in more extensive plains of other pasture groups. Scattered trees of *Eucalyptus microtheca* (coolibah) occur in some of the swamps. The extent of flooding, and hence the area of abundant annual species, varies from year to year according to rainfall incidence.

(iv) *Inferior Mitchell Grass Pastures*.—The heavy-soil plains that occur in areas of higher rainfall have pastures inferior to the typical barley Mitchell grass pastures. The zone of transition is broad. It corresponds approximately with the 17-18 in. isohyets on the tableland, and the 23-24 in. isohyets in the Gregory River valley. There is a general trend, with increasing rainfall, for perennial andropogonous genera such as *Eulalia, Bothriochloa*, and *Dichanthium* to replace the *Astrebla* spp. as dominants. Scattered plants of *Astrebla pectinata* and *A. elymoides*, and dense areas of *A. squarrosa* may occur and because of their presence the pastures are often referred to as Mitchell grass pastures. However, the other genera contribute far more to the total pasturage. The dominant species are taller than the barley Mitchell grass pastures and are often 3-5 ft. high. An annual *Sorghum* sp. growing 3-6 ft. high is often abundant but its density varies considerably from year to year. The lower storey, which includes some similar annuals, is also taller in these pastures; for example *Iseilema vaginiflorum* (red Flinders grass) often exceeds 2 ft. in height. Although these pastures are more bulky their average protein content at maturity is lower, and the stock-carrying and fattening capacity less than the barley Mitchell grass pastures.

The plant communities in which these pastures are developed are the *Eulalia fulva—Dichanthium fecundum* Grasslands, and the two closely related Woodlands dominated by *Eucalyptus microtheca* and *Bauhinia cunninghamii* respectively. In the last two the low, scattered trees provide ample shade.

(v) *Spinifex Pastures.*—Harsh sclerophyllous grasses of the genus *Triodia* (spinifex) dominate the ground flora of many plant communities in the region. Such pastures cover most of the better-drained parts of the topography and many of the low-rainfall areas. Other perennial grasses are usually very sparse, but the spaces between the large spinifex hummocks are partially occupied by short, ephemeral species following rain. The spinifex is unattractive to stock except when young growth occurs following fire, and when in seed. Even in the young stages not all species are palatable. The main value of these pastures is in the early feed provided by ephemeral species, which respond quickly to light falls of rain. As their productivity is low and surface water is usually absent, spinifex pastures are only utilized where they are adjacent to better areas. When accessible from water these pastures provide light browsing when feed is short.

Frequent burning of the spinifex results in its destruction and in the establishment of ephemeral species and some perennial shrubs and weeds. It is possible that in some areas carefully controlled, frequent burning and grazing could induce a ground flora that, though only suitable for stocking lightly, would be an improvement on the spinifex. Information on this subject appears to be lacking as the inherently low carrying capacity of the natural flora has precluded the use of these areas other than at their margins and near existing waters.

(vi) Aristida *Pastures.*—In many of the woodlands and shrub woodlands of the lower-rainfall areas, as for example in the *Eucalyptus pruinosa* association and the *Ventilago viminalis* alliance, there are rather sparse pastures in which mid-height perennial grasses and short grasses and other herbs are equally important. *Aristida pruinosa,* a harsh three-awned grass, is a common dominant. Other perennials present in small proportion include *Themeda australis* (kangaroo grass), *Sehima nervosum* (white grass), and *Chrysopogon pallidus*. Short, annual grasses growing to 12 in. in height include *Sporobolus australasicus*, *Aristida* spp., and others. Small, annual forbs are also numerous. The pastures respond quickly to rain and provide good early feed. However, their stock-carrying capacity is low, particularly during the dry season after the annual species have matured. At this time some of the shrub and low tree species provide light but useful top feed. Excessive grazing may lead to the dominance of harsh perennial and annual species.

(vii) *Desert Annual Pastures.*—Perennial pasture species are very sparse, or lacking, in many of the arid zone communities growing on alluvial or calcimorphic soils. The ephemeral pastures are composed largely of the short annual grasses and herbs that occur in the *Aristida* pastures with which they intergrade. They closely resemble the *Sporobolus australasicus*—*Enneapogon* spp. Grassland, which occurs on the gravelly rises in the Mitchell grass plains. They are light-carrying pastures, most useful early in the season, and some of the species respond to winter rains. Light top feed is provided by the scattered shrub species.

Typical communities in which these pastures occur are the *Eucalyptus terminalis*—*Cassia* spp. Shrub Woodland, and the *Acacia aneura* Woodland. These pastures occur on relatively light-textured surface soils and are very susceptible to overgrazing, especially near the margins where they adjoin country with a much higher carrying capacity.

(viii) *Coastal Woodland Pastures.*—Many of the woodlands of the higher-rainfall sections of the region have pastures reaching 3-4 ft. in height at maturity and in some instances 5-6 ft. *Themeda australis* (kangaroo grass), *Heteropogon contortus* (bunch spear grass), *Sehima nervosum* (white grass), the perennial *Sorghum plumosum*, and *Chrysopogon* spp. are the commonest taller grasses. The pastures are dense, and short grasses and other herbs are usually sparse. There are many variations in botanical composition associated with changes in soils and drainage. On wetter flats forest blue grass (*Bothriochloa intermedia*) is common and smaller plants are abundant. These include some legumes in small quantity. The low nutritive value of these pastures at maturity is responsible for the low average stock-carrying capacity. Such pastures in this region with its very marked dry season are much inferior to somewhat similar pastures near the east coast.

(ix) *Deciduous Woodland Pastures.*—A very mixed pasture type is associated with the deciduous woodland occurring on outcrops of limestones and calcareous rocks in several of the land systems in the north of the region. Perennial species include *Triodia* spp. (spinifex) and mid-height grasses such as *Themeda australis* (kangaroo grass), *Heteropogon contortus* (bunch spear grass), and species of *Chrysopogon*, *Cymbopogon*, and *Aristida*. The perennials are of only medium density and shorter species are prominent, particularly *Enneapogon* spp., *Brachyachne con-*

vergens, and numerous forbs. Small patches of barley Mitchell grass pastures may occur intermixed with the above in areas where deeper soils have formed. Although this pasture type does not carry cattle at high stocking rates it is usually much superior to the spinifex-dominated pastures of the surrounding areas formed on "acid" rocks. Several of the shrub and tree species provide useful top feed and the wide variety of ground species enhances its value.

(x) *Miscellaneous Pastures.*—The following pastures occur in areas of less extent:

(1) Salt meadow pastures. On the inland edge of the salt flats of the coast is a narrow band of rather dense pasture dominated by *Xerochloa barbata* (rice grass) growing to a height of 1-2 ft. Shorter grasses such as *Digitaria* spp., *Brachyachne tenella,* and *Sporobolus actinocladies* are prominent. These pastures are normally far superior to the taller pastures of the adjacent woodlands.

(2) Forest pastures. Where the tree cover approaches forest density, as for example in the *Acacia shirleyi* Forest, or the *Eucalyptus tetrodonta —E. miniata* Shrub Open Forests, the pastures are commonly very sparse and of very low carrying capacity. In many places the absence of surface waters reduces their value to a negligible figure.

(3) Coastal swamp pastures. In seasonally flooded depressions in the coastal plains, pastures are dominated by tall, coarse *Sorghum* sp., *Oryza australis* (wild rice), and *Coelorhachis rottboellioides,* all of which may grow to 6 ft. or more in height and are of little pasture value. Where shallow water is present for longer periods, the semi-floating grasses *Pseudoraphis spinescens* and *Leersia hexandra,* and various reed species (*Eleocharis* spp.), provide useful local grazing over long periods.

III. Pasture Improvement

No form of pasture improvement is practised in the region at the present time, nor is it possible, from present knowledge, to indicate any economic means of raising the productivity of any of its pastures. Requests are frequently received for advice concerning the introduction and distribution of better pasture plants. Much of the region must be classed as semi-arid, and all of it is arid for at least half of the year. Superficially there would seem to be little likelihood of successful and economic replacement of the existing species by introduced ones by the usual methods of pasture improvement. However, many local areas receive run-off from surrounding country and thus receive far more water than is indicated by the annual rainfall. Such areas may be suitable habitats for better species. The importance of such areas in determining the total carrying capacity of a locality, relative to the less productive areas surrounding them, suggests that any improvement would be of some significance. Improvement of any kind is not likely to be accomplished quickly. It may be only by the slow natural spread of species initially established at selected sites. The possibilities can only be determined by a thorough ecological study of introduced species in the environment. At the present time there are no determined principles to serve as a guide in the general project of developing the most useful flora for such regions. It would be indeed fortuitous if the native species were the best possible ones for a form of land utilization based on grazing beef cattle. *Cenchrus ciliaris* (buffel grass) has proved a valuable introduction to the 15 in. rainfall country in Western Australia. It is not improbable that a systematic study would indicate equally useful species for other low-rainfall areas. The problem is not one only of this region. A similar situation is to be found in most of northern and central Australia, and probably affects a total area of several hundred thousand square miles in the summer-rainfall zone. For this reason it is recommended that a small unit be established to study this long-term problem. The Stuart Highway, which runs from 10 in. rainfall country in Central Australia to 60 in. rainfall country at Darwin, enables a transect to be made across a wide range of environments with comparative ease. It is recommended that an officer be stationed at Katherine (or possibly Alice Springs) and that he be equipped with a vehicle to permit him to travel this transect. He would make a systematic ecological study of introduced species in relation to various type environments accessible from the highway, with the objective of defining principles concerning the value and the establishment and natural spread of better species in the native flora. His investigations would include studies on the modification of spinifex pastures by controlled burning and grazing.

IV. Pasture Management and Utilization

Beef cattle are the main animals grazing the pastures of the region, but some sheep for wool are grazed in the south-eastern corner. In general, and particularly in the higher-rainfall sections, the pastures are unsatisfactory for sheep, being tall and of wide protein-carbohydrate ratio for the greater part of the year. The areas that have been regarded favourably at various times for wool production are the shorter grass pastures of the heavy-soil areas of the Barkly Tableland and the adjacent "desert" country. In general appearance these closely resemble the Mitchell grass sheep pastures of southern Queensland. Attempts have been made to maintain sheep in such country, particularly in the southern portions near the Queensland-Northern Territory border. In spite of prolonged attempts there has been a retreat of the sheep front to the south-east. This has been attributed to various factors, including difficulties of protection against dingoes, low reproductive rate of sheep in this environment, and the high cost of transport and its effect on property development and wool marketing. It is not clear which was the most adverse factor, but it is evident from this survey that an additional factor is important.

