General Report on Survey of Katherine-Darwin Region, 1946

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CONTENTS

List of Maps

FOREWORD

The development of northern Australia has been slow in comparison with that of the southern and eastern States and in general this region has been a considerable financial burden to the remainder of the continent. Over 100 years have elapsed since the first settlements in the north, yet vast areas remain unproductive and are still only sparsely populated.

The utilization of this region is a responsibility of international as well as domestic significance and in 1945 the Commonwealth Government, together with the States of Queensland and Western Australia, established a Committee known as the Northern Australia Development Committee to plan the coordinated development of this part of the continent.

At the first meeting of this committee in January 1946, it was agreed that systematic surveys of the natural resources of the main areas of Northern Australia should be made and it was recommended that reconnaissance surveys should commence during the following dry season.

Several regions in the Northern Territory, Queensland, and Western Australia were considered worthy of survey. Priority was given to the areas shown in Figure 1 (overleaf) and of these first priority was allotted to the Darwin-Katherine region, in which considerable financial expenditure had been incurred during the war years.

The Council for Scientific and Industrial Research (now the Commonwealth Scientific and Industrial Research Organization) was subsequently requested to make these surveys and the organization of a survey party was commenced in March 1946. Field work for the Katherine-Darwin region was completed that year and an advance report distributed to Commonwealth Departments in July 1947. The present publication is a revised version of this advance report.

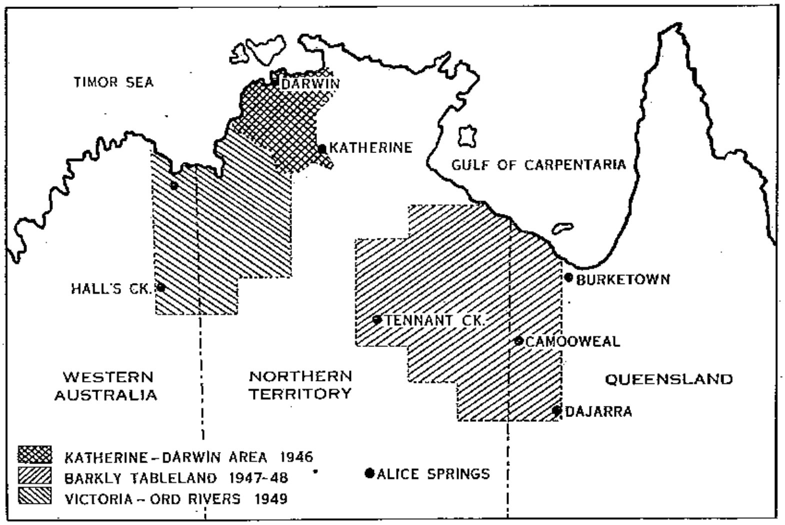

Fig. 1.—Locality plan.

RECOMMENDATIONS

It is recommended that:

(1) Consideration be given to a general plan for the development of the land industries of the region based on the following:

(*a*) The establishment of an agricultural community based on the production of:

- (i) Fodder and summer cereal crops to be used in conjunction with the pig industry, farm fattening of cattle, dairying (local supply), and the poultry industry;
- (ii) Exportable crops such as peanuts, rice, tobacco, and possibly cotton, oil, and fibre plants;
- (iii) Fruits and vegetables initially for local consumption, but with the possibility of export to the south, and supply to a small local canning industry.

(*b*) The establishment within the region of a meat-processing works to provide:

- (i) A local market for fat cattle, scrub and cull cattle, and pigs;
- (ii) A local supply of protein by-products for the pig and poultry industries, and fertilizers for intensive agriculture.

(2) In order to implement the above plan, certain plant and animal investigations should be conducted. The most urgent are:

(*a*) The investigation of the possibilities of economic crop production under natural rainfall conditions in the Tipperary, Elliott Creek, and Litchfield Land Systems, the initial experiments to be conducted near Katherine;

(*b*) A thorough exploration of the possibilities of tobacco production;

(*c*) Investigation of the peanut industry with the object of achieving greater and more stable production, and the introduction of a system of mixed farming;

(*d*) Following the experiments concerning summer cereal production, the possibility of producing a type of pig satisfactory for the local and export trade should be examined;

(*e*) Extensive testing of pasture grasses and legumes should be commenced with the major objective of improving stock-feeding conditions during the dry season;

(*f*) The growing of rice on the "bull-dust" plains should be investigated, initial experiments to be commenced on the plains near Adelaide River township;

(*g*) The problems of breeding efficient and satisfactory types of beef and dairy cattle suited to conditions in Northern Australia should receive consideration;

(*h*) A small herd of dairy cattle should be established at Katherine with the object of determining the possibilities of milk production based on locally grown foodstuffs.

(3) 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 their combined productions may be sufficient to establish an economically sound unit.

SUMMARY

Introduction

(1) An area of nearly 27,000 square miles in the Katherine-Darwin section of the Darwin and Gulf Land Administration Division of the Northern Territory was surveyed during the dry season of 1946. The region is bounded by the East Alligator River on the east, and on the south by a line 20 miles south of the Katherine and Daly Rivers.

(2) The objectives of the survey were to record accurately the nature of the country, to assess its potentialities and to make recommendations with respect to its development.

(3) The survey was conducted by land traverses that totalled over 3,000 miles and a brief aerial reconnaissance of about 800 miles.

(4) Subsequently a map of the region was produced from aerial photographs, the interpretation of which was based upon the records of the land traverses.

Land Classification

(5) The region surveyed includes country of a most variable nature.

(6) It was examined mainly with respect to geology, geomorphology, topography, soils, vegetation, and present land use.

(7) In order that the developmental possibilities of the region might be assessed in a systematic way, the lands of the region have been classified into units, termed Land Systems.

(8) A Land System has been defined as an area, or group of areas, throughout which can be recognized a recurring pattern of topography, soils, and vegetation.

(9) Eighteen Land Systems have been described, mapped, their areas estimated, and potentialities assessed.

(10) Climate, soils, vegetation, and irrigation possibilities, upon which development of the land industries depends, are discussed in detail.

Climate

(11) The climate of the region is monsoonal with a short wet season and a long dry season.

(12) Rainfall is the dominating climatic feature affecting plant growth. In this region it exerts a very definite limiting influence on production in that, apart from specially favoured seepage and flooded areas, growth is restricted to a short wet season.

(13) Total annual rainfall varies from 35 in. per annum in the south-east to 60 in. in the north and north-west. The total annual rainfall is reasonably reliable and drought years rarely occur but the time of commencement and the duration of the wet season both vary.

(14) The period of adequate rainfall (defined in this report) varies from 14 weeks in the south of the region to 20 weeks in the north. The growth period for crop plants is somewhat longer than this, varying mainly with soil type and kind of crop.

Irrigation

(15) There appears to be little scope for extensive irrigation developments for the following reasons:

(*a*) Difficulty and high costs involved in harnessing the extremely seasonal flow of the major streams;

(*b*) The absence of extensive areas of suitable soils near the possible sources of water;

(*c*) The engineering difficulties of distributing water to the areas of suitable soils that do exist.

Small-scale irrigation by pumping is possible along portions of the major rivers, but in most instances would involve a lift of 40 to 60 ft. and could be economically applied only to high-return crops.

Soils

(16) The soils of the region may be grouped as follows:

(*a*) Estuarine deposits, which now constitute the sub-coastal plains. These soils are flooded for several months each year, are very heavy-textured, and cannot be considered of value for anything other than pastoral purposes and perhaps rice-growing at the margins.

(*b*) "Acid" alluvial soils of low-moderate fertility which cover flats of various extent throughout much of the region and extensive plains bordering the northern rivers. These are all liable to flooding for short periods. They do not appear suitable for extensive agriculture other than, perhaps, the growing of rice.

(*c*) Levee soils of fair fertility. These are the most attractive soils in the region, but are not of great extent (not greater than 20,000 acres) and many areas are relatively inaccessible in the wet season. They are mostly irrigable, and in general, where not subject to flooding, are satisfactory for intensive agriculture.

(*d*) Residual soils:

(i) lateritic soils;

(ii) shallow podsolic and stony podsolic soils;

(iii) red limestone and associated soils;

(iv) skeletal soils.

The lateritic soils are highly leached and of low fertility. Except those developed on granite, the podsolic and stony podsolic soils are not attractive agriculturally. The red limestone and associated soils are topographically and physically suitable for agriculture. The better of these soils are only moderately fertile. The skeletal soils are stony and usually occur on steep slopes.

VEGETATION

(17) The dominant vegetation on all well-drained areas is some form of open forest or, in some places, palm scrub. Flooded areas carry either grassland or swampy grassland, most commonly fringed by parkland or a mixed community in which *Tristania, Grevillea, Banksia,* or *Pandanus* are prominent.

(18) The lush jungle of the wet tropics is absent, but small patches of monsoon forest occur.

(19) Pastures represent the main assets in the vegetation. Timber resources are minor, and often inaccessible. There are few other plants of economic value.

PASTURES

(20) The pastures of the region may be grouped as follows:

(*a*) Pastures of the sub-coastal plain, seasonally flooded for several months, but which provide excellent feed after the flood waters have receded and when other pastures are mostly mature and very dry. In the north, these pastures are grazed mainly by buffaloes, while in the west they are largely unstocked or held as aboriginal reserves.

(*b*) Pastures of the acid alluvial flats and plains which make rapid growth during the flood period, but which quickly mature and deteriorate in quality once the waters recede. Flooding is less prolonged than in (*a*).

(*c*) Pastures of the open forest, parkland, and palm scrub areas which include many tall and medium height species which quickly deteriorate in nutritional value.

(*d*) Pastures of small, often isolated, wet areas within the open forest region which maintain their growth for a longer period than the pastures of the open forest.

(21) Growth of pastures following the commencement of rains is very rapid and the nutritional level quickly falls. This is raised for a short period at the end of the wet season by burning, which, if conditions are satisfactory, promotes a new growth which persists for a few weeks. Thus, apart from small areas specially favoured by springs or seepage. stock depend upon two short periods of new growth, interspersed by two long periods of poor nutrition.

(22) Little has been attempted or achieved with respect to pasture improvement and, apart from burning, no system of pasture management is practised.

Topography and Floods

(23) The topography of the area is variable. Many streams rising in the much dissected watersheds of the central or south-eastern sections flow to the west and north coasts. During the wet season these overflow their banks. In consequence, the sub-coastal plains are flooded intermittently over a period of six to eight months each year, and the extensive acid alluvial plains and the smaller flats for a shorter period.

(24) As a result of this annual flooding, many portions of the region, including some of the river levees, are inaccessible by road transport for several months each year. This handicaps the establishment of extensive permanent roads and also provides extreme difficulties in the management of large properties. It is a major influence deterring general development.

Present Land Use

(25) Most of the region is held as large-scale pastoral leases or grazing licences, or is set aside as aboriginal reserves.

(26) Numerous agricultural leases have been taken out but agriculture is now restricted to (*a*) the Daly River levee; (*b*) the Katherine River levee; (*c*) small areas along the main north-south road such as at Adelaide River, Coomalie Creek, Hayes Creek, and Berrimah; and (*d*) a few small areas near Darwin and on the pastoral properties. The total number of farms is approximately 30 but is increasing.

(27) Crop production is restricted to peanuts, vegetables, and small-scale fruit production.

(28) Agricultural production has been attempted in numerous other localities, mainly associated with the north-south railway and mining developments, but has not persisted.

(29) The pastoral industry occupies the major portion of the region, but it is not a flourishing industry. Several factors have contributed to maintaining the industry in its present primitive state of development:

(*a*) Inadequate and erratic markets;

(*b*) Low nutritional value of the natural pastures for two long periods each year;

(*c*) Natural handicaps and hazards that make management of properties difficult.

In consequence of the above, mortality is high and stock are of poor quality and low weights.

(30) The cattle population of the region is about 50,000, of which half are concentrated in the Daly River basin and adjoining areas. In the north-eastern section of the region, buffaloes are the main grazing animals, and pastoral leases are held chiefly for the purposes of holding shooting licences. The buffaloes are shot for their hides, the average number of hides exported during the period 1914-41 inclusive being about 6,500 annually.

(31) About nine shooting camps are operating. Very few beef cattle are run on these properties, and the main source of income is the sale of buffalo hides. With its low expenditure on permanent improvements this is probably at present the most prosperous industry in the region.

Reasons for Present Lack of Development

(32) In spite of the fact that the major proportion of the region is theoretically occupied and much effort and money have been expended, little has been achieved in the way of development. This may be explained by the following:

(*a*) The alternation of short growing season with a long dry period and its effects on pastures and crop production.

(*b*) Absence of any prospects for extensive irrigation.

(*c*) Difficulties of handling stock during the wet season and movement of stock during the dry season.

(*d*) Difficulties of land communications during the wet season and the general lack of communications internally and externally.

(*e*) Floods and other hazards.

(*f*) Marketing problems, including lack of extensive nearby markets.

(*g*) Lack of adequate suitable labour.

(*h*) Inadequate knowledge of plant and soil husbandry under the prevailing climatic conditions.

(*i*) The fact that in the past, settlement in this region has offered no advantage in competition with more congenial localities in other parts of Australia, and the region itself has not possessed a population adequate for its development.

Areas which may be Suitable for Agricultural Development

(33) This survey has indicated that the areas which most warrant investigations are:

(*a*) The Daly River basin and associated areas which include:

(i) The calcimorphic and sandy soils along and between the Katherine and Flora Rivers;

(ii) Similar soils on Tipperary Station and between the Douglas and Ferguson Rivers, and smaller areas of granitic soils bordering this area near the north-south highway;

(iii) Granitic soils and soils of the Elliott Creek series between the Reynolds and Daly Rivers south and north-west of Mt. Litchfield;

(iv) Granitic soils north of Katherine and near the main road.

(*b*) The flooded "acid" alluvial flats and plains of the Marrakai, Brocks Creek, and Finniss Land Systems.

(a) *The Daly River Basin*

(34) Prospects of development on the soils in this area rest with the success of agriculture under natural rainfall but, owing to the relatively poor soils and short growing season, field investigations are necessary to determine suitable crops and methods of land husbandry. Amongst the crops that should be considered are fodder crops, summer cereals, leguminous grains, oil seeds, tobacco, and cotton.