Because of the marked summer incidence of the rainfall the pastures of the region mostly lack the highly nutritious winter herbage species common to the Mitchell grass areas in southern Queensland. As a consequence the pastures are less satisfactory nutritionally for sheep than they are for cattle. This is most marked in the more northerly portions of the Barkly Tableland. Also, as much of the heavy-soil area lacks fencing material and natural water supplies, it is cheaper to develop the country for cattle than it is for sheep. For these two reasons it is unlikely that there will be any major expansion of the sheep industry within the region, at least not until regional development has reached a much more advanced stage, and technical problems concerning sheep fertility have been solved.

The present cattle industry is conducted on a very extensive system. In consequence there is little, if any, conscious attempt at pasture management. This is particularly true of the broken country north of the tableland where natural watering points are more frequent and less accessible and where timber and scrub hinder the handling of stock. Where the industry depends largely upon bores for stock water, as on most of the Mitchell grass country, there is in effect a form of pasture management. During the rainfall season stock tend to congregate around the surface waters. As these dry the stock are moved to the bores. Thus in many instances the pastures surrounding the bores are spelled during their main growth period and are able to build up ample food reserves. They are grazed largely in the mature stage. Within a radius of $\frac{1}{4}$ mile from a bore there is frequently a marked reduction in the density of the perennial species, due both to close grazing and constant trampling. Beyond this point there is much less obvious reduction although plant counts indicate a slight increase in density of Mitchell grass plants up to $\frac{1}{2}$ mile from bores, and in some sections of the plains even up to 2 miles. In general the reduction in density observed is of little consequence and the pastures cannot be regarded as suffering unduly from excessive grazing. This, however, is not true of the stock routes, where in places the Mitchell grass species have been considerably reduced in density, indicating that even these species will not stand constant abuse. Grass fires and occasional flooding are both responsible for thin stands of Mitchell grass in some portions of the plains. However, in general fires on these pastures are avoided. Burning of spinifex pastures is practised to a small degree but in a spasmodic and irregular manner and its possible advantages or repercussions have not been fully defined.

In the areas near natural waters, pastures have been influenced by grazing and in those northern parts of the region where stock are largely uncontrolled, soil erosion has resulted from excessive grazing near permanent streams and waterholes. In these areas there is no form of pasture management in practice, grazing being almost entirely uncontrolled.

It is unlikely that any advanced form of pasture management is necessary in the region so long as excessive grazing or trampling are not permitted to reduce the stand of perennial species. However, it would appear that the pasturage produced could be used more effectively than it is at the present time. In a later section the relationship of distance between watering points and pasture utilization is discussed. An increase in the number of watering points per unit area would necessarily involve much additional fencing in order to control stock. However, the scope for additional control thus presented would permit a higher standard of stock husbandry to be achieved. This, plus the more efficient use of the pasturage, could make a slightly more intensive form of land use both economically possible and desirable.

V. Stocking Rates of Natural Pastures

It is difficult to obtain an accurate estimate of the potential stock-carrying capacity of a particular natural pasture type and in any method of estimation a degree of speculation cannot be avoided. Pastoral properties commonly include a variety of country and several distinctive pasture types of very different carrying capacities. Hence stock statistics based on areas of properties may be very misleading. From the data concerning types of country obtained by this survey an attempt has been made to make a realistic estimate for the "black-soil" areas in the Northern Territory portion of the Barkly Tableland and adjacent Georgina basin, by relating stock numbers to the actual areas of described pastures.

The total areas of country occurring within 5 miles of waters or bores have been mapped (Fig. 9). It follows that the major proportion of the stock must graze almost entirely within these defined areas. The computation shows that in 1948, 17,200 sq. miles of country accessible from permanent water carried approximately 280,000 head, that is at an average stocking rate of just over 16 beasts per sq. mile, a figure far above the normally accepted one for the "black-soil" region. The total area grazed may be slightly greater in that temporary surface waters are available for short periods following rains. However, as the computed area includes all the main drainage systems the additional areas grazed must be relatively small. No account has been taken of travelling stock.

The area defined includes parts of four land-use groups, each dominated by a major pasture type. "Relative" values for each have been assessed by examination of the species present, and by reference to the opinion of experienced managers and stockmen. The stocking rate appropriate to each land-use group can be computed by equation. The four land-use groups and their areas are Mitchell Grass Country (14,310 sq. miles), Inferior Mitchell Grass Country (1,590 sq. miles), Bluebush Swamps (790 sq. miles), and Drybog Country (520 sq. miles). The

Inferior Mitchell Grass Country can safely be assumed to have about two-thirds the stocking rate of the Mitchell Grass Country, and the accessible Drybog Country about one-third. As only small areas of these are involved, modification of these values has little effect on the computations. There is some variation of opinion as to the relative values of the Bluebush Swamps and the Mitchell Grass Country and they range from a ratio of

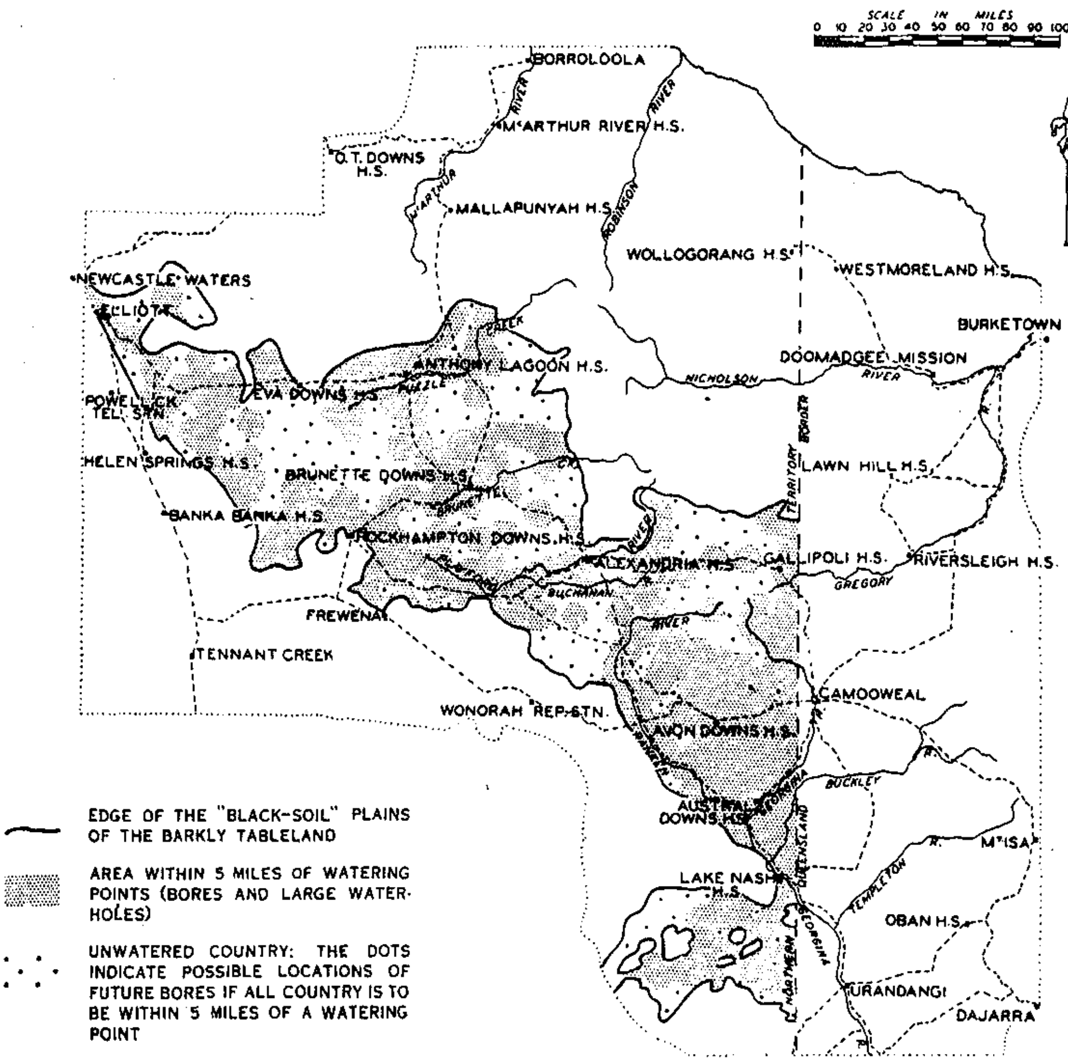

Fig. 9.—Map showing areas served by water in the Northern Territory portion of the "black-soil" plains of the Barkly Tableland (based on information collected in 1948). The unwatered country may have intermittent water supplies. In some of the unwatered country the ground water has a high fluorine content and is not suitable for stock.

4 : 1 to as high as 20 : 1. A consequence of accepting a very low or high ratio in favour of the Bluebush Swamps is that the computed stocking rate for Mitchell grass is correspondingly exaggerated in the opposite direction and may reach untrue levels. The computed values of actual stocking rates on the basis of a range of ratios are shown in Table 56.

As the higher stocking rates for the Bluebush Swamps appear to be quite impracticable it seems that the true stocking rates of both groups must be near the range of the first three ratios. It must be concluded that at the present time the sections of the Mitchell grass plains supplied with stock water are grazed at a rate between 12 and 15 beasts per sq. mile and the Bluebush Swamps at rates between 60 and 100 per sq. mile.

This sort of analysis cannot be applied either to the more arid parts of the region or to the coastal sections as there are not sufficiently extensive and uniform areas of utilized country to form a basis of estimation.

TABLE 56

COMPUTED VALUES OF ACTUAL STOCKING RATES ON BLUEBUSH SWAMPS AND MITCHELL GRASS

Ratio in Favour of Bluebush Swamps	Computed Stocking Rates (per sq. mile)	
	Bluebush Swamp	Mitchell Grass
4:1	60	15
6:1	84	14
8:1	100	12.7
16:1	156	9.8
20:1	176	8.8

For these areas the stock-carrying capacity has been assessed by reference to the botanical composition of the pastures and their growth characteristics, the presence or absence of top-feed species, and by comparison with other regions. The rates adopted must be regarded as reasoned guesses rather than accurate estimates.