(35) These areas total 8,120 square miles of which only a portion, possibly one tenth (500,000 acres), would be suitable for agriculture. A more detailed soil survey would be necessary to assess the actual areas suitable.

(36) As the area between the Katherine and Flora Rivers is the most accessible and is reasonably close to the existing railway and the township of Katherine, it is recommended that investigations should be initiated in this area. The C.S.I.R.O. Research Station at Katherine is conveniently placed to provide a base for these investigations.

(b) *The Marrakai Plains, etc.*

(37) A form of agricultural production which warrants investigation is the production of rice under natural rainfall on the freshwater alluvial flats and plains of the Brocks Creek, Marrakai, and Finniss Land Systems. These are flooded for several months each year, and by the construction of suitable levees, this period might be extended. However, the survey was conducted during the dry season and this proposal requires further examination, particularly, in the first instance, by engineers.

Peanuts

(38) Peanut-growing is the only agricultural industry that has maintained an export trade over a long period. Present land and crop husbandry are poor, but production has persisted in spite of this. There is scope for considerable improvement in, and a possible extension of, production.

Tobacco

(39) Tobacco is one of the few high-return exportable crops that might be produced in this area. For this reason its possibilities should be fully explored and an attempt made to establish the industry.

Pig Industry

(40) If it proves possible to produce summer cereals, such as grain sorghums, on an extensive scale, there is the possibility of establishing an export pig industry, providing there is established within the region a killing works to process pig meat, and to supply adequate animal protein concentrates to balance the carbohydrate supply.

Pastoral Industry

(41) The aspects of the pastoral industry that may be most responsive to scientific investigation are (*a*) quality of stock; (*b*) health of stock; and (*c*) nutrition.

(42) Possible overwhelming factors are difficulties of property management, unsatisfactory marketing conditions, and low nutritive value of pastures during the dry season. Only by the provision of an adequate outlet for stock, accompanied by possibilities of improved stock nutrition, can the financial expenditure necessary for satisfactory property development and the improvement of stock and stock husbandry be encouraged.

(43) To provide a market for both the cattle and the pig industries, the establishment of a meat processing works in the region appears desirable.

Factors that must Influence a General Plan for the Development of the Land Industries

(44) In the past, efforts have been concentrated mainly on forms of production that can be directly marketed, and in consequence products that first require processing, or can be marketed only indirectly, have been neglected. In order that the full production capacity of the region may be utilized, it is considered that a plan for the development of land industries of the region as a whole, coordinating the various forms of production, is necessary. Factors which must influence such a plan have been indicated in Section V of the report.

(45) The present white rural population is probably less than 100 and any considerable increase in this number in the relatively near future must be expected as a result of agricultural rather than pastoral development. However, agricultural production will be able to attract the energetic and progressive type of individuals necessary for its development only if investigations can first demonstrate that a stable and prosperous production can be achieved.

(46) Further, stable development can be expected only if settlers can be provided with adequate extension services and acceptable social and communal facilities. In the past, settlements in any area have not been sufficiently extensive to permit this to be done.

(47) In consequence, it is recommended that agricultural investigations should initially be concerned only with areas of suitable soils large enough to make possible the establishment of a community of reasonable size. This would have the advantage of restricting the number of research problems and enabling concentration of effort in this direction. Subsequently, research personnel could apply their accumulated experience and facilities to other areas.

Programme of Research

(48) There are innumerable problems in the area that warrant investigation, but the most urgent are those associated with the suggested plan for the development of land industries. These investigations have been indicated in the list of recommendations.

GENERAL REPORT ON SURVEY OF KATHERINE-DARWIN REGION, 1946*

Compiled by C. S. CHRISTIAN† and G. A. STEWART‡
in collaboration with
L. C. NOAKES§ and S. T. BLAKE

I. GENERAL INTRODUCTION

The field work on which this report is based was begun in March 1946 at the request of the Northern Australia Development Committee. The survey party was organized by the C.S.I.R. and included personnel from several cooperating bodies. Field work was completed in 1946 and an advance report was distributed in July 1947.

(a) *Personnel*

The survey party consisted of the following:

Officer-in-Charge	C. S. Christian	C.S.I.R.
Soils Officer	G. A. Stewart	C.S.I.R.
Geologist	L. C. Noakes	Commonwealth Bureau of Mineral Resources
Botanist	S. T. Blake	Department of Agriculture and Stock, Queensland
Transport and Supply Officer	H. Mason	
Mechanic	A. R. Greenwood	
Cook	F. Bradford (subsequently replaced by T. Howe)	
Camp Assistant	R. Munyard	
Astro-Survey personnel	Sgt. L. Beadell Cpl. F. Cohen	Army Survey Corps

(b) *General Itinerary*

The party left Melbourne on June 2, 1946, travelled by road to Quorn, S.A., by rail to Alice Springs, N.T., and then by road to Katherine, N.T.,

* Prepared at the request of the Northern Australia Development Committee.

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|| Department of Agriculture and Stock, Queensland.

which was reached on June 15. The period June 15 to 23 was spent in final preparations for field work, which was commenced on June 24. The party remained in the field until the end of October when the approach of the wet season caused operations to cease. The return journey was begun early in November, the party travelling by road to Canberra, which was reached on November 15.

(c) *Area Surveyed*

The area surveyed lies in the northernmost section of the Northern Territory (see Fig. 1). Owing to the absence of previous surveys as comprehensive as this one, and the unknown nature of much of the country, no definite boundaries were set for the first year's operations. The survey was confined to the region enclosed by the Daly and East Alligator River watersheds. This represents the north-west third of the Darwin and Gulf Land Administration District of the Northern Territory. This region includes the townships of Darwin, Katherine, and Pine Creek, the Daly River settlement, the Pine Creek, Finniss River, and other mineral fields, and several of the farms established by the Army for vegetable production. The railway and the new north-south highway bisect the area from the north-west to the south-east.

Most of the portion of the Northern Territory that receives 40 in. or more of rainfall per annum (excluding Arnhem Land Aboriginal Reserve) falls within the region surveyed. It includes all the areas of any direct value to the support of the population of Darwin.

Although most of the area has been traversed at some time or other by prospectors, cattlemen, police, or members of the armed forces, little exact recorded information is available concerning much of it.

(d) *Maps and Aerial Photographs*

Only a very small proportion of the total area has been subject to cadastral surveys, and these have been restricted mainly to the townships, agricultural leases, the north-south railway, and the few main roads, and the more accessible river systems. No overall topographic survey has been attempted. Boundaries of the larger properties exist only on maps in terms of latitude and longitude. The available maps of the region are:

(i) Military maps—strategic series; scale 8 miles to 1 in. The following maps completely cover the area surveyed: Darwin, Delamere, Arnhem, Birdum. These maps lack detail and are in some respects inaccurate. They are of little use for field work.

(ii) Military maps—scale 4 miles to 1 in. series. The published maps of Darwin, Pine Creek, and Katherine cover the area adjacent to the north-south railway and provide coverage for about one-third of the total area. They have been compiled partly from aerial photographs, and partly from other sources. They include much more detail than the eight mile series and where compiled from aerial photographs proved of much greater value.

(iii) Military maps — scale one mile to 1 in. series; emergency edition. These are the most useful maps available but unfortunately cover only a small part of the total area, namely portions of that covered by the Darwin and Pine Creek four mile sheets.

(iv) Lands and Survey Department, Northern Territory, 10 mile series.

(v) Property and Survey Branch, Department of the Interior, Pastoral Map, 30 miles to 1 in.

(vi) Aeronautical maps, 1 : 1,000,000 series.

The Army Survey Corps made available all aerial photographs of the area and these were carried in the field. The region surveyed had not been photographed completely. Various portions had been covered for special purposes as emergency required. They were photographed at different times, by various units, at different scales, and by different methods. Further, the direction of photographic runs varied considerably, and they frequently intersected. These factors made the handling of photographs in the field extremely difficult. Where trimetrogon photographs only were available the oblique portions were of restricted value except for navigation purposes.

(*e*) *Equipment*

The survey party was equipped with the following vehicles:

1x 3 ton 4x4 WD Truck, "Chevrolet"; 1x 15 cwt. 4x4 WD Truck, "Chevrolet"; 1x 15 cwt. 2x4 Panel Van, "Chevrolet"; 2x "Jeeps" with trailers; 1x Water Trailer. The party carried tentage, camping and cooking gear, medical outfit, and repair kits. A radio transceiver was used for communication with the Alice Springs Flying Doctor Base.

Scientific apparatus carried included stereoscope, binoculars, cameras, compasses, aneroid barometers, and soil sampling and botanical collecting equipment.

(*f*) *Objectives and Scope of Survey*

The immediate objectives of the survey were to record accurately the nature of the country, to establish a sound basis upon which the production possibilities of the region might be appraised, and to make general recommendations concerning development and further investigations. However, the survey also had other responsibilities. It was scientific in nature and it was essential that the results of the survey should establish a foundation on which future more detailed work or special scientific investigations might be based. It was necessary therefore to classify and describe in a systematic way the more or less permanent qualities of the country, that is the inherent land characteristics such as surface geology, topography, soils, and vegetation. These are largely determined by regional geology, geomorphology, and climate. Apart from their fundamental interest, a study of these causal factors and the recognition of areas with common or dissimilar origins was found to be essential in order that aerial photographs might be satisfactorily interpreted from field data. The latter were obtained on land traverses which, in an extensive reconnaissance survey of this nature, had to be restricted to sampling typical cross sections of the various types of country within the region.

The complete survey required that attention should be paid to each of the following:

(i) Description and interpretation of the causal factors, regional geology, climate, and geomorphology.

(ii) Description and classification of the inherent land characteristics, topography, soils, and vegetation.

(iii) Description and delineation of land units in terms of inherent land characteristics and present climate.

(iv) Collection and investigation of records of past and present forms of production.

(v) The appraisement of agricultural and pastoral potentialities from these and the recorded experience available from similar regions.

(vi) Selection of those areas in which development is most feasible.

(vii) Planning of an initial programme of investigation related to possible forms of development in the areas selected.

(*g*) *Technique and Methods*

The technique of survey was a matter for considerable thought during the early part of the investigation. Such a thorough examination of an undeveloped region of this size by a scientific team had not been attempted in Australia before. This first survey was, therefore, in many respects, an experimental one, and the actual method of working had to be developed as the survey progressed. It was necessary that the efforts of all members should be coordinated towards a common objective, rather than that each scientific member of the party should examine the area and record his data independently. Further, this coordination had to be done in the field as well as in the laboratory subsequently. A high degree of cooperation was achieved and the practicability of, and advantages that can be gained from, scientific team-work of this kind were amply demonstrated during the course of the survey.

The survey was planned as a reconnaissance, therefore it could function and interpret only on a broad scale. The usual methods of detailed land classification could not be adopted. It was necessary to observe and define the major soil and vegetation units and to determine their relationships and distribution, but because of the limitations of time and the large area covered, it was not possible to map these units as such. A much broader mapping unit, a composite unit, had to be devised, one composed of a number of land type units.

In order that it might have some basic significance to future investigators, it was necessary that this composite mapping unit adopted should constitute a system, rather than a mere association of lesser units combined to form a convenient geographical entity. A considerable amount of thought was given to this problem and a new unit, the *Land System,* was devised. We have defined this unit, which is a composite of related units, as *an area, or groups of areas, throughout which there is a recurring pattern of topography, soils, and vegetation.* A change in this pattern determines the boundary of a land system. A *Land System* may be *Simple, Complex,* or *Compound.*

A Simple Land System is a group of closely related topographic units, usually small in number, that have arisen as the products of a common geomorphological phenomenon. The topographic units thus constitute a geographically associated series and are directly and consequentially related to one another.

A Complex Land System is a group of intermixed and related *Simple Land Systems.*

A Compound Land System is a group of land systems enclosed within the one boundary for convenience in mapping. Unless small size determines the grouping, the land systems grouped in this way should have many topographic, soil, or vegetation features in common.

Many simple land systems are too small to be delineated separately at the mapping scale necessary on this survey. Thus most of the land systems mapped by this survey are either complex or compound. It has not been considered necessary for the sake of this general report to differentiate between these two classes.

A land system can be continuous or discontinuous, providing it does not extend over too wide a climatic range. A boundary may be, to a degree, somewhat arbitrary where there is a broad transition zone. Boundaries frequently, but not always, coincide with geological boundaries. Geomorphic processes are more important than the basic geological material, although the two are obviously related. A land system may comprise several geological groups that have lost their surface identity as the result of a dominating geomorphic influence. On the other hand, several land systems may occur within one geological group as a result of different geomorphic influences.

If the pattern of a land system is adequately sampled and described, and the boundaries of the system can be defined, then the broad potentialities of the area occupied by any system can be determined without investigating the whole area in detail. An approach of this nature enables the work of survey and appraisal to proceed at a much greater pace than could be done by standard traverses.

The general procedure adopted was to examine maps and aerial photos and so obtain a broad picture of the natural features before commencing field work. The amount of detail that can be recognized on aerial photos depends largely on the scale and quality of the photographic prints. The photos available were adequate to determine larger geological outcrops and structures, the general topography, and drainage systems. Details of vegetation are not recognizable as such but changes in vegetation are indicated by changes in the photographic pattern superimposed on the above detail. It was found that where two areas have similar photographic patterns the inherent land characteristics are also very similar provided that the areas are in the same geomorphological unit and are confined to a narrow climatic range. This fact made it possible to obtain information on inherent characteristics of relatively large areas in a limited time by use of traverses planned to cross-section and sample the various photographic patterns. Where recorded information on any of the inherent land characteristics was available it was used in planning traverses and determining the degree of sampling necessary. For this region the most useful records available were incomplete geological and topographical records of varying degrees of accuracy.

No attempt was made to map fully land systems in the field but sufficient information was collected to permit the completion of the mapping in the laboratory at the conclusion of field operations. Information was collected throughout the traverses on general geology and geomorphology, topography, soils, vegetation, and land use.

Two types of records were made:

(i) Detailed records concerning the above characteristics at selected sites, chosen as being typical of the various land units.