VI. The Land-use Groups and Present Land Use

(a) *Mitchell Grass Country* (*Area* 28,700 *sq. miles*)

This land-use group, which includes seven land systems, consists almost entirely of broad plains of barley Mitchell grass pastures and covers a very large proportion of the area popularly known as the Barkly Tableland.

The seven land systems form a more or less continuous belt of country extending from just south of Newcastle Waters to Camooweal and southward down the valley of the Georgina River. The flat to gently undulating topography is cut by widely spaced seasonal streams, most of which flow to inland basins. In the central portion there are very large, nearly flat, continuous plains, but in the north-western and southern portions the plains are broken by small areas of other land-use groups. In the north-west these are mainly small swamps or lateritic rises but in the south they consist of areas of limestone desert and of light-textured alluvial soils.

Most of the soils of the land-use group are heavy clay "black soils". The grassland plains are mainly treeless, but gidgee (*Acacia cambagei* or *A. georginae*) is prominent in some of the land systems, particularly in those along the Georgina River. A sparse band of *Eucalyptus microtheca* (coolibah) occurs along the depressions and widely spaced streamlines. Scattered *Atalaya hemiglauca* (whitewood) and other small trees occur on gravelly rises, which are common in some of the land systems. These carry short, annual pasture species.

In addition to the barley Mitchell grass pastures the plains of this land-use group include areas of weeping Mitchell grass pastures in depressions and small areas of bluebush pastures too small to be mapped separately. The lateritic rises carry spinifex and low trees, the limestone deserts and light-textured alluvial areas sparse trees and shrubs and short annual grasses or spinifex. These inclusions are useful stock refuges which provide a small amount of top-feed.

Access to this land-use group has been made relatively easy by the Barkly and Stuart Highways and the group itself has a network of fire-ploughed roads connecting the homesteads and serving many of the bores on the properties. Such "black-soil" roads are easily constructed and maintained but are unsatisfactory as main roads in that they are impassable in places in the wet season. The main stock route from the northern and western portions of the Northern Territory to Queensland traverses this land-use group. The stock route to Alice Springs passes its western edge.

Some sheep are raised for wool in the south-eastern corner but the major form of land use at present is the production of beef cattle stores and some fat cattle. In the Northern Territory portion, where cattle only are now raised, properties are larger than in the Queensland portion and in general are less developed. In few instances do properties consist only of areas of this land-use group. Most include areas of other groups of inferior stock-carrying capacity. However, in the north-western half the inclusions of areas of the bluebush swamps are of particular value.

The mean annual rainfall ranges from 10 in. in the southern portions of the land-use group to 20 in. in the north-east. The assessment of the useful agricultural period indicates that throughout the land-use group it is inadequate for a stable dry-land agriculture. For example, at Anthony Lagoon in the most northern portion, which has the highest rainfall, an agricultural growing season of 12 weeks is experienced in only one-quarter of the years. However, along this northern margin a season of 8 weeks is received in three-quarters of the years. In very favourable parts of the topography small-scale production of special short-season fodder species may be possible but this could be justified only if the animal industries reach a very much higher state of development. The land-use group and its surrounding country lack adequate catchment areas or suitable topography for large-scale water conservation and extensive irrigation is impracticable. The underlying sediments do not contain mineral deposits of any importance and mining is not likely to play any part in its development. It is obvious that the only potential is in the further development of the animal industries and mainly of the beef-cattle industry.

The whole of the land-use group is theoretically occupied, but there is scope for more complete utilization. It is all useful grazing country, the main limiting factor being water supply. Surface waters are mostly seasonal and permanent holes are few in number. The stock industries are dependent upon supplies of underground water, which are obtainable at depths of 200-400 ft. throughout the land-use group. The number of watering points at present is insufficient to utilize the whole area. A large portion of the south-eastern section is well served but over much of the remainder bores are widely spaced and substantial areas are beyond stock walking distance of existing waters. The scope for additional land use by the establishing of more watering points in the Northern Territory portions is discussed more fully in conjunction with associated land-use groups later in this report.

The present stocking rate of this type of country is computed to be 12-15 beasts per sq. mile on areas where stock water is available. With more intensive development, that is with closer watering points and additional fencing, it should be possible to maintain an average of 15 beasts per sq. mile. Accepting this figure it is estimated that the land-use group has a *maximum* stock-carrying potential of approximately 428,000 head of cattle. At present mostly store cattle are sold but in good seasons a proportion of fats is produced from these pastures, and a larger proportion is fattened on the associated areas of bluebush swamp.

(*b*) *Northern Mitchell Grass Country* (*Area* 900 *sq. miles*)

Four areas of country with topography, soils, and vegetation very similar to the previous land-use group and comprising one land system only, are situated in the valleys of the Gregory River and some of its tributaries. This land-use group is isolated from the previous one and, because of its location and rainfall, has slightly different potentialities.

The areas, which are easily traversed except for some major streams, are accessible from Burketown by a road traversing the heavy clay plains and the river levees, and by a much rougher road from Camooweal and Mt. Isa. There is stock route access to the railhead at Kajabbi, which connects with the east coast of Queensland. Permanent stock-watering supplies are provided by the major streams, but shallow bores or wells are also necessary in some portions. Ground water is readily obtainable.

Lands of the group are used for beef-cattle breeding and for topping off stock bred in the adjacent land-use groups. A large proportion of the turn-off is sold for killing. The more abundant natural water supply has permitted stock to be carried at a slightly higher average rate than in the previous land-use group, but the potential stocking rate is about the same. There is only limited scope for more intensive development on the present pattern, the maximum stock-carrying potential being approximately 14,000 head. Agricultural settlement under dry-land conditions is not feasible, but the growing of short-season fodder crops to supplement the natural pastures is worth investigation.

The soils are very similar to those of the Kimberley Research Station on the flood plain of the Ord River, where the production of crops under irrigation is being investigated. Although the Gregory River has only a small catchment area, it is a permanently flowing stream. Water conservation on a large scale is unlikely, but suitable sites for small dams may occur in the rugged headwater country. If the Kimberley experiments demonstrate that an irrigated agriculture is feasible, the possibilities of water conservation for irrigation in this area should be examined. The area of commandable soils far exceeds that of the Ord River, but the river catchment is very much smaller. In addition to the heavy-soil plains the Gregory River has narrow levees of lighter-textured soils on which irrigation would permit a small-scale intensive agricultural development. A more complete hydrological study of the Gregory River and its tributaries to determine the scope for water conservation is recommended.

(*c*) *Inferior Mitchell Grass Country* (*Area* 3,900 *sq. miles*)

The most northern part of the "black-soil" plains of the Barkly Tableland (Creswell and Joanundah Land Systems) has topographic and soil features generally similar to the Mitchell Grass Land-Use Group. However, in this area of slightly higher rainfall the pastures are of the inferior Mitchell grass type, in which the better *Astrebla* species are sparse, and the bulk of the pasturage is produced by other perennials that are less valuable when mature.

Extensive, nearly treeless plains occur in the Creswell Land System, but the Joanundah Land System consists mainly of fringes of country at the margins of the plains and adjacent deserts. These fringes are wetter than the main plains and have scattered coolibah trees. There are also scattered rises with a woodland vegetation and mixed pastures. The two land systems are grouped together, as both are breeding country with a stock-carrying capacity only about two-thirds of that of the Mitchell Grass Country. Their combined maximum stock-carrying potential is approximately 39,000 head.

Although the areas are mostly accessible from the main roads, internal fire-ploughed roads are not numerous. The country is used for beef-cattle breeding, but the industry is not developed so much as in the Mitchell Grass Land-Use Group. There are no permanent streams and waterholes are sparse. Adequate sub-artesian water is available at depths of 200-400 ft. Although rainfall conditions are not satisfactory for a permanent agriculture, very short-season fodder crops might be successfully grown in a small way in the most favourable locations. Their production could be contemplated only if the cattle industry and the region as a whole reach a far more advanced stage of development.

(*d*) *Northern Inferior Mitchell Grass Country* (*Area* 1,400 *sq. miles*)

The one land system of this land-use group comprises several areas of nearly flat "black-soil" plains with some limestone patches, and odd levees along major streams, in the higher-rainfall section of the region. They are located in the valleys of Gregory, McArthur, and Limmen Bight Rivers.

The large area in the east is accessible from Burketown and is served by the stock route to Kajabbi. The smaller areas in the west are less easily accessible and are surrounded by hilly, inferior country. Their main stock outlet is to the Barkly Tableland. The eastern area is traversed by the Gregory River and its anabranches, but otherwise has few natural waters. Subsurface water is available from shallow bores and wells. At Burketown, to the east of the surveyed area, there is a small flowing bore. The western areas have more permanent surface waters, but the position regarding ground water is not known.

Scattered trees of coolibah and bauhinia occur through the pastures, which are otherwise similar to those of the Inferior Mitchell Grass Country. Their stock-carrying capacity is much the same and hence the maximum potential is about 14,000. However, this land-use group has slightly more favourable rainfall conditions, the mean estimated useful agricultural period being about 12 weeks. Although a permanent dry-land agriculture based on export of plant products is unlikely, there would seem to be scope for fodder crop production. However, it is doubtful if the cattle industry, in its present form, could effectively utilize supplementary fodders. The land-use group produces mostly store cattle and this is likely to continue.

The eastern area of this group is an extension of the plains of the Northern Mitchell Grass Country and much of it would be commandable by irrigation water if conservation is possible. The findings of the Kimberley Research Station should apply to this area also. Soil erosion is prominent in the areas adjacent to the McArthur and Gregory Rivers. The soils are very unstable when wet. The intensity of rainfall is high and any denudation of the soils near the deeply entrenched main streams quickly leads to extensive gullying.

(*e*) *Bluebush Swamp Country* (*Area* 1,400 *sq. miles*)

The one land system of this land-use group consists of many scattered, small areas commonly known as bluebush swamps. They occur mainly in the western section of the Barkly Tableland. These swamps are the distributary areas of inland streams and may be flooded for several months each year. They are mostly surrounded by areas of Mitchell Grass Country and are easily accessible to stock. The bluebush pastures, of which there are many variants, provide good stock-fattening feed as the swamp waters recede. The estimated carrying capacity during the fattening period is 6-10 times that of the adjacent Mitchell Grass Country. The importance of these swamp pastures lies mainly in their potential for increasing the proportion of stock that can be fattened or topped off. Their full potential will be reached only if transport facilities are developed to ensure the successful marketing of the fattened stock.

TABLE 57

VARIATION IN RAINFALL AT ANTHONY LAGOON AND NEWCASTLE WATERS

	Anthony Lagoon (Av. rainfall 18 in. p.a.)	Newcastle Waters (Av. rainfall 17 in. p.a.)
Less than 10 in.	1/10 of years	1/10 of years
10-15 in.	3/10 of years	2/10 of years
15-20 in.	3/10 of years	4/10 of years
More than 20 in.	3/10 of years	3/10 of years

The total area of these swamps has been determined from the aerial photographs, and represents the area over which flooding has resulted in a recognizable change in the ground surface. The area flooded varies from year to year according to rainfall incidence, but there are not any recorded data from which actual areas of flooding can be compiled. The proportion of years receiving various amounts of rainfall is given in Table 57 for Anthony Lagoon and Newcastle Waters to illustrate broad seasonal variations.

In years of extensive flooding it is likely that some portions of the swamps are not accessible at any time, while in years of light rainfall the area of flooding is small. If, on the average, one-third to one-half of the mapped area is flooded and accessible each year, and if the stock-carrying capacity of the accessible areas during the fattening period following the wet season is 80 beasts per sq. mile, the estimated average fattening potential of the swamps is 40,000-50,000 head per annum. It is evident that these swamps are of major significance, and that if fully utilized they could fatten a very large proportion of the total annual turn-off of the heavy-soil plains of the Barkly Tableland.

The swamps supply their own surface water for a period, but later in the dry season cattle depend either upon a few large waterholes or on bore supplies. Additional bores are necessary if these areas are to be fully utilized. The possibility of improving the value of these swamps by introducing better species from south-west Queensland, or from similar swamp areas in other parts of the world, is worthy of attention. In many places the margins of the swamps tend to be overgrazed and the bluebush itself has been much depleted.

(*f*) *Drybog Country* (*Area* 2,200 *sq. miles*)

Three areas in the western section of the Barkly Tableland have loose, fluffy surface soils commonly called drybog. The soil profile cracks deeply into more or less hexagonal blocks 3-4 ft. across, with domed centres that give the dry soil a very uneven surface. These areas do not often receive run-off from the surrounding higher country. The run-off usually accumulates in the bluebush swamps around the margins of these old lake bottoms, but in very wet years flooding extends to the whole area. Scattered coolibah trees are commonly present, but in places large areas of dying trees possibly indicate long intervals between floodings.

The pastures are very sparse and are of low stock-carrying capacity in their native state. The areas are accessible but the rough surface and deep cracks discourage stock movement. Where it is possible to consolidate the surface by trampling immediately after the wet season, traversability for stock is greatly improved and it is said that this consolidation leads to a denser growth of pasture species. These areas have no agricultural potential and their pastoral potential per unit area is probably only one-third that of the Mitchell Grass Country, even when fully developed. Their maximum potential is estimated at 8,000-10,000 head.

(*g*) *Broken Mitchell Grass Country* (*Area* 7,000 *sq. miles*)

This land-use group includes three land systems and several complex mixed areas. In each case patches of Mitchell Grass or Inferior Mitchell Grass Country are intermixed with lightly timbered areas of stony or sandy country, mostly of low stock-carrying capacity. Some sections of the latter carry *Aristida* pastures and some top feed. Many of the areas are accessible from surrounding land systems but there are inaccessible portions in the north. Traversability is relatively good. Surface water supplies are mostly poor. Underground water is available in the southern areas, but bores have not been sunk in the northern areas and the position there is obscure.

The main potential of this land-use group depends upon the proportion of Mitchell grass and other better type pastures. These may comprise one-third to three-fifths of the total area according to the land system, and hence are of some importance. Areas close to communications or to better country have already been developed for beef-cattle raising. The less accessible portions are likely to remain undeveloped until the more extensive areas of better and more accessible country are further exploited. The total stock-carrying potential is estimated at 30,000 head.

(*h*) *Hilly Country* (*Area* 29,000 *sq. miles*)

This group forms a wide arc extending north-west from Dajarra and also includes some small areas within the inland desert areas. The eight land systems that compose it have in common a naturally low stock-carrying capacity, a low pastoral potential, and the absence of any agricultural potential. The group consists largely of hilly country, some very rugged, mostly with stony soils. Much of it is difficult to traverse except along the valleys of some of the land systems, and much of the northern belt is very inaccessible.

The stock-carrying capacity varies slightly. Spinifex pastures of very low value cover large areas. Where soils have formed on calcareous rocks, as in the Thorntonia and parts of Mt. Isa and Redbank Land Systems, deciduous woodland pastures occur, and even small areas of barley Mitchell or inferior Mitchell grass pastures. In some of the valley bottoms there are coastal woodland pastures and on slopes *Aristida* pastures in low woodlands. The useful areas are not individually extensive and their intermixture with very inferior or rough country makes handling and marketing of stock very difficult. The stock-carrying potential has been estimated at 33,000 head, but this assumes that many of the less accessible areas are utilized. It is mainly breeding country. The areas in the north are moderately well served by springs, flowing streams, or permanent waterholes. The remainder lacks adequate water and the locating of underground water is much more difficult than in other land-use groups because of the complicated geological structures.

The main value of the land-use group is in its mineral resources. The silver-lead mines at Mt. Isa, the gold mines at Tennant Creek, and various small mines occur within it. Further prospecting is considered to be warranted.

(*i*) *Southern Desert Country* (*Area* 24,700 *sq. miles*)

Nine land systems are included in this land-use group, which is characterized by low rainfall, gently undulating to undulating topography, light-textured soils, and low scrub or woodland vegetation. It includes several areas in the southern half of the region. The margins are accessible from the main communications and traversability is fair.

Surface water supplies are very poor but underground water can generally be obtained by boring. Some sections carry *Aristida* or desert annual pastures, which provide useful early feed and light top feed and are valuable adjuncts to other land-use groups. In some of the land systems in the south-east, formed on limestone, small patches of heavy soil carry a variant of the barley Mitchell grass pastures. Apart from the marginal areas, the desert alluvial areas, and the limestone deserts accessible from the Georgina Valley, these desert areas do not have sufficient pastoral potential to warrant their development. The stock-carrying capacity varies considerably according to the proportion of useful country within the various land systems. The total potential is estimated at 32,000 head.

(*j*) *Northern Desert Country* (*Area* 14,700 *sq. miles*)

Several large areas in the northern half of the region constitute this land-use group. The western areas are accessible from main existing communications and some of the eastern portions from Burketown. Much of the country is difficult to traverse because of either deep sandy soils or dense, scrubby or forest vegetation. The gently undulating, lateritic country has leached soils. The vegetation varies from forests to woodlands, often with a dense, scrubby understorey.

The pastures are typically sparse forest pastures of very low value but small pockets of slightly better pastures occur. Many cattle properties include portions of this land-use group but these contribute little to the total stock-carrying capacity. The stock potential for the whole group is not more than 3,000 head. *Stylosanthes sundaica* (Townsville lucerne) may be adapted to some of the higher-rainfall sections. If introduced its slow natural spread could eventually result in a small but worth-while increase in productivity of areas accessible to stock.

There are minor timber resources in the lancewood forests of the Beetaloo Land System and in the scattered areas of cypress pine in the Westmoreland Land System. The leached soils have no agricultural potential but the possibilities of establishing cypress pine forests on an extensive scale in areas near the coast may be worth examination.

(*k*) *Coastal Country* (*Area* 6,100 *sq. miles*)

This land-use group consists of gently sloping alluvial country fringing the Gulf of Carpentaria and including the littoral and the alluvial plains extending inland to the foothills. The mean annual rainfall is 25-30 in. Various points are accessible by boat but there is no well-developed sea transport system. There are few roads within the land-use group but the eastern portions are accessible from Burketown, and the western from Borroloola. Travelling within the land-use group is restricted by the deeply entrenched streams running in a northerly direction. Between the streams traversing is easy.

The littoral includes sand dunes, salt marshes, and salt meadows. The last have pastures superior to most in the northern part of the region, but relatively unstocked. This narrow band occupies about two-fifths of the group and has a stock-carrying capacity of 8-10 beasts per sq. mile. The extensive alluvial plains are mostly covered by *Eucalyptus* Woodland or Open Forest with generally less valuable pastures described as coastal woodland pastures. Small areas of coastal swamp pastures also occur. The alluvial plains have a potential stock-carrying capacity of about five beasts per sq. mile, but are not stocked at this rate at present. Although there are several cattle stations in this part of the region the country is not fully utilized. Surface waters are plentiful but the outlet for stock at present is difficult except at the eastern end. Communications are mostly poor. Should better transport facilities for stock be developed for the more productive parts of the region these coastal areas would no doubt be further utilized, but mainly only for breeding purposes. The estimated stock-carrying capacity is 30,000. Although these lands are in the higher-rainfall zone of the region there is no known economic method of pasture improvement at the present time. Species such as Townsville lucerne and *Cenchrus ciliaris* (buffel grass) may be slowly incorporated in some parts of the natural pastures if development proceeds.

The narrow levees of Settlement Creek and the Nicholson River would be suitable for small-scale intensive agricultural development if irrigated. Limited amounts of water are available from these streams and small-scale conservation may be feasible. Tobacco is one of the crops worthy of attention, but the isolation of the area is likely to delay any development of this nature.

VII. Land Use on the Barkly Tableland in Relation to Water Supplies

A special study has been made of the distribution of stock-watering points in relation to land use on the Barkly Tableland, which is not only the most intensively developed part of the region but also has the greatest possibilities for further development. Information was collected in 1948 on the occurrence of permanent waterholes and bores, and the locations of the latter are shown on the Land Traverse Map. As this part of the region is an area of low rainfall and high evaporation the number of permanent waterholes is few. Stock depend mainly upon bore water. From information gained on this survey Noakes and Traves* have shown that underground water is held in sub-artesian basins in the sediments of the Barkly Group. Water can be obtained throughout the "black-soil" areas and the supply is likely to be adequate for any expansion or development of the cattle industry. In Part V the presence of salts in excessive quantities in water obtained from some bores, and of excessive fluorine in a small number also, is recorded. Figure 9 shows the areas of the "black-soil" plain of the Northern Territory portion of the Barkly Tableland served by bore waters in 1948. In mapping these boundaries it has been assumed that stock can effectively graze within a radius of 5 miles from watering points. The number of bores recorded in this section in 1948 was 161 and the number of waterholes observed or identi-

* Noakes, L. C., and Traves, D. M.—A geological reconnaissance of the Barkly region of the Northern Territory and Queensland. To be published as a bulletin of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics.

fied from aerial photographs was 159. However, in some sections many of these watering points are closer than the limit of 10 miles. The total area of "black-soil" country served by water in 1948 was 17,210 sq. miles distributed between four land-use groups as in Table 58.