(ii) Continuous but more general records throughout the progress of the traverses.

Detailed records were made at 306 sites. In the initial stages the survey was concerned more with the recognition and description of the main soil and vegetation units. Later, as this information was coordinated with other land characteristics and their interrelationships determined, it became easier to recognize them on sight so that the need for detailed observation became less and less. During the first half of the survey one detailed observation was made on the average for each five miles of land traverse, while each ten square miles of country sampled was represented by one mile of traverse records. The relationship between traverse mileage and area sampled was maintained throughout the survey but the frequency of detailed observation dropped in the later stages and the final average figure was one per ten miles of traverse.

Soil samples were taken from a range of major soil types and were forwarded to the C.S.I.R. Division of Soils in Adelaide for laboratory examination. Botanical specimens were collected wherever desirable

Photographic records were made at all stages of the survey. These included black and white stills, some of which have been used to illustrate this report, 35 mm. "Kodachrome" stills, and 16 mm. cinematograph shots. The cinematograph shots have been edited and combined into a short film (Northern Australia Reconnaissance Survey, Part 1) with commentary, indicating the major characteristics of the region.

Owing to inaccuracy of some of the available base maps it was necessary to revise some base maps from aerial photographs in the laboratory. This was done by the principal point plot method using known fixed positions or astro-fix data obtained by the Army Survey personnel attached to the party.

Traverse data and land system boundaries were plotted on aerial photos and the correlation between photographic pattern and inherent land characteristics was determined. Once these relationships were established it was possible to extend the boundaries of land systems with reasonable accuracy. The portions of the region photographed were interpreted in this way. Where no photographs were available mapping was completed by plotting of traverse information, use of any recorded data, and interpolation.

From the data obtained the following maps have been prepared:

(i) Map showing land and air traverses.

(ii) Map showing major geomorphological units.

(iii) Map of the land systems.

(iv) Revised geological map.

(*h*) *Field Procedure*

The field data were collected by a small party on long traverses operating from the base camp, which was moved to strategic points as the survey proceeded. The traverse party consisted of the four scientific personnel plus usually one, or sometimes two others. The party, which travelled in the two "Jeeps" with the minimum amount of gear, remained away from the base camp for periods of two to ten days. Subsequently, it has been found that a larger vehicle in which all scientific personnel can travel together permits much more effective coordination of efforts.

When possible, existing or old tracks were used, but adequate sampling necessitated that a portion of travelling should be across country without tracks. The field party then navigated by compass bearings, speedometer readings, and reference to major topographic features. One of the "Jeeps" was equipped with an aero-compass and by means of this, general directions were given to the front "Jeep" which, more often than not, was engaged in forcing a way through the vegetation.

In general, it proved impracticable for this party and the astro-fix personnel to work together in the field, as the latter needed to remain at each astro-fix site for two or more days at a time. Consequently, with a few exceptions, this group proceeded to preselected sites independently of the land survey team.

While in the field the land traverse party maintained daily contact with the Alice Springs Flying Doctor Service by means of a Traeger Transceiver. It was thus able to receive messages and, through Alice Springs, to contact the base camp.

The total length of the land traverses exceeded 3,000 miles. The area mapped in terms of geology and land characteristics by this survey is approximately 27,000 square miles. This area was completed with 4½ months actual field work.

(i) *Aerial Reconnaissance*

A liaison with the R.A.A.F. was established in order that aerial reconnaissances might be made to assist in the interpretation of aerial photographs, particularly in those areas not covered by land traverses. Unfortunately, owing to shortage of personnel at the time, the R.A.A.F. was able to provide a plane for one day only. The courses of the flights made have also been plotted on the map. The total distance flown was about 800 miles. These flights were of considerable assistance in helping to form the general picture of the region and its land systems, in addition to checking the interpretation of some portions not visited by land traverses.

(j) *Assessment of Agricultural and Pastoral Production Possibilities*

Climatic and soil conditions are the main factors determining type and limitations of agricultural and pastoral production. Both, however, are modifiable factors. Deficiency of rainfall may, in suitable circumstances, be overcome by irrigation and by land husbandry, while the chemical and physical characteristics of soil may be greatly changed by appropriate agricultural methods and the application of fertilizers.

However, any modification of the environment, climatic or edaphic, represents financial expenditure, and therefore the extent to which the soil-climate complex can be modified in practice must be considered in the light of economics.

Climatic factors determine the general adaptability of plants and although it is possible to indicate, in a general way, the range of plants that may be of value within a region, there are definite limitations to the extent to which this can be done. On the one hand, climatic data from isolated or sparsely occupied regions are usually inadequate for precise interpretation, and on the other, knowledge of climatic indices, by which conditions of plant growth in one region are compared with those of another, is still very incomplete. This is particularly true of summer rainfall regions, as many of the indices in use have been developed for temperate regions.

The level of production of those plants that are adapted to a climatic region is determined in the main by soil factors and methods of husbandry. Further, although an examination of the chemical and physical characteristics of soils may place a given soil in a general fertility class it can do no more than indicate this in an approximate way. The extent to which a soil, and hence production, can be modified economically and practically can be determined only by direct field investigations of both plant and soil over a period of years.

A reconnaissance survey of this nature is able to provide the basic information concerning the nature of country, its climate, soil, and vegetation, and to make general recommendations concerning forms of production worthy of consideration. Further, it can frequently indicate some of the problems that must be overcome if production is to be successful. It cannot hope to assess the degree of success that might be attained. This can only be measured after the appropriate field trials have been conducted and, where necessary, problems of production investigated. Records of past experience may assist, and are of particular value in respect to forms of production that have achieved some degree of success.

Where failures have occurred in the past it is not always possible to decide, from existing records, whether this has been due to the entirely unsatisfactory nature of the particular form of production, whether an unfortunate choice of variety or husbandry has contributed, or whether labour difficulties and other economic factors have handicapped production.

In the section dealing with the potentialities of the land systems an attempt has been made to indicate economic uses, if any, to which the various lands might be put. In making these determinations the facts concerning climate, topography, soils, and vegetation have been examined, together with past records of production, and relevant information concerning production from other sources. These determinations, however, concern only the physical possibilities of production. The broad economic problems such as total available markets and the competitive status of any specific form of production, relative to other sources of those products, have not been considered in this report.

(*k*) *Reports and Publications*

Apart from the Advance Report (1947) and this revision, it is intended that additional reports and scientific papers will be published. A report entitled "A Geological Reconnaissance of the Katherine-Darwin Region, Northern Territory" was prepared by L. C. Noakes and published as Bulletin No. 16 of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics. A more comprehensive report on the pedology of the region by G. A. Stewart is in course of preparation.

One contribution to the systematic study of the flora of the region has been published by Blake (1953),* who has further contributions in preparation.

It is anticipated that additional papers in this field will be published from time to time as the herbarium studies of the collected specimens are

* 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.

continued. In addition, when the identifications of botanical specimens have been completed a list of plant species in the region will be published.

Finally, it is planned that, when additional surveys in northern Australia have been conducted, the results of more comprehensive studies in the fields of ecology, geomorphology, and climatology will be prepared for publication.

(*l*) *Modifications to the* 1947 *Advance Report*

This revised version differs in minor respects from the Advance Report distributed in 1947. There has been some rearrangement of the material; new material, figures, and tables have been included; some sections have been expanded and a new one dealing with the hydrology of the area added.

Changes have been made to soil group names, and some corrections and additions have been made to the scientific names of plant species following the herbarium examination of collected material. The appendices to the Advance Report have been deleted.

Since the Advance Report was prepared, the region has been revisited by members of the survey team on several occasions. These visits have provided additional information and have permitted a general review of the conclusions and recommendations previously submitted. It has not been found necessary to change these in any significant respect.

II. General Description of the Region

(*a*) *Introduction*

The region surveyed is in the north-west corner of the Northern Territory (Fig. 1) and includes the country west of longitude 133°E., and between latitudes 12° and 15°S. It is an area of low relief ranging from sea-level to 1,000 ft. A much-dissected divide, which runs diagonally across the region in a south-east to north-west direction, forms the major upland area. To the north and west of this divide the country is of lower relief and the low foothills of the divide merge into plains. These extend to the coast where they terminate in low cliffs, or form low-lying swampy areas subject to seasonal flooding. They are traversed by the mature and senile streams flowing to the north and east.

To the east, the central divide merges into the Arnhem land plateau, portion of which forms a scarp at the eastern edge of the plains in the northern section. South of the main divide there is the Daly River Basin, a somewhat lower area of gentle relief, drained by the Daly River and its tributaries, and fringed on the south by plateau residuals.

The whole region lies within the zone of monsoonal climate, with a summer wet period of 3 to 5 months and a total annual rainfall of 35 to 60 in.

A large proportion of the region is covered by either stony skeletal soils, or alluvial soils that are mostly subject to seasonal flooding. The more extensive of the remaining soils are highly leached Tertiary lateritic or residual soils.

On upland areas the main vegetation is *Eucalyptus*-dominant open forest, with palm scrub occupying many sandy areas in the higher rainfall sections. Areas subject to flooding have fewer trees and there occur extensive areas of grassland, or grass-reed swamp communities.

The region has not been intensively developed and is now occupied mainly by large cattle stations. Buffaloes occur in the place of cattle in the north-eastern coastal section, where large grazing licences are held for the right to shoot the buffaloes for their hides. Agricultural development is restricted to a very small number of small farms producing mostly vegetables or peanuts. In the past, mining has been a major industry, producing gold, copper, tin, wolfram, and tantalite, but this industry is now confined to small-scale production.

The total population, excluding full-blood aboriginals, recorded at the 1947 census for all police districts from Darwin to Katherine was 6,294, distributed as follows:

Darwin (town only)	2,538
Parap (adjoining Darwin)	3,005
Adelaide River	86
Brocks Creek	42
Daly River	51
Pine Creek	201
Katherine	371
Total	6,294

Of this total only 751 were from centres away from the adjoining township areas of Darwin and Parap.

Some indication of the stage of development in the primary industries is given by the following figures. For the whole of the Northern Territory at the time of the census, only 1,084 people, of a total of 10,868, were engaged in primary industries, excluding mining. Grazing ranked first with 917, agriculture and small farms 92, fishing and hunting 69, forestry 6, and mining and quarrying 388.

(*b*) *Climate*

(i) *General.*—The climate of the region is monsoonal, with a characteristic "wet" season of three to five months, and a "dry" season of seven to nine months. The bulk of the rainfall occurs during the period November to April. Rain rarely falls between May and September.

There is a close relationship between many climatic factors and distance inland. The 60 in. isohyet passes just south of Darwin in a WSW-ENE direction. The direction of maximum change in climate is approximately normal to this line. Darwin is on the coast in the northwest of the region, while Daly Waters is inland about 300 miles from

Darwin and just south of the region surveyed. Data for these two stations (Table 1) define the climatic limits for the whole region. The figures for Katherine, which is nearly 200 miles inland, are more or less intermediate between those of the above stations.

TABLE 1

CLIMATIC DATA FOR DARWIN AND DALY WATERS

Climatic Factor	Darwin	Daly Waters
Total annual rainfall	60 in.	26 in.
Number of rainy days	100	55
Intensity of rainfall (rain per wet day)	0.60 in.	0.47 in.
Mean maximum temperature	90.9°F.	94.0°F.
Mean minimum temperature	74.3°F.	66.7°F.
Mean temperature, hottest month (November)	85.9°F.	88.3°F.
Mean temperature, coolest month (July)	77.4°F.	68.8°F.
Normal mean relative humidity (driest month)	59% (July)	39% (September)
Normal mean relative humidity (most humid month)	80% (February)	67% (February)

(ii) *Summer Conditions.*—Darwin has a period of five months during the summer when the relative humidity exceeds 70 per cent. and the mean temperature is over 75°F., the mean maximum temperature being 90.6°F. At Daly Waters, the mean relative humidity does not exceed 70 per cent. in any month, and exceeds 60 per cent. in three months only (January to March). To offset this, however, the mean maximum temperature is 6°F. above that of Darwin, and, for the months October to December, it exceeds 100°F. Summer conditions throughout the region are therefore somewhat unpleasant, but perhaps the most trying feature is the higher humidity of the coastal regions.

(iii) *Winter Conditions.*—Winter conditions are pleasant, especially inland, although maximum temperatures remain high. At Darwin the mean maximum temperature for the period May to September is 89.4°F. and the mean minimum 70.5°F. For Daly Waters the figures are 88.3 and 58.1°F. respectively. Relative humidity is much lower than during the summer months, the mean figures for the two stations for the winter period being 61.8 and 43.8 per cent.

(iv) *Climate in Relation to Plant Growth.*—Rainfall is the most important climatic factor affecting plant growth in this region and outweighs other factors. The important features of rainfall are total annual rainfall, intensity, reliability, length of season of adequate rainfall, and the time of commencement of this period.

In a relatively small region these factors are often closely related. Thus, proceeding inland from the coast, the total annual rainfall decreases from 60 in. at Darwin to 35 in. at Katherine and 26 in. at Daly Waters. Likewise there is a decrease in the intensity of rainfall and in the period of adequate rainfall.

The intensity of rainfall is high and in consequence active erosion proceeds on all major slopes or bare surfaces. As a direct result, much of northern Australia consists mainly of rocky uplands interspersed by areas of deposition. High intensity of rainfall at the beginning of the season can have a very adverse effect on the surface structure of cultivated soils.

The reliability of total annual rainfall in this region is high. The average deviation from the mean, expressed as a percentage of the mean, is 16.6 per cent. for Darwin and 21.2 per cent. for Katherine. The only other portions of Australia with as low a variability as this are the south-east and south-west corners of the continent and Tasmania. The standard deviations are respectively 12.05 and 9.71 per cent. and the coefficients of variability 21.9 and 25.6 per cent.

Total annual rainfall itself, however, is inadequate to indicate production possibilities or crop adaptability and in many cases may be quite misleading. More important is the period over which adequate rain falls and the time of commencement of this period.

(v) *Time of Commencement of the Season.*—Following several rainless months of the dry season, light, early showers of rain are ineffective. To estimate when seasonal rainfall adequate for crop establishment begins, an arbitrary figure has been adopted, namely a total of two inches of rain within a week. When this criterion is satisfied but is not followed by at least one month of "adequate rainfall" (defined below) the season is regarded as having made a false start. The new start is considered to be made at the end of the first 28-day period of "adequate rainfall".