It is evident that there are still large areas of the Northern Territory Barkly Tableland not served by water and it is estimated that 140 more bores would be necessary if all the country is to be within 5 miles of a watering point. The additional stock-carrying potential cannot be estimated proportionally. Small parts of the unwatered areas may already be utilized for short periods while seasonal surface water remains, and some untested areas may have underground water with high salt or fluorine content. An estimate based on present standards of stock husbandry shows that 120,000 additional stock could be carried on the Northern Territory portion of the Barkly Tableland as a result of increased watering facilities alone.

TABLE 58

"BLACK-SOIL" COUNTRY SERVED BY WATER IN 1948

Land-use Group	Area Served by Water (sq. m.)	Area Not Served by Water (sq. m.)
Mitchell Grass Country	14,310	6,290
Inferior Mitchell Grass Country	1,590	1,960
Bluebush Swamps	790	550
Drybog Country	520	1,320
Total	17,210	10,120

Another aspect of stock water supply is the distance apart of watering points in relation to efficient pasture utilization. Where artificial watering points have to be established there is a tendency to space these according to the maximum distances at which stock can graze from a watering point. Although this approach permits the greatest possible area to be served by water with the least amount of capital expenditure by reducing the number of bores and the amount of fencing to a minimum, it is not at all certain that it allows pastures to be most efficiently utilized. Different classes of stock can travel different distances to pasture from water. As the dry season progresses and the pastures near the bores are consumed stock have to travel considerable distances each day or go to water once every two days. It is likely that the loss of energy in locomotion alone represents a significant wastage of food supply and hence of body weight. Added to this is the fact that stock have to travel most when pastures are in the poorest nutritive condition. This is a particular handicap to breeders, which are usually in calf or have calves at foot at this time. As such animals cannot travel such long distances for feed as steers and spayed cows they are less able to utilize the pastures fully. It seems probable that placing watering points closer could effect a far more efficient use of the food supply and be of considerable advantage to breeding cows and young stock. The economy in use of the food supply might well repay the additional capital costs by reducing stock losses, increasing body weight and percentage turn-off, and improving quality. It is not possible to indicate what represents the optimum distance of watering points for different kinds of country. This is a problem that might well be made the subject of a special study from the points of view of pasture maintenance and utilization, and economic animal production. Such information would be of value not only to property managers but also to administrative departments interested in determining optimum property size and permissible intensity of development.

VIII. Agricultural Potentialities of the Region

The agricultural potentialities of the region may be briefly summarized as follows:

(i) *Dry-land Agriculture.*—It is unlikely that a permanent, self-sufficient, dry-land agriculture can be established in the region, but climatic conditions appear satisfactory for the growth of short-season fodder crops on the better soils of land-use groups (*b*), (*d*), and (*k*), and in specially favoured locations in (*c*). In some seasons, successful crops of peanuts and crops with similar requirements might be grown on suitable soils in groups (*b*) and (*d*). In all cases applications of phosphatic fertilizer are likely to be necessary for satisfactory crop production.

Agricultural development is not likely to proceed until there have been further advances in, and intensification of, the beef-cattle industry. It is doubtful if at the present time this industry could effectively utilize the agricultural potential.

(ii) *Small-scale Intensive Agriculture under Irrigation.*—The narrow levees of the Nicholson and Gregory Rivers and of Settlement Creek could be utilized for intensive agricultural crops such as tobacco if irrigated. Each of the streams flows for the greater part of the year and there may be possibilities for small-scale water conservation for this purpose. The investigations on tobacco production under irrigation at the Katherine Research Station will have some application to these areas.

(iii) *Larger-scale Irrigated Agriculture.*—The plains of the Gregory River and its tributaries have similar soil characteristics to, but are far more extensive than, the flood plains of the Ord River valley in Western Australia. If the investigations at the Kimberley Research Station show that such land can be economically developed under irrigation, the results might equally well apply to this area. However, the catchment of this river system is small, and even if satisfactory dam sites can be located, the conserved water would not be sufficient to irrigate more than a small proportion of the land available.

IX. Pastoral Potentialities of the Region

The starting point for any prediction of the pastoral potential of a region is the estimate of the maximum number of stock that can be carried. In Table 59 are summarized the figures for the estimated stock-carrying potential for each land-use group and for the region as a whole. In making these estimates it has been assumed that there will be an intensification of the industry with full utilization of country and that the herd characteristics will remain much as they are at the present time. The figures have been calculated from the areas of each type of country described and mapped by this survey and from the assessed stock-carrying capacity of the pastures present in each. They are estimates of *maximum* potentials. As estimates of this kind depend so much upon assumptions made, the basis of estimation is also indicated in Table 59.

The figures in Table 59 refer only to stock-carrying potential. The percentage turn-off and the proportion of fats and stores that might be marketed are not shown. This will vary considerably according to the type of livestock husbandry practised. Of the 11 land-use groups in Table 59 some fat stock can usually be produced from (*a*) and (*g*). A large proportion of the turn-off from (*b*) is sold as fats, and most of the stock carried by (*e*) could be turned off as fats. The prediction of percentage turn-off from an estimated maximum potential must be regarded mainly as an academic exercise. The figures in Table 60, which are given for general interest only, are based on the 1947 pattern and standards of production.

In order that the potentials indicated might be approached, certain improvements and developments, which if fully applied could lead to still greater numbers, are necessary. These are listed below:

(1) The provision of additional watering points, to make all useful country accessible to stock.

(2) Further intensification of watering points in the better country, and provision of necessary fencing to increase efficiency of pasture utilization above present standards and to permit stock to be controlled and the various classes of stock to be segregated and managed.

(3) Achievement of optimum size of property.

(4) Provision of transport facilities to permit marketing of fat stock or young cattle, as well as older cattle, and to assist in reducing the hazards of full stocking that would accompany intensification of the industry.

(5) Improvement in stock husbandry and herd management. The present standards are a reflection of the stage of development of the region as a whole, which in turn has been influenced by price levels of the past. The achievement of higher standards is possible and should be profitable as regional development, particularly transport, progresses.

TABLE 59

ESTIMATED MAXIMUM CATTLE-CARRYING POTENTIAL

Land-use Group	Area (sq. miles)	Basis of Estimation: Proportion of Usable Country	Basis of Estimation: Stocking Rate (per sq. mile)	Maximum Potential: Northern Territory Portions	Maximum Potential: Queensland Portions	Maximum Potential: Total	Classes of Stock Carried
(*a*) Mitchell Grass Country	28,700	Mostly usable	Mostly 15, some 12	323,000	105,000	428,000	Breeders, stores, and small percentage fats
(*b*) Northern Mitchell Grass Country	900	All usable	15	—	14,000	14,000	Breeders, stores, and larger proportion of fats
(*c*) Inferior Mitchell Grass Country	3,900	Mostly usable	10	39,000	—	39,000	Breeders and stores
(*d*) Northern Inferior Mitchell Grass Country	1,400	Mostly usable	10	2,000	12,000	14,000	Breeders and stores
(*e*) Bluebush Swamp Country	1,400	Changeable, average 2/5 usable	80	44,000	1,000	45,000	Mostly fats
(*f*) Drybog Country	2,200	Mostly usable	5	10,000	—	10,000	Breeders and stores
(*g*) Broken Mitchell Grass Country	7,000	1/4-3/5 usable	10-12	30,000	—	30,000	Breeders, stores, and small percentage fats
(*h*) Hilly Country	29,000	1/10-1/2 usable	3-10	18,000	15,000	33,000	Breeders and stores
(*i*) Southern Desert Country	24,700	Very variable	2-10	19,000	13,000	32,000	Breeders and stores
(*j*) Northern Desert Country	14,700	1/20 usable	4	2,000	1,000	3,000	Breeders and stores
(*k*) Coastal Country	6,100	Mostly usable	Mostly 5, some 10	10,000	20,000	30,000	Breeders and stores
Total	120,000			497,000	181,000	678,000	

The figures for estimated total turn-off for the Northern Territory and Queensland portions of the region are 62,900 and 24,200 respectively. Thus, it will be observed that on this basis it should be possible theoretically to top off approximately 70 per cent. of the cattle produced by the Northern Territory portion of the region on the bluebush swamps if these were fully utilized for this purpose. The proportion of stock on these swamps not successfully topped off in any one season is likely to be balanced by the small proportion of fat cattle produced on the other areas.

TABLE 60

ESTIMATES OF POTENTIAL TURN-OFF (1947 STANDARDS OF PRODUCTION)

Land-use Group	Maximum Stock-carrying Potential	Assumed Percentage Turn-off	Estimated Turn-off per Annum
(a) Mitchell Grass Country	428,000	15	64,200
(b) Northern Mitchell Grass Country	14,000	15	2,100
(c) Inferior Mitchell Grass Country	39,000	12	4,700
(d) Northern Inferior Mitchell Grass Country	14,000	12	1,700
(e) Bluebush Swamp Country	45,000	Stock from associated areas fattened	
(f) Drybog Country	10,000	10	1,000
(g) Broken Mitchell Grass Country	30,000	12	3,600
(h) Hilly Country	33,000	10	3,300
(i) Southern Desert Country	32,000	10	3,200
(j) Northern Desert Country	3,000	10	300
(k) Coastal Country	30,000	10	3,000
Total	678,000		87,100

The fattening potential of the bluebush swamps would be accessible mainly to cattle from the central portions of the region. Cattle from the Gregory River basin would be expected to move eastward, but their numbers no doubt would at least be balanced by stock moving in from the west.

Should the industry throughout the region be modelled to produce young store cattle mainly, such as is successfully done on at least one Georgina basin station, the percentage turn-off could be somewhat higher and the total for the region could be of the order of 100,000 per annum when fully developed.

Either system could equally well utilize the pasture resources of the region but there would be a degree of danger in the second in that the region would be more dependent upon climatic conditions in the fattening areas. Should the receiving areas not be in a position to take stock because of poor conditions, the breeding properties could soon become grossly overstocked.

X. Regional Land-use Potentialities in Relation to Development

The development of northern Australia was the objective that initiated the present series of regional surveys. If that objective is a factor of national importance, and there is growing evidence that the effective occupation of northern Australia has considerable significance to this country, every effort must be made to utilize its natural resources as completely as possible for these are less abundant than in any other parts of the continent.

The pattern of the cattle industry in the Barkly region has followed exploration and intrusion from Queensland and it is now tied to the east and the south by the only transport medium, the stock routes, and, with the large cattle companies, by chains of stations that act as resting depots for cattle moving to the fattening areas or to the market. While this inherited pattern has some obvious advantages to the existing cattle industry, it is not at all certain that its continuation will permit the most effective use of land resources, or their full application to northern Australian development. It is not the function of this survey to propound a policy of development for this must be a product of many considerations involving other things than land characteristics and potentialities. It has the responsibility, however, to record the facts about land potentialities which should be taken into consideration in arriving at such a policy.

The significant facts regarding land-use potential of the Barkly region that emerge from this survey are:

(1) Climatic conditions define the region as one of pastoral rather than agricultural potentialities.

(2) It is not feasible to develop the small dry-land agricultural potential until such time as the region as a whole, through its pastoral industry, has been more fully developed.

(3) There may be possibilities for development of irrigation in coastal sections, but this development cannot be on a very large scale because of the small size of catchment areas and the low rainfall received by them. The actual form of irrigated agriculture could not be clearly defined at this stage.

(4) There is a large belt of hilly country of low pastoral value but worth further examination for mineral resources. The Mt. Isa mines occur in this belt, but the possible occurrence of other deposits of such importance cannot be predicted and cannot directly influence any plan for regional development unless, and until, they are located.

(5) The region has a maximum stock-carrying potential of the order of 678,000.

(6) The annual turn-off of stock must vary according to the season, age of the stock, purpose for which they are produced, and the

degree to which the cattle industry is intensified. The estimate for the maximum mean annual turn-off from the Northern Territory portion is approximately 63,000 and from the region 87,100 when all lands are fully utilized. In a large proportion of years the region could top off or fatten 45,000 or more of these. Alternatively, the region might turn off up to 100,000 annually, consisting mainly of young stock but including some older stores and aged animals.

(7) Whichever form of intensification of the cattle industry is followed, and in practice neither is likely to be adopted to the exclusion of the other, the development of transport facilities would be essential for full land use.

(8) Intensification of the cattle industry would mean a much more complete use of the pasture resources. This in itself must result in an increase in the hazards associated with variations in annual rainfall, for the intensity of stocking would be raised, and the areas of reserve country limited. These would be offset to a degree by more efficient pasture utilization in normal years, but in years of acute drought a transport system would have additional importance in that it would enable a proportion of the stock to be removed to other regions.

It is of interest to note that if the emphasis is placed on the production of fat cattle, the number produced by this region, plus that from the Katherine-Darwin region and associated country, is likely to be adequate to support a killing works in the north. In the report by Christian and Stewart (1953) on the survey of the Katherine-Darwin region certain agricultural and pastoral potentialities were indicated, but it was pointed out that "In any overall plan of development of the cattle industry, the somewhat limited potential production of this region should be linked with that of areas to the south in reasonable proximity, in order that the combined production may be sufficient to establish an economically sound unit." It is doubtful if the Katherine-Darwin region alone could support a killing works, or that the land-use potential of that region could be fully developed without such an outlet for stock. To what extent these two regions should be linked in development may be determined by factors other than those examined by this survey.

A large proportion of the cattle from the western part of the Northern Territory cross the Barkly region on their way to Queensland and New South Wales, and many are held on the better pastures of the region for varying periods in transit. Thus portion of the fattening potential of the region is being utilized at the present time merely to sustain stock bred and fattened elsewhere. It would appear to be a better use of the pasture resources if at least a proportion of such stock could go directly to killing works from these pastures.

If the emphasis is placed on breeding stock in the region rather than fattening, the average annual supply of cattle for fattening elsewhere is not likely to exceed an average of 100,000 annually even if mainly young stock are produced. Of this number only a proportion would be available for southern fattening areas. This form of production could utilize the pasture resources as well as could breeding and fattening, but it may contribute less to the development of northern Australia.

Finally it should be pointed out that the Barkly region has a closer geographical relationship to the northern regions than it has to the more densely populated regions of the east and the south. The inherited pattern of the cattle industry should not be permitted to obscure this relationship in the considerations of a long-term development policy for northern Australia.

SUMMARY OF THE MAIN CHARACTERISTICS OF THE LAND SYSTEMS OF THE BARKLY REGION

Land System	Most Common Topography, Soil, and Vegetation
Wonorah	Gently undulating; Lateritic Red Earths; *Eucalyptus brevifolia* Woodland or *E.* spp. (low mallees)—*Acacia* spp. Shrubland
Pollyarra	Gently undulating; Lateritic Red Earths and Lateritic Podzolic soils; *Eucalyptus dichromophloia* Woodland and *E. brevifolia* Woodland
Beetaloo	Gently undulating; Lateritic Red Earths and Lateritic Podzolic soils; *Acacia shirleyi* (lancewood) Forest
Elliott	Gently undulating; Lateritic Red Sands; *Jacksonia odontoclada—Acacia* spp. Scrub
Westmoreland	Gently undulating; Tertiary Lateritic Podzolic soils; *Eucalyptus tetrodonta—E. miniata* Shrubland Open Forest
Camil	Gently undulating; Tertiary Non-lateritic soils; *Triodia pungens* Shrub Grassland
Camilrock	Gently undulating; Tertiary Non-lateritic soils and many limestone outcrops; *Triodia pungens* Shrub Grassland
Prentice	Gently undulating, with low limestone rises; calcified Lateritic soils; *Eucalyptus argillacea—E. terminalis* Shrub Woodland
Barkly	Very gently undulating; Heavy Grey Pedocals; *Astrebla pectinata* Grassland
Creswell	Very gently undulating; Northern Heavy Grey Pedocals; *Eulalia fulva—Dichanthium fecundum* Grassland
Robinson	Rough topography with large rock masses separated by steep-sided gorges; skeletal soils and rock outcrops; *Eucalyptus brevifolia, E. dichromophloia,* or *E. aspera* Woodlands
Redbank	Hilly; mostly skeletal soils with *Eucalyptus brevifolia* or *E. dichromophloia* Woodlands on "acid" rocks; and *E. argillacea—E. terminalis* Woodland on limestones
Kilgour	Steeply to gently undulating; mostly Podzolic Truncated Lateritic soils and Kilgour Heavy Grey Pedocals; *Eucalyptus brevifolia* Woodland and *Astrebla pectinata* Grassland respectively
Yelvertoft	Undulating; mostly skeletal soils or truncated gravelly Lateritic Red Earths; *Eucalyptus brevifolia* or *E. dichromophloia* Woodlands
Ashburton	Hilly; skeletal soils; *Eucalyptus brevifolia* or *E. dichromophloia* Woodlands
Tennant Creek	Flat-topped hills and broad valleys; skeletal and alluvial soils; *Eucalyptus brevifolia* Woodland
Helen Springs	Gently undulating to low hilly; skeletal soils, Igneous Calcareous Desert and Heavy Pedocal soils; *Eucalyptus brevifolia* Woodland, *Terminalia grandiflora* Woodland, and *Astrebla pectinata* Grassland respectively
Mitchiebo	Undulating low hilly; skeletal or Podzolized Desert Alluvial soils; *Eucalyptus brevifolia* Woodland or *E. pruinosa* and *E. argillacea—E. terminalis* Shrub Woodland

Argadargada	Very gently undulating; Southern Heavy Grey Pedocals; *Astrebla pectinata* Grassland and *Acacia georginae—Astrebla pectinata* Woodland
Joanundah	Very gently undulating; Northern Heavy Grey Pedocals; *Eucalyptus microtheca—Eulalia fulva—Dichanthium fecundum* Woodland
Drylake	Very gently undulating; Drylake Heavy Grey Pedocals; *Eucalyptus microtheca* Shrub Woodland
Austral	Very gently undulating; Heavy Grey Pedocals and Heavy Brown Pedocals; *Astrebla pectinata* Grassland and *Acacia georginae—Astrebla pectinata* Woodland
Tobermorey	Undulating to low hilly; Limestone Calcareous Desert soils; *Acacia georginae—Cassia* spp. or *Eucalyptus terminalis—Cassia* spp. Shrub Woodlands
Wonardo	"Black-soil" plains; Heavy Grey Pedocals or Heavy Brown Pedocals; *Astrebla pectinata* Grassland
Waverley	Undulating to low hilly; mostly skeletal soils; *Eucalyptus brevifolia* Woodland
Mt. Isa	Rugged and hilly with north-south ridges; mostly rock outcrops or skeletal soils; *Eucalyptus brevifolia* Woodland
Thorntonia	Rough, rounded hills or stepped slopes; skeletal soils and rock outcrops; *Eucalyptus argillacea—E. terminalis* Shrub Woodland or deciduous softwood communities.
Rolyat	Gently undulating; mostly limestone outcrops with some Limestone Red soils; deciduous softwood communities or *Eucalyptus argillacea—E. terminalis* Woodland
Littoral	Salt flats, salt meadows, and sand dunes with a variety of plant communities
Gregory	Very gently undulating "black-soil" plains; Heavy Grey Pedocals; *Astrebla pectinata* Grassland
Keighran	Gently undulating; Deep Yellow Podzolic soils; *Eucalyptus argillacea—E. terminalis—E. tectifica* Woodland
Balbirini	Very gently undulating "black-soil" plains; Northern Heavy Grey Pedocals; *Eulalia fulva—Dichanthium fecundum* Grassland
Kallala	Very gently undulating "black-soil" plains; Heavy Brown Pedocals; *Astrebla pectinata* Grassland or *Acacia georginae—Astrebla pectinata* Woodland
Moonah	Gently undulating mixed "black-soil" plains and "red-soil" rises; Heavy Brown Pedocals and Georgina Alluvial Red-brown Earths; *Astrebla pectinata* Grassland or *Acacia georginae—Astrebla pectinata* Woodland and *Acacia cambagei* Shrub Woodland respectively
Bundella	Undulating; "Bundella" soils; *Eucalyptus argillacea—E. terminalis* Shrub Woodland
Gosse	Flats; soils of the "Desert" Distributary complex; *Eucalyptus dichromophloia* Woodland, *E. pruinosa* or *E. argillacea—E. terminalis* Shrub Woodland
Sylvester	Bluebush swamps; Distributary Heavy Grey Pedocals; *Chenopodium auricomum* Shrubland
Georgina	Gently undulating "black-soil" plains cut by braided streamlines; Heavy Grey Pedocals; *Astrebla pectinata* Grassland

Fig. 1.—The extensive areas of flat to very gently undulating country of the Barkly Tableland have heavy clay soils and an almost treeless grassland vegetation in which barley Mitchell grass (*Astrebla pectinata*) is the commonest dominant.