Using this criterion, which eliminates false starts in the season, it is found that the mean commencement date for stations near Darwin is November 20, and that for each 100 miles inland in a south-easterly direction from Darwin, the opening of the season is delayed approximately ten days.

The time of commencement of the season of adequate rainfall at any one locality is subject to variation, which is reasonably uniform throughout the region. In approximately one year out of four it varies from the mean value by more than plus or minus four weeks.

(vi) *Length of Period of "Adequate Rainfall".*—To define adequate rainfall, the arbitrary figure of a minimum total of three inches of rain within a 28-day period has been adopted. The season of adequate rainfall has been defined as the total number of weeks over which consecutive 28-day periods, assessed at 14-day intervals, satisfy this criterion. Two figures have been obtained, the first for the period immediately following the commencement of the season, as defined above, the second for the longest period within the season which satisfies the criterion. The two differ very little except where an initial start was followed by a break in the season and then subsequently by the longer period of adequate

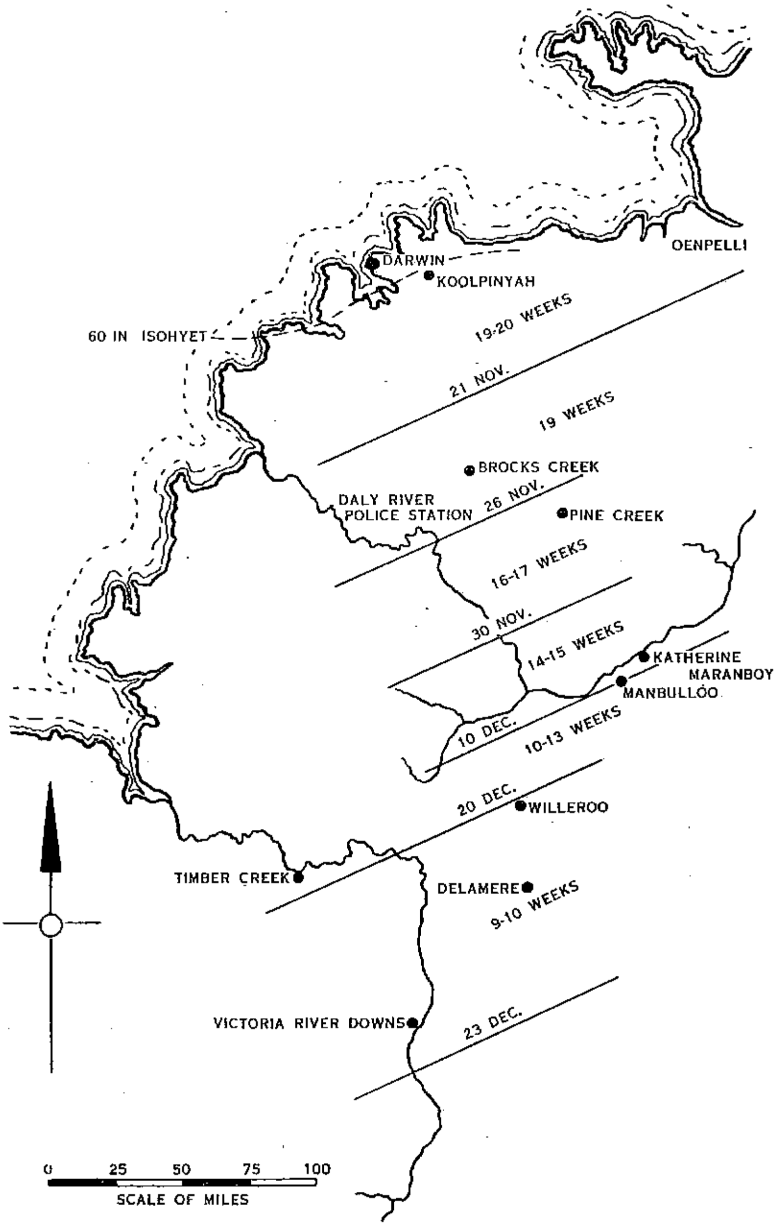


Fig. 2.—Map showing time of commencement of season and length of season of minimum adequate rainfall.

rainfall. The net effect of the second method is to increase the mean length of season by approximately three weeks.

As with the time of commencement of the season, the period of adequate rainfall, determined in this way, is very closely related to distance inland. At Darwin, the length of season determined by the second method is approximately 20 weeks, and this decreases by four weeks in a regular manner for each 100 miles distance to the south-east.

The length of season with adequate rainfall, as defined above, is not presented as being the actual length of growing season. A number of factors influence this: type of crop, drainage, soil type, and soil husbandry. Some deep-rooted crop species are able to continue growth on accumulated soil moisture for lengthy periods after the cessation of rains and the true length of growing season would vary accordingly. Likewise, the period of growth following the cessation of rains is influenced by depth of soil and its water-holding capacity. The data presented are actual rainfall characteristics and cannot be interpreted precisely in terms of plant growth until further field information concerning plant reaction to climatic factors within the region is available.

TABLE 2

PERIOD OF ADEQUATE RAINFALL AND LENGTH OF GROWING SEASON

Locality	Length of Growing Period (P/S.D. exceeds 0.5)	Length of Period of Adequate Rainfall (Min. rainfall exceeds 3 in. per 28 days)
Darwin	26 weeks	20 weeks
Pine Creek	20 weeks	17 weeks
Katherine	19 weeks	15 weeks
Timber Creek	18 weeks	12 weeks
Victoria River Station	16 weeks	9.5 weeks

The data for time of commencement of season and the length of the period of adequate rainfall are summarized in Figure 2, which clearly illustrates the trend in climatic conditions. It is interesting to compare these figures for length of adequate rainfall with the length of growing season as determined by P/S.D. relationships (see Table 2).*

If a period of four weeks, representing a mean period of growth that might be expected after the completion of the season, is added to the length of period of adequate rainfall, a figure for total length of growing period is estimated, based on rainfall. Comparing this with the corresponding figure based on P/S.D. relationships, it is seen that the latter are proportionally higher in the areas of lower rainfall and higher evaporation. Field observations suggest such figures should be regarded with caution.

* See Prescott, J. A. (1938).—"The climate of tropical Australia in relation to possible agricultural occupation." *Trans. Roy. Soc. S. Aust.* 62: 229-40, and, by the same author (1939).—"The agricultural possibilities of monsoonal Australia." *Proc. R. Geogr. Soc. Aust., S. Aust. Br.* 39: 52-60.

(c) *Regional Geology*

As a result of this survey a much more comprehensive and exact knowledge of the geology of the region has been gained, and a new geological map prepared. The map and a complete report on the geological studies are presented in a separate report by L. C. Noakes, "A Geological Reconnaissance of the Katherine-Darwin Region, Northern Territory", Bulletin No. 16 of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics.

A brief account of the geology of the region is presented in this section as an introduction to the studies in geomorphology and land classification which follow.

Geologically, the area has been comparatively stable since Pre-Cambrian time. The record of sedimentation includes Lower and Upper Proterozoic, Lower Cambrian, Upper Palaeozoic, Lower Cretaceous, and unconsolidated Quaternary alluvia. As a direct result of the stability of the region, most of these sediments, except the steeply folded Lower Proterozoic sediments, remain sub-horizontally bedded. This has been a major factor influencing the topographic form.

Lower Proterozoic rocks are represented by the Brocks Creek Group which has been metamorphosed and steeply folded with a general north-south strike. It has been intruded both by granite batholiths and by sills of amphibolite. The Group consists predominantly of slates with sandstones, quartzites, tuffs, phyllites, and schists and in some places sills of amphibolite and beds of crystalline limestone. These basement rocks extend over large areas in the central and northern part of the region.

The Litchfield and Cullen Granites intrude only the Lower Proterozoic rocks. The Cullen Granite occurs as a number of outcrops within the Brocks Creek Group in the central part of the region, and in some places is overlain by sediments of the Buldiva Quartzite and the Daly River and Mullaman Groups. The Litchfield Batholith occurs in the western portion of the region. It has been partly covered by Upper Palaeozoic and Cretaceous sediments and Recent estuarine deposits, and it now outcrops in three separate areas.

The Buldiva Quartzite of Upper Proterozoic age consists mainly of sandstones, quartzites, and conglomerates. They are generally sub-horizontally bedded but have suffered some faulting and monoclinal folding and are strongly jointed. They outcrop most extensively on the Arnhem Land Tableland and in a north-south belt across the lower Daly River. A few small isolated outcrops occur where the Buldiva Group has been infaulted into the underlying metamorphics.

Rocks of volcanic origin are represented only by minor outcrops and can probably be correlated with the Lower Cambrian volcanics of the Kimberley area, Western Australia.

Lower Cambrian sediments are represented in this region by the Daly River Group, which consists mainly of sandstones and limestones with some interbedded shales. They are generally sub-horizontally bedded. These rocks outcrop over the major part of the Daly River Basin and extend south beyond the limits of the area surveyed.

The Palaeozoic rocks of the Elliott Creek Formation are interbedded shales, sandstones, and limestones, also generally sub-horizontal. They occur over a relatively small area in the mid-western part of the region. This formation shows some similarities to both the Cambrian sediments of the Daly River Group and the Permian sediments of the Port Keats Group, but no correlations can be made at present. The Permian sediments of the Port Keats Group consist of sub-horizontal sandstones, shales, and limestones. They occur in the south-west corner of the region.

The Mullaman Group of Lower Cretaceous sediments, all of which are sub-horizontally bedded, probably extended over most of the region as a relatively thin veneer but are now found only on scattered tableland remnants in the centre and south and at lower levels in the northern parts around Darwin. They can be divided into an upper portion of marine shales and sandy shales, sometimes calcareous, and a lower portion, which occurs only in the central and southern sections, of poorly consolidated freshwater sandstone and conglomerate.

After the exposure of the land surface in Post-Cretaceous time there followed a period of peneplanation and, by Late Middle (?) Tertiary, the development of extensive areas of lateritic formations, some of which still persist as remnants of the old land surface.

Finally, an uplift of the land initiated a new cycle of erosion towards the end of the Tertiary Period, and changes in sea-level in Quaternary time led to the exposure of extensive Post-Tertiary alluvial deposits. The land history from the Tertiary period of laterization to the present day is treated fully in the following section.

(*d*) *Geomorphology*

(i) *Introduction*

Geomorphology is the study of the nature, history, and origin of land forms which, together with vegetation, make up the present landscape or type of country. As indicated in the General Introduction, it was through studies of this nature that it was possible to interpret aerial photographs accurately and thus map the country in detail, in spite of the fact that, in the time available, land traverses could sample portions of it only.

The history of land form before the Tertiary uplift is very obscure. However, remnants of the Tertiary land surface still remain and its formation represents the most suitable landmark from which to begin the study of geomorphology in this region.

Following the exposure of the land in Post-Cretaceous time the terrain was subjected to a long period of erosion which, because of the low relief, was not very active and could not deeply dissect the land surface. In some places it was sufficient to completely remove the sediments of the

Mullaman Group, but in general the land surface persisted as one of low relief. This, together with suitable climatic conditions, made extensive laterization possible and by the Late Middle Tertiary laterization of the remaining sediments of the Mullaman Group and of other exposed rocks had taken place. This process was not universal and did not occur on steep slopes or exposed surfaces of the hard rocks of the Brocks Creek Group which formed and still persist as residual ridges in the Tertiary land surface.

The present cycle of erosion was initiated by Late Tertiary uplift, which included warping and faulting. The warping was apparently only slight in the north, reached a maximum in the vicinity of Pine Creek, and fell gradually to the south. Major faulting is apparent in the down-movement of the block to the west of the long north-south fault line that forms the western boundary of the Mt. Tolmer Tableland. Some indication of the degree of warping and faulting is given by the present altitudes of the residuals of the Tertiary land surface.

In the northern section, the lateritic plains reach a maximum of 200 ft. above sea-level. To the south, Mt. Tolmer Tableland is 750 ft. and the residuals near Adelaide River are 700 ft. The maximum elevation is 900 ft. in the vicinity of Pine Creek. On the western fault block, Mt. Litchfield and Mt. Greenwood are 650 and 500 ft. respectively.

Following these land movements, consequent streams developed on the Tertiary lateritic land surface and the present cycle of erosion commenced. In the central, northern, and eastern sections, the rivers now flow from south to north down the warp slope. In the southern and western portions they flow to the west and north-west across the fault block.

The low relief of northern lateritic areas protected them from severe erosion. In the central and north-central part of the region, exposure of the north-south strike of the steeply folded Brocks Creek Group enabled the north-flowing streams to reach maturity rapidly by erosion of the least resistant steeply dipping beds.

In the south, within the Daly Basin, the resistant rocks of the Brocks Creek Group and the Buldiva Quartzite, which form a barrier across the Daly River valley, and the horizontal bedding of the Daly River Group have not permitted streams to reach the same stage of maturity or to erode so rapidly.

The down-faulted western portion has a much more mature topography. Where it was sufficiently elevated, erosion must have been relatively rapid. This would have been possible because of the relative softness of the rocks and the absence of any barriers across the streams flowing to the nearby sea.

The next phase in the geomorphological history for which there is evidence is a rise in sea-level during Pleistocene time of the order of

200 ft. This led to the drowning of the mouths of all the major streams and the deposition of extensive estuarine sediments.

In addition, this rise in base level caused the more mature streams of the north-central portion to deposit extensive flood plain alluvia in their broad, mature valleys.

Finally, there is evidence of a fall in sea-level of about 20 ft. in Recent time. This has exposed large areas of the estuarine deposits, which now form extensive coastal plains just above sea-level.

Geomorphologically, the region can be regarded as one division which can be subdivided, in terms of the processes which have operated and their land-form products, into Geomorphological Subdivisions and Units (Table 3).