Fig. 2.—Mitchell grass is a coarse, drought-resisting, perennial tussock grass 2-3 ft high, the tussocks being 9-12 in. in diameter and about 2 ft apart. The spaces between the tussocks are almost bare, but after rains they are commonly covered by annual species.

Fig. 1.—The heavy clay soils (Heavy Grey Pedocals) of the plains crack into large blocks during the dry season. Cracks frequently extend to 3 ft and occasionally to 6 ft below the surface. During the wet season these soils become very boggy and before air transport was developed, stations were isolated for several months each year.

Fig. 2.—In the widely-spaced shallow depression lines on the plains, weeping Mitchell grass (*Astrebla elymoides*) is generally dominant over a dense cover of annual herbage of which Flinders grass (*Iseilema* spp.) is the commonest constituent. These areas are preferentially grazed by stock.

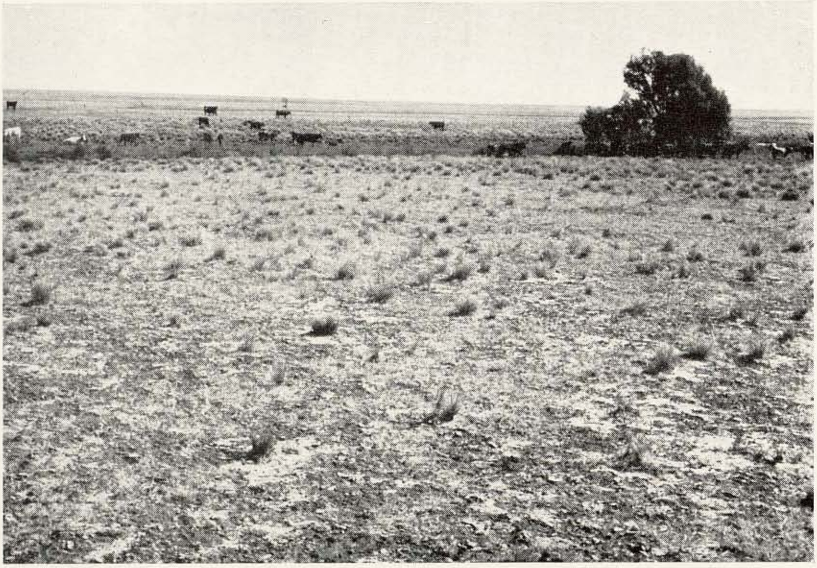

Fig. 1.—Some of these depression lines are deeper and are fringed by coolibahs (*Eucalyptus microtheca*). Such small streams are widely spaced but may flood extensively during the wet season. Permanent waterholes are infrequent.

Fig. 2.—In some parts, low walls (overshot dams) have been constructed across the shallow streams to make artificial waterholes, which provide water for stock for some months after the end of the wet season.

Fig. 1.—Water supply is the chief factor limiting use of land for grazing in inland areas. The main supply is from bores 200-400 ft deep, sunk by means of percussion drills.

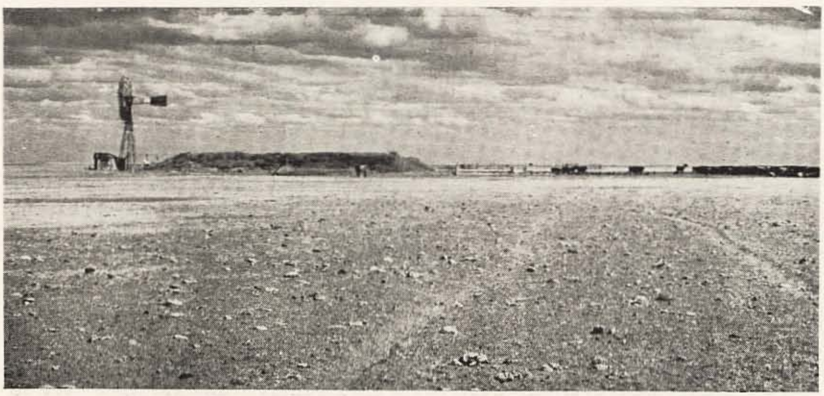

Fig. 2.—When adequate supplies of water are struck, the bores are equipped with large windmills or engines which pump water into raised earth tanks from which it gravitates into long troughs. One thousand head of cattle grazing around a bore require approximately 10,000 gallons of water per day. In the immediate vicinity of bores the ground is bared by grazing and trampling.

Fig. 1.—In general, the Mitchell grass pastures withstand grazing well, and it is only near watering points and along stock routes that permanent destruction of the perennial grass cover occurs. By the end of the droving season some parts of stock routes are devoid of all vegetation, thus limiting movement of stock late in the season.

Fig. 2.—Lateritic residuals (locally called deserts) occur as very low rises scattered throughout the broad plains of the Barkly Tableland. Features of these residuals are lighter-textured soils, termitaria, and woodland vegetation. Supplejack (*Ventilago viminalis*) and other low trees and shrubs growing on the edge of these desert areas provide valuable top feed for stock grazing on the grasslands of the plains.

Fig. 1.—Near the Georgina River in the south-eastern part of the region gidgee (*Acacia cambagei* and *A. georginae*) is commonly found. It grows on very stony heavy soil and the ground flora consists of annual grasses and forbs. Gidgee has a hard wood used extensively for fence posts.

Fig. 2.—In the northern part of the Barkly Tableland there are some areas with yellow-grey podzolic soils on which coolibah (*Eucalyptus microtheca*) and browntop (*Eulalia fulva*) are dominant. Browntop is seldom grazed by stock in this region.

Fig. 1.—Near Newcastle Waters and in several other locations, gutta percha (*Excoecaria parvifolia*) is found growing on heavy clay soils flooded for several months of each year.

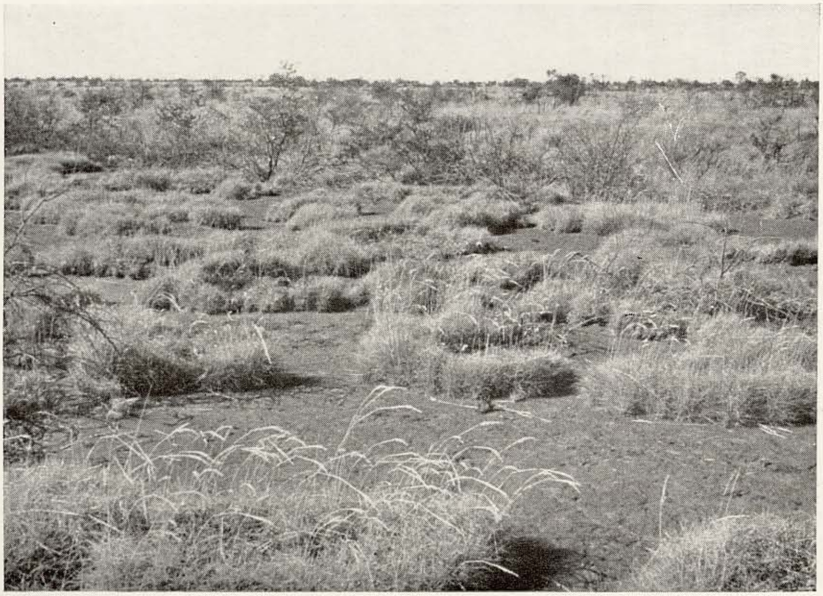

Fig. 2.—South of the broad plains of the Barkly Tableland is an extensive "desert" of lighter-textured soils (mainly lateritic) on which spinifex (*Triodia* spp.) is common. In parts such as this the other vegetation consists of scattered low shrubs (mainly *Acacia* spp.).

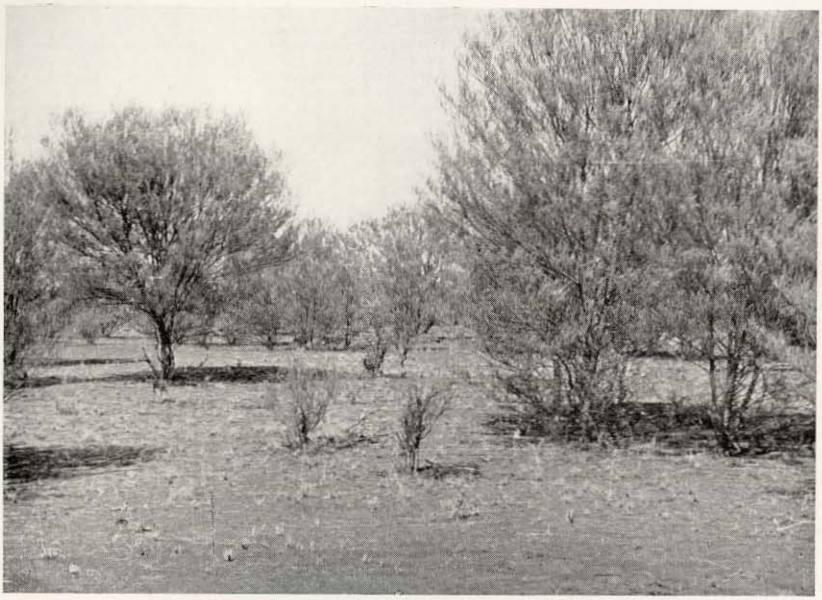

Fig. 1.—In some southern parts mulga (*Acacia aneura*) is dominant. On deeper soils the ground flora is generally dominated by a mixture of annual grasses such as kerosene grass (*Aristida* spp.) and oat grass (*Enneapogon* spp.). Following rain, these annuals form a dense cover which rapidly fattens stock. During dry periods stock can survive on mulga and other top feed.

Fig. 2.—On shallow limestone soils in low rainfall areas bloodwood (*Eucalyptus terminalis*) is dominant in a woodland community and spinifex (*Triodia* sp.) is often dominant in the ground layer. Annual grasses are common following rain.

Fig. 1.—The Stuart Highway, near the gold mining township of Tennant Creek (in distance), passing dissected stony areas dominated by spinifex (*Triodia* sp.). Snappy gum (*Eucalyptus brevifolia*) occurs sparsely.

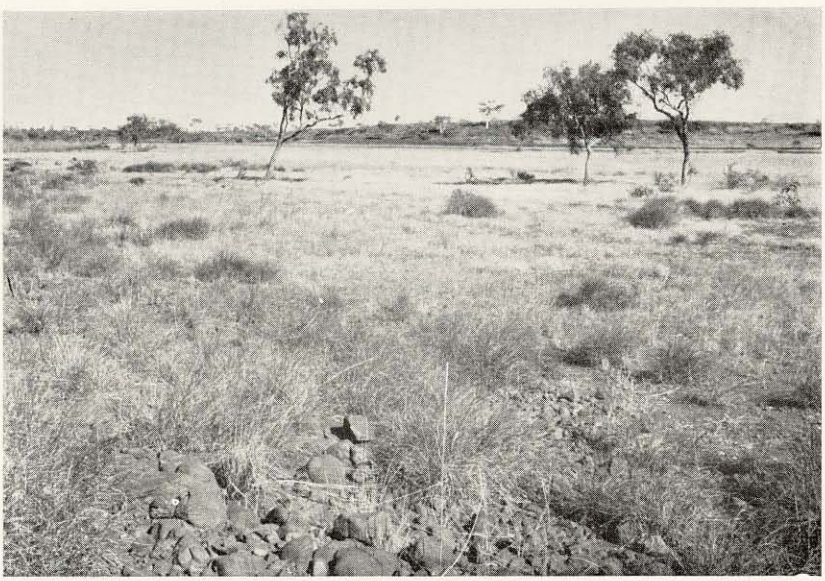

Fig. 2.—Near Helen Springs Station there is an area of volcanic country on which spinifex (*Triodia* sp.) and snappy gum (*Eucalyptus brevifolia*) are common on skeletal soils. On the heavy clay soils of the flats there is a sparse woodland of nutwood (*Terminalia grandiflora*) in which the ground flora is dominated by Mitchell grass (*Astrebla pectinata*).

Fig. 1.—Where rainfall is higher (25-30 in. per year), the spinifex of the rocky areas is a *Plectrachne* sp. A variety of low trees dominate woodland communities. In this photo the trees are bloodwoods (*Eucalyptus ferruginea*) and the shrubs are *Acacia* sp.

Fig. 2.—On lateritic soils to the north of the Barkly Tableland where the rainfall is 25-30 in. per year large areas have a woodland vegetation dominated by bloodwood (*Eucalyptus dichromophloia*) and spinifex (*Plectrachne* sp. or *Triodia* sp.).

Fig. 1.—In the Beetaloo Land System lancewood (*Acacia shirleyi*) forms forests on a variety of lateritic soils. In other parts of the area lancewood is restricted to steep scarps of laterite-capped mesas. Lancewood is highly valued as a timber for posts and rails.

Fig. 2.—Bullwaddy (*Macropteranthes kekwickii*) thickets are also a characteristic constituent of the Beetaloo Land System.

Fig. 1.—Where laterite is formed on limestones sinkholes are sometimes formed by slumping of the surface into underground caverns. The sinkhole figured is about 100 yd across and 80 ft deep. Such holes permit the study of the lateritic profile, which may be 40-60 ft deep.

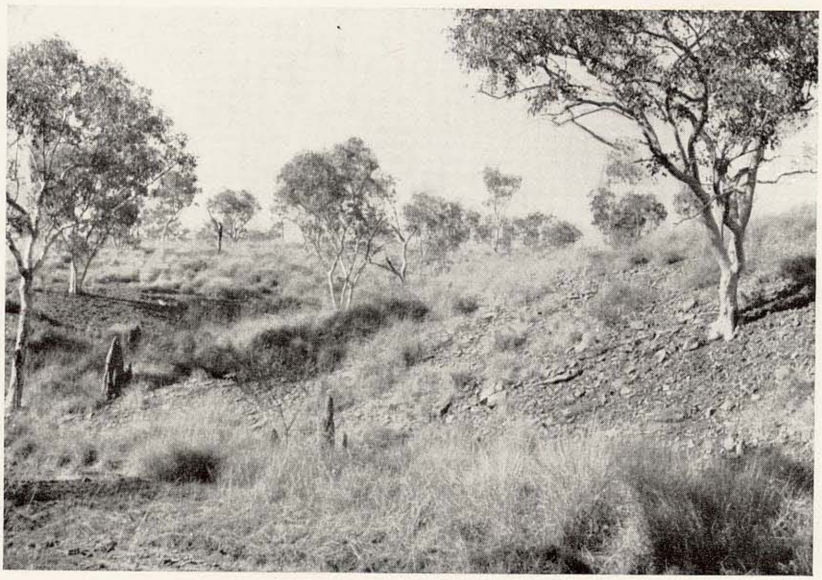

Fig. 2.—In the dissected hilly country north of the Barkly Tableland snappy gum (*Eucalyptus brevifolia*) and spinifex (*Triodia* sp.) occur in a woodland community on skeletal soils formed on acid rocks.

Fig. 1.—Where the skeletal soils are formed on limestones trees such as *Bauhinia cunninghamii* and *Gyrocarpus americanus* dominate on deciduous woodland with sparse grasses.

Fig. 2.—The dissected hilly country north of the Barkly Tableland carries a low *Eucalyptus* woodland vegetation. Except for better areas in valleys this country is of no use as grazing land.

Fig. 1.—On areas of low-level laterite near the Gulf of Carpentaria, open forests dominated by stringybark (*Eucalyptus tetrodonta*), woollybutt (*E. miniata*), and bloodwood (*E. dichromophloia*) and with a shrub layer of *Calytrix microphylla, Jacksonia odontoclada*, and *Bossiaea phylloclada* occur.

Fig. 2.—The levees of the major streams flowing into the Gulf of Carpentaria have a woodland vegetation in which ghost gum (*Eucalyptus papuana*) is prominent. The ground flora consists of *Sorghum* sp., kangaroo grass (*Themeda australis*), bunch spear grass (*Heteropogon triticeus*), and *Sehima nervosum*.

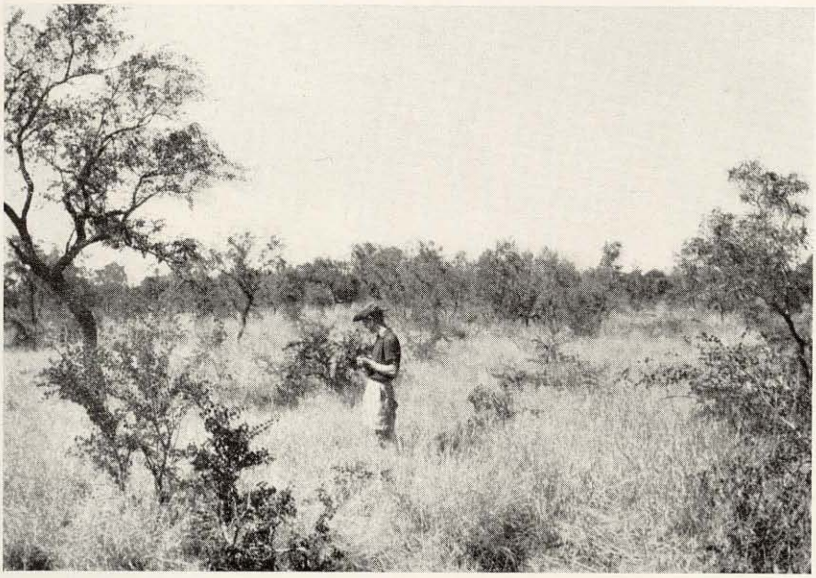

Fig. 1.—On areas of heavy soils under high-rainfall conditions (>30 in. per year) low trees are common in contrast to similar soils in lower rainfall regions. Bean tree (*Bauhinia cunninghamii*) is prominent. The ground storey contains browntop (*Eulalia fulva*), blue grass (*Dichanthium* sp.), and other perennial grasses.

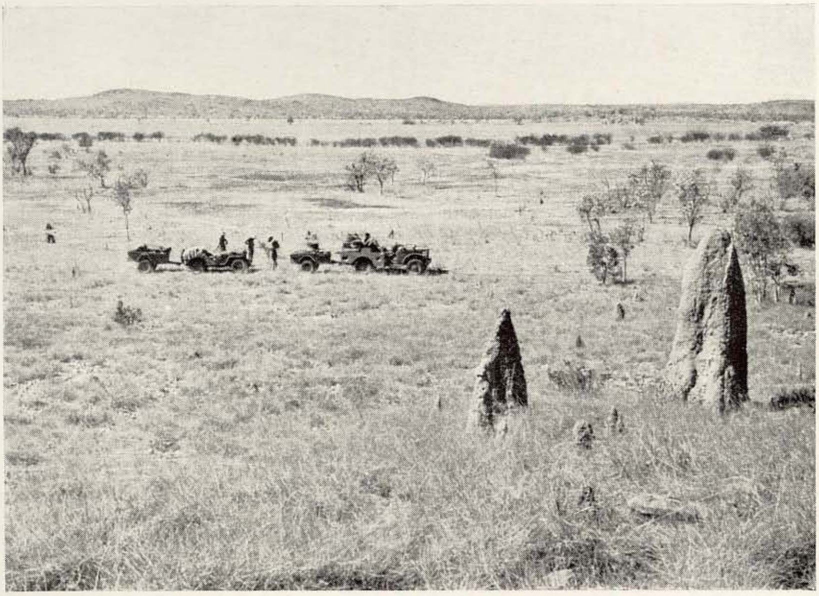

Fig. 2.—The survey team travel in four-wheel-drive vehicles making continuous records along traverse routes and stopping for more detailed observations every few miles.

Fig. 1.—Lagoon. Near the coast, rainfall is higher and surface water is more plentiful. Lagoons are common on the coastal plains. They are usually fringed by red gum (*Eucalyptus camaldulensis*).

Fig. 2.—Near the coast, saline waters regularly flood low-lying areas of the Littoral Land System. Samphire is common on the mud flats but slightly higher areas carry a grassland in which sand couch grass (*Sporobolus virginicus*), golden beard grass (*Chrysopogon* sp.), or rice grass (*Xerochloa* sp.) are common.