TABLE 3

SUBDIVISIONS AND UNITS OF THE KATHERINE-DARWIN GEOMORPHOLOGICAL DIVISION

Geomorphological Subdivisions	Geomorphological Units
(*a*) Remnants of the lateritic Tertiary land surface, i.e. areas which have been little eroded	(1) Northern Lateritic Plains (2) Elevated Lateritic Residuals; areas of little erosion surrounded by areas of much greater erosion
(*b*) Areas in which erosion has been active, and in which the lateritic Tertiary land surface has been removed, or did not occur	(3) Elevated Backbone Country (4) Daly River Basin (5) Western Fault Block Plain
(*c*) Areas in which deposition has been active	(6) Flood Plains Alluvia of Northern Rivers (7) Estuarine Alluvia

The distribution of the units is shown on the accompanying geomorphological map. An extra mapping unit has been used to indicate those areas where flood plains and elevated backbone country are too mixed to map separately.

(ii) *Description of Geomorphological Units*

(1) *Northern Lateritic Plains.*—These plains of lateritic soils formed on rocks of the Brocks Creek Group, Mullaman Group, and Litchfield Granite, extend discontinuously across the northern portion of the region and are less than 200 ft. above sea-level. In spite of relatively high rainfall (50-60 in. per annum) their erosion has been generally retarded by the lack of relief and the high permeability of their soils. Some dissection of the lateritic profile has taken place in the north-western section and dissection is encroaching from southern eroded areas, but progress is delayed by the resistant nature of some lower lateritic horizons.

(2) *Elevated Lateritic Residuals.*—These form part of the high topography and represent the last remnants of the lateritic Tertiary land

surface. They occur mainly as cappings to mesa-like residuals in much-eroded country, but also to a lesser extent as residual portions of the lateritic plains within the elevated backbone country. The preservation of the mesas can be ascribed mainly to the hardness of the silicified lateritic horizons formed on the shales of the Mullaman Group, and constituting the cap rock, whereas the residual upland plains occur in portions of the backbone that have not yet been subjected to active erosion.

(3) *Elevated Backbone Country.*—This extensive area of eroding upland country extends over the central and eastern parts of the region with an extension in the western sections southward across the Daly River. This geomorphological unit includes rocks of the Brocks Creek Group, Cullen Granite, and Buldiva Quartzite, all of which develop characteristic topographic forms.

The Brocks Creek Group of steeply folded metamorphics exercises strong structural control of drainage where the topography is steep. By erosion of the softer steeply dipping beds, streams rapidly reach maturity, while the topography remains relatively immature. As topography becomes more gentle, structural control decreases. In small areas of gently undulating topography where a depth of soil has been formed, structural control is almost absent and drainage tends towards the dendritic pattern. Further, deeper soils are more permeable than exposed rock or skeletal soils and the intensity of the drainage pattern decreases as the depth of soil increases. The metamorphic rocks have been severely folded and in consequence have many fracture lines or lines of weakness. On weathering, the rocks readily break along these lines into small fragments ($\frac{1}{2}$ to 3 in. across). These fragments do not readily break down further, hence stony or gravelly soils are features of areas of steeper topography on the Brocks Creek Group. This phenomenon is further encouraged by the high intensity of the rainfall, which quickly removes fine material from steep slopes.

In general, the Cullen Granite is not strongly jointed and the drainage pattern is normally dendritic. On gentle topography, gritty, permeable surface soils and a compact clay subsoil produce a drainage pattern of moderate intensity. On steep topography, outcrops consist of large, rounded boulders, and the high run-off gives a relatively intense drainage, the pattern of which may be controlled by jointing where that is a feature.

The sub-horizontal or gently dipping beds of sandstones, quartzite, and conglomerate of the Buldiva Quartzite have a strongly developed joint pattern. Erosion of exposed rock has followed these joint lines which give a strong structural control of drainage with the production of irregular boulders or large stone outcrops. The course of the Katherine River gorge, with its many right-angle bends, is a good example, on a large scale, of this structural control of drainage. These rock structures, and in some cases the individual sandstone beds, are relatively much more permeable than those of the Brocks Creek Group or the granites, and the drainage pattern in outcrop areas is less intense. On limited areas of gentle topography permeable sandy soils are formed and the drainage pattern is of moderate intensity, as with the granite soils.

(4) *Daly River Basin.*—This geomorphological unit includes most of the area drained by the upper Daly River and its tributaries, many of which rise in the elevated backbone country. Erosion of this basin as a whole has been retarded by the barrier of rocks of the Brocks Creek and Buldiva Quartzite at the western edge of the basin, striking at right angles to the Daly River. Because of the sub-horizontally bedded strata, the topography in this unit is relatively mature in appearance, but the streams are actually less mature than in the previous unit. They must cut through the horizontal beds and cannot evade resistant strata by selectively eroding softer material. In consequence, small falls and rapids are characteristic of the stream courses. Alluviation has been restricted to small flood plains along the lower Katherine and Flora Rivers and the Daly River, where the establishment of local base levels, imposed by resistant sub-horizontal strata, has been responsible for the deposition. These plains are not of sufficient extent to map separately.

The dominant types of sediments in this division are sandstones and limestones with some shales. The sandstones form irregular outcrops which are usually stony with some boulders. On gentle topography, permeable soils with a compact clay subsoil formed on a single sub-horizontal stratum give a dendritic drainage pattern of moderate intensity. Outcrops of limestone are of two major forms. They may occur as low hills of irregularly weathered, often rugged, boulders or as scattered, platey boulders, which in some places cover large expanses. In these outcrop areas, caves and sink holes are evidence of extensive underground drainage. On gentle slopes, the deep, permeable soils give much sub-surface drainage. In consequence, the drainage pattern is dendritic and of low intensity.

Shales were observed only as minor beds within sandstone and limestones and exert no marked geomorphological influence.

(5) *Western Fault Block Plains.*—These irregular plains of the western fault block were either not elevated to the same degree as the central portion of the region or were subsequently down-faulted. This lower altitude, proximity to the sea, softness of rock, and the lack of any resistant barriers to streams permitted rapid reduction towards base level. The topography is mainly undulating, with rocky hills in some places. Litchfield Granite, Palaeozoic sediments, and minor areas of the Brocks Creek Group are the basement rocks of the division. The geomorphological features of the Litchfield Granite are similar to those of the Cullen Granite.

The Upper Palaeozoic sediments of the Elliott Creek Formation are interbedded sandstones, shales, and limestones. Steep topography does not occur and the only outcrops are beds of sandstones and massive boulders of limestone. In most places the sediments are closely interbedded, and the soils are of mixed origin. They are of moderate permeability and give a dendritic drainage pattern of fairly low intensity.

The Port Keats Group were seen outcropping only at the base of Mt. Greenwood. They are sub-horizontal and, from the nature of the soils, appear to be mixed arenaceous and calcareous sediments. The soils are fairly permeable. The drainage pattern is similar to that of the Elliott Creek group.

(6) *Flood Plain Alluvia* (Plate 4, Fig. 2; Plate 5, Fig.1).—A rise in sea-level in Pleistocene times raised the base level of streams and caused the more mature streams to alluviate their broad valleys. These flood plains are most extensive on the major northern rivers with smaller areas along smaller streams to the north-west and minor areas not shown on the map along some of the small streams of the western plains.

It has not been possible to map accurately the smaller expanses of the flood plains of the northern rivers so two mapping units have been used. The area mapped as "Flood Plain Alluvia" covers only the largest expanses of plain, and includes relatively minor areas of backbone foothills. "The Mixed Backbone Country and Flood Plain Alluvia" is a unit which includes larger areas of foothills and the smaller expanses of flood plain.

The topography of the flood plains is flat to very gently undulating. The sea recession in Recent times rejuvenated the streams only sufficiently to allow them to deepen their channels through the flood plains, which are still liable to seasonal flooding.

(7) *Estuarine Alluvia.*—The considerable rise in sea-level during Pleistocene time drowned the mouths of all major streams and the flooded areas have been largely covered with estuarine deposits. The subsequent fall in sea-level was sufficient to expose large areas, but the consequent stream rejuvenation was not sufficient to cause significant dissection of these deposits. The topography is flat or nearly so and deep seasonal flooding (4-8 ft.) still occurs. The salt flats and mangrove swamp areas are portions of the estuarine deposits that were not elevated beyond reach of high tides.

(*e*) *Hydrology*

(i) *Introduction.*

The hydrological features of a region are determined largely by its climate, but topography, rock type and structure, soils, and vegetation are also important. Thus all regions have a characteristic hydrology although this may be modified in some instances by conservation and control. The extent to which this can be done is determined largely by the production potential of the area itself.

The region surveyed receives sufficient rainfall annually to cover it to a depth of 3-5 ft., yet, for more than half the year, many areas have inadequate readily available water for live-stock industries. A very large proportion of the water received by the region drains to the sea soon after the rains cease. It is evident that potential development must be considered in relation to the particular hydrological features.

(ii) *Natural Water Resources*

(1) *Major Streams.*—The hills, ridges, and tablelands of the elevated lateritic residuals and backbone country form the headwaters of all the major streams which flow towards the northern or western coasts. The Daly River with its tributaries, the Katherine (Plate 17, Fig. 2), Flora, Ferguson, and Douglas, and the Reynolds and Finniss Rivers flow generally from east to west; the Blackmore, Darwin, and Elizabeth Rivers flow in a north-westerly direction, while the Howard, Adelaide (Plate 12, Fig. 2), Mary, its tributary the McKinlay, and the West, South, and East Alligator Rivers all flow towards the north coast.

(2) *Natural Characteristics of Drainage Systems.*—The monsoonal nature of the climate, with a high intensity of rainfall per wet day, is important in determining the characteristics of drainage systems. The average rainfall per wet day for Darwin is 0.60 in.

Prescott (1931)* has drawn attention to the fact that this intensity occurs only in northern Australia. Values for the southern third of Australia do not exceed 0.30 in. This high rainfall intensity results in rapid run-off, thus the rivers are primarily broad, deeply cut flood-water channels, often with irregularly terraced, steep banks, which are able to discharge great quantities of water in a short time. In the wet season the rivers run strongly. They regularly overflow in their lower courses while floods further upstream are not infrequent.

As the rainfall season lasts for only 3-5 months, only spring-fed streams continue to flow throughout the dry season (see Plate 8, Fig. 2). Some non-permanent streams flow for parts of their courses where locally spring-fed, and most of the larger streams have some permanent water-holes or billabongs. The only river system with an appreciable flow throughout the dry season is the Daly and its tributaries, but this flow is only a very small fraction of the wet season flow. The rate of flow of its tributary the Katherine River has been estimated to be 130,000 cusecs during the wet season while the dry season flow may not exceed 30 cusecs (Standish 1944).†

The major characteristics of the rivers are shown in Table 4. These include the nature of the country they rise in and that through which they flow, the nature and extent of associated alluvia, and the nature and navigability of their estuaries and lower courses. These are navigable to small craft only. Distances given in the table are approximate air-miles from the coast.

* Prescott, J. A. (1931).—Soils of Australia in relation to vegetation and climate. Coun. Sci. Industr. Res. Aust. Bull. No. 52.

† Standish, J. H. (1944).—Report to C.E., N.T. Force.

TABLE 4

CHARACTERISTICS OF THE MAJOR STREAMS OF THE KATHERINE-DARWIN REGION

River	Permanence	Stream Rises in	Stream Flows through	Flood Plain Alluvia	Estuarine Alluvia	Nature of Estuary	Navigability
Katherine	Spring-fed, dry season flow	Elevated Backbone Country	Daly River Basin	Narrow levees, minor areas of "calcic" flood plain	Flows into Daly River		
Flora	Spring-fed, dry season flow	Rises outside region surveyed	Daly River Basin	Narrow levees, minor areas of "calcic" flood plain	Flows into Daly River		
Ferguson	Spring-fed, dry season flow	Elevated Backbone Country	Daly River Basin	Narrow levees, no flood plain	Flows into Daly River		
Douglas	Spring-fed, dry season flow	Elevated Backbone Country	Daly River Basin	Narrow levees, no flood plain	Flows into Daly River		
Daly	Fed by spring flow of above tributaries	Tributaries	Daly River Basin	Narrow levees, minor areas of "calcic" flood plain	Extensive estuarine plain	Well defined throughout plain	Navigable by small craft for 40 miles inland
Reynolds	Small spring-fed dry season flow	Elevated Backbone Country	Western Fault Block Plains	Narrow levees	Extensive estuarine alluvia	No defined estuary, effluents on to plain	—
Finniss	Minor or no dry season flow	Elevated Backbone Country	Mixed Back-bone, Foothill, and Alluvial Flood Plain	Irregular flood plain interspersed through back-bone foothills	Extensive estuarine alluvia	Effluents on to plain Estuary is well defined only for 7 miles from coast	Unknown

TABLE 4 (*Continued*)

River	Permanence	Stream Rises in	Stream Flows through	Flood Plain Alluvia	Estuarine Alluvia	Nature of Estuary	Navigability
Blackmore	Minor or no dry season flow	Elevated Backbone Country	Northern Lateritic Plain	None	Minor areas of littoral salt flats	Short, well defined	Navigable in short estuary only
Darwin	Minor or no dry season flow	Elevated Backbone Country	Northern Lateritic Plain	None	Minor areas of littoral salt flats	Short, well defined	Navigable in short estuary only
Elizabeth	Minor or no dry season flow	Northern Lateritic Plain	Northern Lateritic Plain	None	Minor areas of littoral salt flats	Short, well defined	Navigable in short estuary only
Howard	Small flow below springs in mid course	Northern Lateritic Plain	Northern Lateritic Plain	None	Minor areas of littoral salt flats	Short, well defined	Navigable in short estuary only
Adelaide	Small dry season flow	Elevated Backbone Country	Elevated Backbone Country	Narrow levees, extensive "acid" flood plain alluvia	Extensive estuarine alluvia	Well defined throughout estuarine plain	Navigable by small craft 30 miles inland
Margaret	Minor or no dry season flow	Elevated Backbone Country	Elevated Backbone Country	Narrow levees, extensive "acid" flood plain alluvia	Flows into Adelaide River		—
Mary	Dry season spring-fed flow in upper course only	Elevated Backbone Country	Elevated Backbone Country	Narrow levees, extensive "acid" flood plain alluvia	Extensive estuarine alluvia	Effluents on to plain. No defined estuary Numerous poorly defined stream channels	

TABLE 4 (*Continued*)

River	Permanence	Stream Rises in	Stream Flows through	Flood Plain Alluvia	Estuarine Alluvia	Nature of Estuary	Navigability
McKinlay	Minor or no dry season flow	Elevated Backbone Country	Elevated Backbone Country	Narrow levees, extensive "acid" flood plain alluvia	Flows into Mary River		
Wildman	Minor or no dry season flow	Northern Lateritic Plain	Northern Lateritic Plain	None	Extensive estuarine alluvia	Effluents on to plain. Estuary well defined for 10 miles	Lower estuary navigable for small craft for 5 miles
West Alligator	Minor or no dry season flow	Northern Lateritic Plain	Northern Lateritic Plain	None	Extensive estuarine alluvia		
South Alligator	Some springs in upper course, no dry season flow in lower course	Elevated Backbone of Arnhem Land Tableland	Elevated Backbone Country	Narrow levees, some "acid" flood plain alluvia	Extensive estuarine alluvia	Well defined except in southern portion of estuarine plain	Navigable to small craft for 30 miles
East Alligator	Some springs in upper course	Elevated Backbone of Arnhem Land Tableland	Stream drops directly from backbone to extensive estuarine alluvial plain			Well defined deep estuary throughout plain	Navigable by small craft for at least 28 miles from coast

(3) *Springs.*—There are many minor springs and soaks through the region, some of which have only seasonal supplies. The major springs of the region may be grouped as follows.

(*a*) Springs of upland areas associated with mesas or edges of tablelands in which sub-horizontal formations overlie the relatively tight metamorphics of the Brocks Creek Group.
These include springs such as those west of Mt. Tolmer Tableland and the springs associated with the Arnhem Land Tableland scarp, e.g. in the upper Katherine River.

(*b*) Springs associated with faulting. These include both thermal and normal-temperature springs. The known thermal springs are the Douglas Springs, the spring at Katherine, and Berry Springs. Berry Springs and the normal-temperature springs of the Howard River both occur in lateritic areas where lateritic formations mask the geological structure, but they are both probably associated with faulting. Other known normal-temperature springs probably associated with late Tertiary faulting are the Hayes Creek Spring and the springs of the Rock-Candy Mountain ranges to the south-west of Tipperary Homestead. The springs that feed the Flora River are outside the area surveyed and their origin is not known.

(iii) *Artificial Water Resources*

(1) *Water Conservation Structures.*—Because of the extremely seasonal nature of stream flow, any large-scale continuous use of water in this region must involve some form of water conservation. Indeed, the paucity of dry season flow virtually limits the amount of usable water during the dry season to the capacity of the conservation structure. The extremely seasonal flow also offers special engineering problems, particularly with respect to the diversion of water from streams. Adequate provision must be made to allow the high wet season flow to pass unimpeded, or flooding could be accentuated. At the present time there are few or no data concerning seasonal or annual variation in the rates of flow of the various streams.

There appear to be many sites in the Elevated Backbone Country of the region where water might be conserved in moderate to large quantities. However, the construction and utilization of conservation structures must be related to the potential use of water and therefore must depend upon a thorough investigation of other resources relative to its use. There is wide scope for the construction of small-scale conservation structures for local use. Their construction and utilization have similar physical difficulties to large-scale conservation structures, but to a lesser degree.

(2) *Underground Water.*—From bore logs, mines, and wells it is apparent that supplies of underground water are available at depths of less than 300 ft. over most of the region. The only artesian bore known is at Manbulloo. It is unlikely that artesian water will be found over a wide

area, but small local artesian basins, similar to that tapped at Manbulloo, may occur in the vicinity of the Daly River. The depth and supply of underground water are governed by geological factors, and geological advice on location of sites for underground water supply is desirable, particularly in those areas occupied by granitic rocks, or those of the Brocks Creek Group. Small supply and cost of pumping are limiting factors in the use of underground water, but, within limits, the site of supply can be chosen adjacent to the point of utilization of water regardless of the nature of the local surface water supply. Further data of depth to water and water supply of the various geological formations are given by Noakes (1949).*

(iv) *Water Requirements and the Potential Supply*

(1) *General.*—During the wet season, and for two or three months after, natural water supplies are abundant, and frequently excessive, throughout the region. Towards the end of the dry season most of the rivers and many of the springs have ceased to flow, many of the waterholes and billabongs have dried up, and, in some parts of the region, surface water supplies are very limited. These parts include most of the Elevated Backbone Country, the Alluvial Flood Plains of the northern rivers, and the Northern Lateritic Plains. The streams of the Daly River Basin, the Estuarine Plain, and scattered sections of the Backbone Country, particularly where associated with the scarp of the Arnhem Land Tableland, maintain permanent supplies from springs or in large lagoons and waterholes.

Most deficiencies in the region could be overcome by water conservation or the use of underground water, but the cost of water conservation will be higher than in many other parts of Australia owing to the extremely seasonal nature of rainfall and stream flow in this region.

The existing and potential sources of water to meet small, intermediate, and large-scale requirements are indicated below.

(2) *Small-Scale Requirements.*—These include small establishments such as homesteads and gardens, minor stock water supplies, and small industrial units. It is likely that these requirements could be met if necessary almost anywhere in the region. Where permanent surface waters do not occur, small supplies could be obtained in most places by wells, shallow bores, or small conservation structures.

(3) *Intermediate Requirements.*—These include larger stock water supplies, small communities, and small-scale irrigation. With the exception of the streams of the Daly River Basin, and other spring-fed streams such as the Upper Mary and Howard, natural supplies of this order are relatively few and widely dispersed at the end of the dry season. They might be

* Noakes, L. C. (1949).—A geological reconnaissance of the Katherine-Darwin region, Northern Territory. Commonw. Bur. Miner. Resour., Geol. Geophys. Bull. No. 16.

supplemented in many places if the demand justified the expense by conservation, or multiple tapping of underground water supplies.

(4) *Large-Scale Requirements.*—Supplies for large towns, large irrigation projects, and large-scale industrial use, e.g. hydro-electric power, present greater difficulties. The only possible sources of large supplies are large conservation structures. The domestic supply for Darwin from the Manton River Dam is the only example in the region at present.

Large-scale irrigation projects require not only a large water storage, but also sufficient areas of suitable soils on which the water might be used. The present use of water for irrigation is mostly by pumping from permanent streams for small areas of intensive cropping. The pump lift of 40 ft. limits extension of these areas, for such a lift is economical only for high-return crops.

No large areas of soils obviously commandable and suitable for irrigation were observed. Any irrigation proposals in this region should be regarded as long-range projects. Topographic surveys are first necessary to ascertain those areas which might be commanded by water. Then the suitability of soils for irrigation in such areas and the possible forms and economics of crop and animal production would have to be investigated.

A proposal has been made from other sources (see Annual Report of the Administrator, Northern Territory, 1944) that the Katherine Gorge (Plate 9, Fig. 2) might be dammed to provide water for irrigation and hydro-electric power. Between Katherine and the gorge most soils are unsuited to irrigation. Some suitable soils do occur in the vicinity of Katherine but the terrain rising away from the river is broken by rock outcrops, and they may not be commandable. No doubt other sites where water might be conserved in large quantities could be found in the more rugged backbone country but, in the absence of suitable soil areas for irrigation, no recommendation for large-scale conservation has been made.

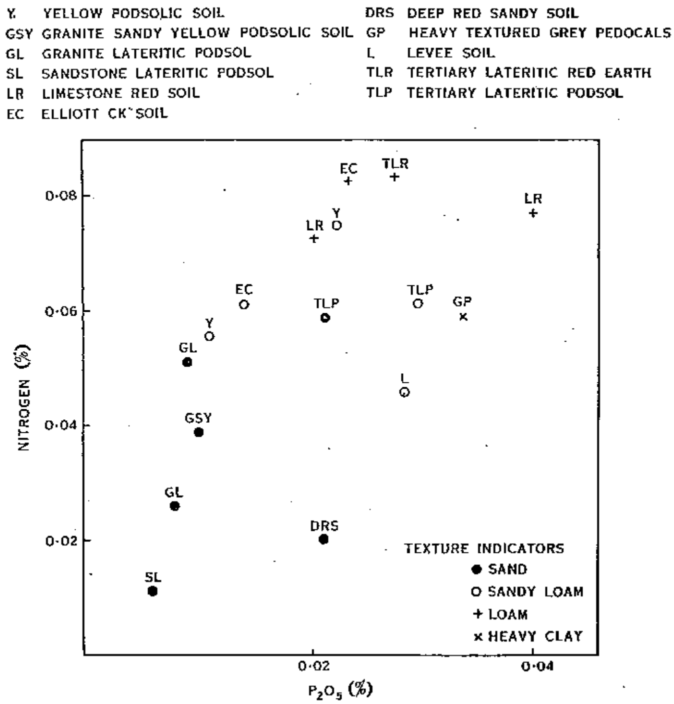
(*f*) *Soils*

(i) *Introduction*

The monsoonal climate has been a dominating influence in determining the nature of the soils of the region. The concentrated wet season of 35-60 in. annual rainfall, alternating with a very marked dry season, is responsible for an active erosion cycle on areas of higher relief and strong leaching of soils on areas of low relief. The active erosion has given rise to extensive areas of skeletal soils characteristic of steeper slopes throughout the region. The eroded material has been deposited to form the flats and flood plains associated with lower stream courses. Residual soils on gentle topography are of limited extent and are, almost without exception, strongly leached. The remaining group of soils are the Tertiary lateritic soils, which are the product of extreme leaching by past climates. They have persisted in some areas of low relief, particularly in the north, and have been subjected to still further leaching since that period with little or no erosion.

The areas satisfactory for arable farming are restricted to some of the residual and Tertiary lateritic soils. Skeletal soils must be excluded by reason of their nature and topography, while most of the soils of the alluvia are liable to seasonal flooding.

Leaching has been sufficient to deplete the bases and give an acid reaction in most soils. Many of the parent materials are "acidic", e.g. granite, metamorphics, sandstones; but, even where calcareous or basic



SOILS WITH HIGH PHOSPHORUS AND NITROGEN

	N	P_2O_5
TERTIARY LATERITIC FLAT	0·245	0·021
ACID ALLUVIAL FLAT	0·130	0·016
COASTAL PLAIN CLAY	0·131	0·045
COASTAL PLAIN PEAT	0·800	0·135

Fig. 3.—Phosphorus and nitrogen contents of some surface soils.

igneous rocks are the parent material, the soil reactions are acid in all except the poorly drained soils. The leached soils are generally light in texture. The surface soil varies from loose sand to loam and the subsoil from sand to light clay.

The high degree of leaching has resulted in soils low in plant nutrients. Laboratory analyses of samples from representative soils have been made by the Chemistry Section, Division of Soils, C.S.I.R.O. In Figure 3 the nitrogen (as percentage N) and phosphate (as percentage P_2O_5 by HCl extraction) contents of various soils are shown. There is a general correlation between texture and the above constituents.

Except for highly organic, poorly drained soils, the phosphate figures are low (< 0.04 per cent.), and the extremely leached sandy soils are very low (about 0.01 per cent.). It appears almost certain that, as with Australian soils generally, universal application of phosphate will be necessary for maximum crop production.

Figures for nitrogen are less than 0.1 per cent. except in some poorly drained soils, the sandy soils being generally less than 0.05 per cent. It is likely that at least these sandy soils will require their nitrogen levels to be raised by application of fertilizers or other means.

A minor element deficiency in citrus corrected by applications of zinc sulphate is already known. It is very likely that the more highly leached soils, particularly the leached sandy soils and the Tertiary lateritic soils, will prove to be deficient in some minor elements.

A fertility assessment based on a study of pedological processes and on chemical analysis has been made for all soils described. Further details on pedological features and chemical analysis are included in the more detailed report on the pedology of the area being prepared by G. A. Stewart.

Soils were examined by boring holes with a four-inch post-hole auger and also by examination of road cuts, quarry and cliff faces (Plate 15, Fig. 2; Plate 20, Fig. 1). The unit of soil observation is the soil profile, which is a vertical section from the surface down to the parent material. In the following descriptions the depth (in.) and nature of horizons are given for typical profiles of the various soil groups. Vegetation terms used in the description of tree cover are described in the following section dealing with vegetation. Accompanying the description of soils are short notes on their occurrence and extent and their agricultural characteristics. These include their physical suitability for agriculture and their fertility assessment. Table 5 shows the fertility assessment, the major physical characteristics, and mode of occurrence of all the soils.

(ii) *Grouping of Soils of the Region*

(1) Skeletal Soils

No skeletal soils have been described in this section but their nature is closely related to the parent material, e.g. very gravelly soils from metamorphic slates and shales; gritty sands with boulders from granite. The nature of the various skeletal soils is described where they occur in various land systems (see Section III).

(2) Residual Soils

(i) Yellow Podsolic soils
(ii) Granite Sandy Yellow Podsolic soils
(iii) Granite Lateritic Podsols
(iv) Deep, Sandy, Light Grey soils
(v) Sandstone Lateritic Podsols

TABLE 5
SUMMARY OF FACTORS INFLUENCING THE AGRICULTURAL VALUE OF VARIOUS SOILS

Soil	Fertility Assessment	Physical Characteristics	Mode of Occurrence
(i) Yellow Podsolic	Low to low-moderate	Shallow (24 in.), light texture	Not very extensive, no promising associated soils
(ii) Granite Sandy Yellow Podsolic Soils	Low-moderate	Deep sandy surface, subsoil variable, well drained	Extensive but generally occur mixed with poorer soils, e.g. Granite Lateritic Podsol
(iii) Granite Lateritic Podsols	Low	Very sandy surface, compact clay subsoil, probably "droughty"	Extensive, generally mixed with Granite Sandy Yellow Podsolic Soils
(iv) Deep, Sandy, Light Grey Soils	Low	Deep, very sandy soils	Extensive areas in south-west region otherwise scattered, small areas
(v) Sandstone Lateritic Podsols	Low	Very sandy surface, compact clay subsoil probably "droughty"	Occurs extensively and also mixed with better soils
(vi) Limestone Red Soils	Moderate	Deep, well drained, physically suited to agriculture	Fairly extensive but generally mixed with poorer soils
(vii) Amphibolite Red Soils	Moderate	Sometimes stony surface, otherwise deep, well drained, physically suited for agriculture	Small scattered areas amongst poorer soils
(viii) "Elliott Creek" Soils	Low-moderate to moderate	Moderately drained, physically suited for agriculture	Extensive areas occur and also small areas mixed with other soils
(ix) Deep Red Sandy Soils	Low	Sandy, deep, well drained	Mixed with other soils in Katherine River area

TABLE 5 (*Continued*)

Soil	Fertility Assessment	Physical Characteristics	Mode of Occurrence
(x) "Moyle" Soils	Low-moderate	Sandy surface, clay subsoil well drained	Relatively small areas mixed with Sandstone Lateritic Podsol and Deep, Sandy, Light Grey Soils
(xi) Heavy-textured Grey Pedocals	Moderate	Cracked heavy clay surface, generally liable to flooding	Generally scattered occurrence
(xii) Levee Soils	Fair	Light-textured, generally above flood level	Narrow broken bands along major streams, often backed by flats liable to flooding
(xiii) "Acid" Alluvial Soils	Low-moderate	Structureless surface, compact clay subsoil, liable to shallow seasonal flooding	Extensive along major northern rivers, smaller areas in western part of region
(xiv) Estuarine Plain			
(*a*) Clay	Moderate	Cracked heavy clay surface liable to deep seasonal flooding	Extensive in northern estuaries, smaller areas in western
(*b*) Peats	Moderate	Water-table at surface through dry season, deep flooding in wet season	Extensive areas in western estuaries, minor areas in northern
(xv) Salt flats		High salt content, liable to deep saline flooding	Irregular band along littoral edge of estuarine plain and in minor estuaries
(xvi) Tertiary Lateritic Red Earths	Low to low-moderate	Well drained, physically suited for agriculture	Some extensive areas in north-west section but generally mixed with other Tertiary soils
(xvii) Tertiary Lateritic Podsols	Low	Sandy, well drained, massive laterite at 3 ft.	Extensive in northern section, mixed with other Tertiary soils
(xviii) Tertiary Lateritic Flats	Low	Structureless surface, compact subsoil liable to shallow seasonal flooding	Minor areas in the above Tertiary soils
(xix) Laterite Dissection Soils	Low	Irregular topography, soils often very gravelly	Occur only in north-west section of the region

(vi) Limestone Red soils
(vii) Amphibolite Red soils
(viii) "Elliott Creek" soils
(ix) Deep Red Sandy soils
(x) "Moyle" soils
(xi) Heavy-Textured Grey Pedocals. Some of the soils formed on the Quaternary alluvia are similar.

(3) Soils of the Quaternary Alluvia
(xi) Heavy-Textured Grey Pedocals similar to those above under (2) (xi).
(xii) Levee soils
(xiii) "Acid" Alluvial soils
(xiv) Estuarine Plain Clays and Peats
(xv) Salt Flat soils

(4) Soils of the Lateritic Tertiary Land Surface
(xvi) Tertiary Lateritic Red Earths
(xvii) Tertiary Lateritic Podsols
(xviii) Tertiary Lateritic Flats
(xix) Soils of Dissected Lateritic Formations

(iii) *Description and Agricultural Characteristics of the Major Soils*

(i) *Yellow Podsolic Soils.*—These are residual on highly folded metamorphics, dominantly slates, of the Brocks Creek Group, in the Elevated Backbone Country.

0-7 in.	Grey sandy loam.
7-24 in.	Yellow-grey or yellow sandy clay loam with fragments of slate. Fragments increase with depth to 24 in. on weathering slate. Stony forms are more extensive than the above profile, which occurs in three relatively small, separated areas.

Agricultural characteristics.—These soils are moderately well drained, of light texture, and lightly timbered. Fertility assessment is *low* to *low moderate*. Because of their scattered occurrence and low fertility they are likely to be used for pastoral rather than agricultural purposes.

(ii) *Granite Sandy Yellow Podsolic Soils.*—These are formed on undulating topography on Cullen and Litchfield Granites of the Elevated Backbone Country and Western Fault Block Plains respectively. They occur mixed with bouldery or more highly leached soils formed on granite.

0-6 in.	Grey coarse sand.
6-24 in.	Drab yellow-grey coarse sand.
24-42 in.	Yellow coarse sand with slight red mottle.
42-50 in.	Yellow, red-mottled, clayey coarse sand.
50-60 in.	Decomposing granite.

Agricultural characteristics.—They are soils of moderate depth, well drained, with very light surface texture. Vegetation cover varies from *scrubby open forest* to *palm scrub*. Fertility assessment is *low moderate* and nitrogen and phosphate both appear very low. These soils are intermixed to varying degrees with poorer soils. Where extensive areas occur, or where they are fringed by better soils, they may be worth consideration for arable agriculture, especially in the western section of higher rainfall.

(iii) *Granite Lateritic Podsols.*—These are more highly leached soils, also formed on granites.

0-6 in.	Light grey coarse sand.
6-18 in.	Yellow-grey coarse sand.
18-36 in.	Yellow-grey clayey coarse sand with light to moderate ferruginous gravel.
36-108 in.	Light grey, with red and yellow mottling, clay with light, soft ferruginous gravel.
108 in.+	Decomposing granite.
	The ferruginous gravel is sometimes cemented into a layer of massive laterite.

Agricultural characteristics.—The highly leached, very sandy surface and intractable clay subsoil are features of this "droughty" soil of *low* fertility, which appears very low in both phosphate and nitrogen. This soil could be considered for agriculture only where it occurs in conjunction with better soils. In most places it carries an *open forest* with scrubby undergrowth.

(iv) *Deep, Sandy, Light Grey Soils.*—These are mostly residual on sandstone but some are formed on water-carried material from sandstone areas. The sandstones may belong to the Buldiva Quartzite, Daly River Group, or Port Keats Group. They are not very extensive and occur in less accessible parts of the region.

0-15 in.	Light grey sand.
15-66 in.	Light yellowish grey sand.
66 in.+	Greyish yellow sand with red mottling. Texture may rise slightly.

Agricultural characteristics.—These heavily timbered, inaccessible, deep, loose sands have little prospect of agricultural use.

(v) *Sandstone Lateritic Podsols.*—These are formed on sandstones of the Buldiva Quartzite, Daly River, or Port Keats Group. They are similar to Granite Lateritic Podsols in most characteristics except that they have finer sand textures.

0-14 in.	Light grey sand.
14-24 in.	Light yellowish grey sand with light to moderate ferruginous gravel.
24-36 in.	Light yellowish grey sand with moderate ferruginous gravel.
36-90 in.+	Light grey with red, yellow, yellow-brown mottling, light clay with light ferruginous gravel.
	Massive laterite horizons are present in some profiles.

Agricultural characteristics.—Like the Granite Lateritic Podsols, these soils appear "droughty" and are of low fertility. In some places they are associated with better soils and in some sections may be usable for agriculture. *Open forest* or *scrubby open forest* are the general forms of vegetation.

(vi) *Limestone Red Soils.*—These are formed on undulating topography on limestones of the Daly River Group and Elliott Creek Formation of the Daly River Basin and Western Fault Block Plains respectively.

The surface soil is sometimes sandy for approximately 24 in. Some extensive areas of the soils occur but they are generally intermixed with areas of Sandstone Lateritic Podsols; skeletal soils; Deep Red Sandy soils, and "Elliott Creek" soils.

0-6 in.	Brown loam.
	Red-brown light clay, friable.
12 in.+	Brownish red light clay.
	Depth to limestone varies from 27 in. to more than 72 in. Deeper soils may have haematitic concretionary gravel in lower part of profile.

Agricultural characteristics.—The soils are deep, well-drained, and of *moderate* fertility. They are physically satisfactory for cultivation. Although they cannot be regarded as good soils their extent, distribution, and general characteristics mark them as being worth agricultural investigation. Irrigation does not appear practicable; therefore, their use, if any, must be restricted to dry-land agriculture. They occur over a range of rainfall, and generally carry a *mixed open forest* vegetation.

(vii) *Amphibolite Red Soils.*—Small, isolated areas of basic intrusive rocks of the Brocks Creek Group in the Elevated Backbone Country give rise to these soils.

0-8 in.	Brown loam, sometimes stony.
8-60 in.	Red-brown light clay, friable.
60-72 in.	Passes gradually into yellow-brown decomposing amphibolite.

Deeper profiles also occur, but their lower horizons are not known. There are no extensive areas of this soil, the normal occurrence being small, irregular areas surrounded by Yellow Podsolic, stony Yellow Podsolic, and skeletal soils.

Agricultural characteristics.—Although non-stony areas are well drained and physically well suited for cultivation and their fertility assessment is *moderate* the nature of occurrence precludes any extensive agricultural development unless the surrounding poorer soils can also be used.

(viii) *"Elliott Creek" Soils.*—This name has been used for these soils as they do not comply completely with any described soil groups. They were first seen and described in the vicinity of Elliott Creek, north of Daly River settlement. Their parent material is closely stratified limestones, shales, and sandstones of the Elliott Creek Formation and Daly River Group and the normal topography is gently undulating. Extensive areas occur and also smaller areas mixed with Limestone Red soil, Sandstone Lateritic Podsols, Deep Red Sandy soils, and skeletal soils.

0-5 in.	Grey fine sand to loam with light to moderate ferruginous gravel.
5-15 in.	Yellow-grey with slight red mottle, sandy clay loam to clay loam with moderate ferruginous gravel.
15-40 in.	Yellow-grey with yellow-brown, red-brown mottle, light clay with moderate ferruginous gravel.
40-63 in.	Yellow with yellow-brown, red-brown mottle, light clay with light ferruginous gravel.
63 in.	Decomposing shale, sandstone, limestone.

Agricultural characteristics.—These soils are physically suited for agriculture, moderately well drained, and fertility assessment is *low-moderate* to *moderate.* Phosphate content is low. Tree cover is generally *open forest* or *palm scrub.* As they occur in considerable areas, sometimes mixed with better and poorer soils, in a region of relatively good rainfall, their possible use for dry-land agriculture is considered worthy of investigation.

(ix) *Deep Red Sandy Soils.*—In the lower rainfall areas near Katherine, deep, red, sandy soils are formed on ferruginous sandstones of the Daly River Group in the Daly River Basin. Topography is undulating to gently undulating. Extensive occurrences are unusual, and normally this soil is intermixed with Sandstone Lateritic Podsols, Limestone Red soils, "Elliott Creek" soil, and skeletal soils.

0-6 in.	Greyish brown sand.
6-12 in.	Brown sand.
12-30 in.	Brownish red sand.
30-54 in.	Red sand.
54-60 in.	Red sand with ferruginous sandstone fragments.

Agricultural characteristics.—These well-drained, very sandy soils are assessed as of *low* fertility. Phosphate content is higher than other sandy soils, but nitrogen is very low. They carry *open forest* vegetation. Where used in conjunction with better soils they may prove suitable for crops like tobacco and peanuts, but their moisture-retaining power is expected to be low.

(x) *"Moyle" Soil.*—Insufficient knowledge is available about this soil to fit it in any group, but it appears to be related to the Limestone Red soils. It is found on undulating topography on calcareous sediments of Port Keats Group on the Western Fault Block Plains. This soil occurs, together with Deep Sandy Light Grey soils and Sandstone Lateritic Podsols, in what is at present one of the least accessible parts of the region.

0-8 in.	Grey-brown sand.
8-20 in.	Yellow-brown sand.
20-33 in.	Light red-brown clayey sand with slight ferruginous gravel.
33-48 in.	Light red-brown sandy clay loam with slight light yellow-grey mottle.
48-78 in.	Light red-brown light clay with slight light grey and light yellow-grey mottling increasing with depth.

Agricultural characteristics.—Although moderately drained and assessed as *low moderate* fertility, this soil is not recommended for immediate investigation because of inaccessibility and its occurrence with poorer soils.

(xi) *Heavy-Textured Grey Pedocals.*—This group of soils includes:

(1) Soils of the basic alluvial flats behind the levees of the Katherine, Flora, and Daly Rivers, liable to seasonal flooding.

(2) Poorly drained soils formed on limestones of Daly River Group. Gilgai structure is sometimes developed.

(3) Poorly drained soils on amphibolites of Brocks Creek Group and Lower Cambrian basic volcanics. On the latter parent material the soils may occur on gentle slopes also.

These are the only pedocalcic soils of the region. They are dark grey or olive-grey heavy clays that crack severely, have lime concretions generally through the profile, and also generally have small purplish-black manganiferous concretions throughout the profile. Maximum depth is generally at least 3 ft.

None of these soils are very extensive, the largest areas being the "basic" alluvial flats on the Daly River and major tributaries. Poorly drained soils on limestone and amphibolite are of minor very scattered occurrence and there are only small areas of the volcanic soils. This group is very similar to the soils of the proposed Ord River Irrigation Area, Western Australia.

Agricultural characteristics.—Fertility assessment is *moderate* but heavy texture, general scattered occurrence, and liability to flooding of the more extensive areas do not favour agricultural development. Normal vegetation is *deciduous parkland* and these soils carry some of the better natural pastures of the region (Plate 18, Fig. 2).

(xii) *Levee Soils*—These occur as narrow (less than 20 chains), irregular bands on both banks of major streams, generally above flood level, and represent coarser fractions of recent alluvia. Despite differences in origin of parent material these immature soils can be considered as one group, as profile differences are not great. The following is a profile from the Katherine River levee at Katherine:

0-8 in.	Grey-brown loamy fine sand with organic matter.
8-18 in.	Yellow-brown loamy fine sand.
18-48 in.	Yellow-brown fine sandy loam.
48-72 in.	Mottled brown, yellow-grey-brown, grey-brown fine sandy clay loam.

Agricultural characteristics.—The soils of the levees are deep, well drained, with sand or loamy sand surface. Timber cover is light, varying from *parkland* to *open forest.* Fertility assessment is *fair,* the highest for the region. These soils are of limited area. Their occurrence as narrow bands along streams and, in many places, the lack of suitable associated soils make them unsatisfactory for large-scale farming. They are suited for limited dry-land development and for specialized crops with irrigation by pumping. Army experience and also current practices indicate that a large variety of fruit, vegetables, and other specialized crops can be grown, but require some form of fertilization, particularly the application of phosphates.

(xiii) *"Acid" Alluvial Soils* (Plate 3, Fig. 2).—These soils are formed on the extensive Flood Plain Alluvia of the northern rivers. The "acidic" alluvia are derived from rocks low in bases, e.g. granites, metamorphics, sandstones, and quartzites. Topography is flat or very gently sloping and the soils are flooded for periods each wet season, but the soils have marked profile development and there is no evidence of present-day deposition of alluvial material. The thin (6 in.) surface horizon has little or no structure and, when dry, is powdery, hence the common name "bull-dust" plains. The most extensive areas are in the northern part of the region along the Adelaide, Finniss, Mary, South Alligator Rivers, and their numerous tributaries, with minor areas in the western part of the region where streams rise in granite areas.

0-6 in.	Grey loam, may vary from fine sand to fine sandy clay.
6-30 in.	Light yellowish grey, with red and yellow-brown mottling, light clay, compact.
30-48 in.	Light grey light clay with red mottling, compact.
48-57 in.	Light grey sandy clay with yellowish grey mottle.
57-70 in.	Greyish yellow sandy clay with red-brown mottling.

Agricultural characteristics.—Although fertility assessment is *low-moderate,* the structureless surface, compact clay subsoil, and seasonal flooding of these soils make them totally unsuited to dry-land agriculture. The possibility of rice culture with some control of natural flooding is considered worth investigation. Vegetation is generally *grassland* or *parkland,* and clearing would not be difficult.

(xiv) *Estuarine Plain Clays and Peats.*—These are the soils of the discontinuous, nearly flat Estuarine Alluvia. They are liable to seasonal flooding which is more prolonged and deeper than that of the "Acid" Alluvial soils. They are generally less than 25 ft. above sea-level and have a water-table throughout the dry season. The group can be divided into two subgroups, differences between which are correlated with differences in water-table during the dry season. The estuarine plains in the north of the region are almost exclusively "black soil plains" but there are considerable areas of swamp in the estuarine plains of the western part.

(1) The clay soils of the "black soil plains" have a dry season water-table at from 2 to 6 ft. In the dry season the surface cracks severely (Plate 11, Fig. 2).

0-21 in.	Grey to dark grey heavy clay, dry, cracked, hard.
21-30 in.	Grey, light grey, yellow-brown, red-brown mottled, heavy clay, moist, stiff plastic.
30-54 in.	Light grey, sometimes bluish or greenish with yellow-brown and red-brown mottling, heavy clay, plastic. Water-table at 30 in.
54-72 in.	Generally similar to 30-54 in. but may be stratified sandy material.

(2) The peat soils of the swamps have a dry season water-table above or near the surface.

0-10 in.	Dark grey to black peaty clay loam.
10-18 in.	Dark grey organic clay with some yellow-grey mottling.
18-72 in.	Light grey heavy clay with yellow-grey, rusty yellow-brown mottling.

Agricultural characteristics.—Deep seasonal flooding combined with very wet or very heavy-textured surface makes these soils unsuitable for general agriculture. Because of their topographic situation there is little possibility of draining the swamps. Although they carry a perennial species of rice (*Oryza fatua*), difficulty of controlling flooding, heavy-textured surface, and a natural vegetation that thrives under prolonged seasonal flooding do not favour rice culture under conditions of white labour and mechanized farming. Their major value is and probably will remain the provision of green pasturage during the dry season when upland pastures are at their lowest nutritional value.

(xv) *Salt Flat Soils* (Plate 16, Fig. 2).—Salt flats occur on Estuarine Alluvia still subject to inundation by saline waters either from peak tides, or a combination of maximum stream flow and high tide. Characteristic Salt Flat soils are formed. The salt flats occur as a seaward fringe to the estuarine plain and also bordering the estuaries of smaller streams.

0-9 in.	Yellow-grey clay loam, containing much crystalline salt, may be puffy on the surface.
9-30 in.	Grey with dark grey and reddish brown mottling, clay loam, wet and sticky.
30 in.+	Steel-grey clay loam with various mottling and some organic staining. Where mangroves grow on areas subject to more regular inundation the 0-9 in. horizon previously described is reduced to a film about $\frac{1}{4}$ in. thick and below that the soil is as described above.

Agricultural characteristics.—The exceedingly high salt content and liability to saline flooding prevent any possible agricultural utilization.

(xvi) *Tertiary Lateritic Red Earths.*—These are the red to yellow-brown soils of the Northern Lateritic Plains and Lateritic Residuals (Plate 16, Fig. 1), originally formed on rocks of the Brocks Creek or Mullaman Groups, probably dominantly slates and shales. Topography is gently undulating. The depth to massive laterite horizon varies from 35 to over 70 in. Some extensive areas occur but in most cases this soil is mixed with other Tertiary soils described below.

0-4 in.	Grey-brown sandy clay loam.
4-12 in.	Brown clay loam.
12-50 in.	Red to red-brown light clay; may have ferruginous gravel in lower part.
50-90 in. approx.	Massive laterite or ferruginous gravel horizon.
90 in.	Light grey, light yellow-brown, red-brown mottled zone, often underlain at irregular depth with light grey pallid zone of variable texture, both of which may be silicified.

Agricultural characteristics.—Good drainage, moderate surface texture, and gently undulating topography make these soils physically well suited for agriculture. However, they are highly leached and fertility rating is *low* to *low moderate*. The low fertility of these soils is indicated by a fertilizer trial with tobacco at the Bagot Compound, Darwin, in 1938-39. Plots fertilized with 375 lb. of a 3-8-3 mixture per acre yielded at the rate of 366 lb. compared with 181 lb. for unfertilized plots. The highly ferruginous nature of the soil may cause phosphate fixation similar to that experienced in lateritic and other red soils in eastern Australia.

These soils occur in the northern higher rainfall areas and the more assured moisture supply favours their agricultural use. However, no investigations are recommended for these soils until crop possibilities have been assured on less leached soils.

(xvii) *Tertiary Lateritic Podsols.*—As with (xvi); these are soils of the Northern Lateritic Plains and Lateritic Residuals. The great depth of weathering makes determination of the original parent material almost impossible, but they appear to be formed from similar rocks to (xvi). There are extensive areas which are often associated with minor areas of other Tertiary soils but, in some parts, the latter predominate.

0-6 in.	Grey sand.
6-15 in.	Light yellowish grey sand.
15-30 in.	Light yellow-grey to yellow-brown sandy loam to sandy clay loam with ferruginous gravel.
30-48 in.	Massive laterite horizon.
48 in.+	Mottled clay which may overlie a pallid zone of variable texture.

Agricultural characteristics.—The sandy surface soil and laterite horizon at less than 3 ft. make these soils unattractive for agriculture. Fertility is assessed as *low* and they are rather heavily timbered (*open forest, tall open forest*). Although they occur in higher rainfall areas, no investigations are recommended until crop production on less leached soils has been investigated.

(xviii) *Tertiary Lateritic Flats.*—These are soils of the Tertiary land surface that are liable to shallow, irregular, seasonal flooding. There are two major subdivisions:

(1) Soils of flats where there is no definite stream line. They have some characteristics in common with "Acid" Alluvial soils but are more highly leached.

0-6 in.	Light grey fine sandy loam.
6-15 in.	Light grey sandy clay loam with slight red mottling.
15-72 in.+	Light grey clay with rusty yellow-brown and red mottling.

(2) Minor soils of flats associated with streams.

0-24 in.	Light grey sand.
24 in.	Massive laterite.

Neither soil occurs very extensively, but normally as minor areas in the upland lateritic soils of (xvi) and (xvii).

Agricultural characteristics.—The deep soils have structureless, leached surface, compact clay subsoil, are liable to seasonal flooding, and dry out quickly in the dry season. These factors, combined with scattered occurrence and *low* fertility, offer little possibility of agricultural utilization. The sandy soils with massive laterite are extremely leached, of very low fertility, and have no prospects for agriculture.

(xix) *Soils of Dissected Lateritic Formations.*—These occur where the lateritic Tertiary land surface has been incompletely dissected and the present soils are formed on exposed lower horizons of laterites or unaltered parent material.

(1) Soils of residuals of old lateritic plateau. These are similar to Tertiary Lateritic Podsols and Tertiary Lateritic Red Earths.

(2) The breakaway of massive laterite or heavy gravels.

(3) Dissection slopes on which soils are formed on exposed mottled and pallid zone. Slopes are generally fairly steep with heavy scree of ferruginous gravel.

0-15 in.	Grey sandy loam with much ferruginous gravel.
15-21 in.	Yellowish grey sandy clay loam with much ferruginous gravel.
21-36 in.	Yellow-brown sandy clay loam with much ferruginous gravel.
36-48 in.	Reddish yellow-brown loam with much ferruginous gravel.
48-72 in.	Light grey clay with rusty yellow-brown mottling of mottled zone.

Agricultural characteristics.—Irregular topography, very gravelly surface, and *low* fertility of these soils make them unsuitable for agricultural use.

(*g*) *Plant Communities*

(i) *Introduction*

Although the region lies within the tropics, the long dry period which is a feature of the monsoon climate of this part of Australia has a dominating influence on the vegetation. With the exception of small, scattered patches of monsoon forests, which are locally known as "jungles" and are a very minor feature of the area, there is no approach to the lush rain forests of tropical regions with better-distributed moisture conditions.

As a direct result of the seasonal drought, sclerophyllous or dry-season deciduous species, or both, dominate all but the flooded portions. The annual leaf-fall of many of the deciduous species is more complete under these conditions than is usually the case where better water relations are maintained. On hills and ridges with excessive run-off, the *Eucalyptus* communities are completely devoid of leaves for portions of the dry season.

In such a climate as this, variation in local drainage conditions is the most important influence determining the kind and distribution of vegetation communities (Fig. 4). Parts of the country are annually flooded for short or long periods. Except where there are stands of *Melaleuca* or *Pandanus,* areas subjected to long periods of inundation carry either grasslands or a mixed grass-reed swamp community.

A wide variety of plant communities exist. A brief description of the major communities follows, and their general positional and constitutional relationships are indicated diagrammatically in Figure 4.

(ii) *General Description of Plant Communities**

The most extensive communities are *open forests* dominated by *Eucalyptus* species ranging from 20 to 70 ft. in height, with an open to very open canopy. There is an understorey of extremely variable density consisting mainly of palms (except in the south-east section) and broad-leaved trees, the latter deciduous in the dry season, with a prominent ground flora dominated by tall grasses (5-10 ft. high) with scattered low shrubs and sub-shrubs.

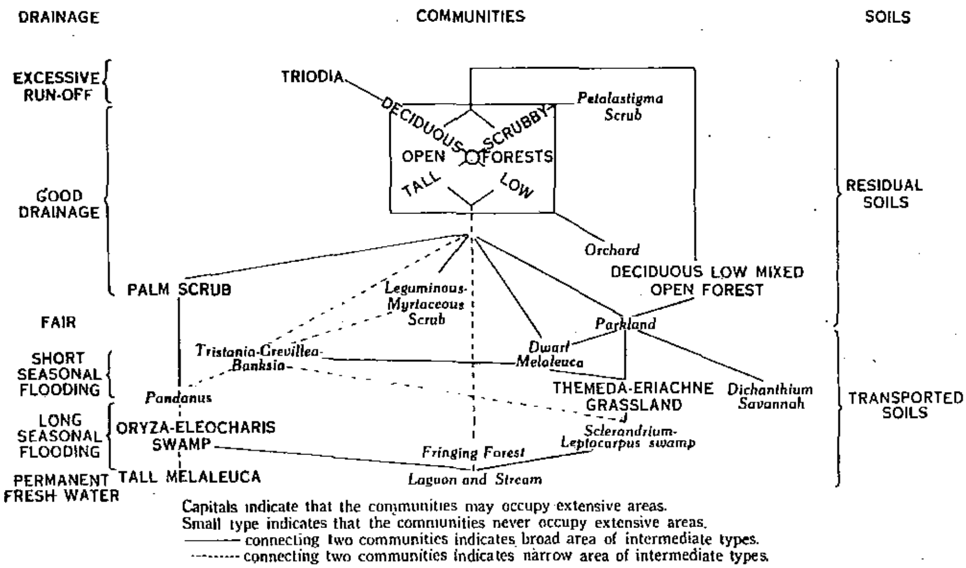


Fig. 4.—The major vegetation communities (excluding monsoon forests and the littoral), showing their general positional and constitutional relationships.

The main species that occur in the open forest communities are:

Eucalypts.—*E. miniata, E. tetradonta, E. bleeseri, E. confertiflora, E. foelscheana, E. tectifica, E. grandifolia, E. polycarpa, E. oligantha, E. patellaris,* and *E. clavigera.*

Other tree species.—*Erythrophleum chlorostachys* (= *E. laboucheri*), *Erythrina vespertilio, Terminalia* spp. (including *T. ferdinandiana*), *Ficus*

* The term community in this section is used to denote a major subdivision of the vegetation. The botanical determinations were made mainly in the field and many are tentative only, and are subject to revision. The nomenclature for eucalypts follows Blake (Botanical contributions of the Northern Australia Regional Survey. I. Studies of northern Australian species of *Eucalyptus*. *Aust. J. Bot.* 1(2): 185), and for the grasses that of current revision, and for the remainder chiefly Ewart and Davies ("Flora of the Northern Territory") and Blake (Studies on miscellaneous northern Australian plants (in preparation)).

orbicularis, Gyrocarpus americanus, Planchonia careya (*Careya australis*), *Buchanania obovata, Petalostigma quadriloculare*,* *P. banksii, Pandanus spiralis, Livistona humilis, Cycas media, Acacia* spp., *Brachychiton paradoxum, B. diversifolium, Grevillea heliosperma, G. mimosoides, Gardenia megasperma, G. pyriformis, Alphitonia excelsa, Hakea arborescens, Owenia vernicosa, Cochlospermum heteronemum, Persoonia falcata, Eugenia suborbicularis, E. bleeseri, Melaleuca leucadendron*,† and *M. minor*.

Lianas.—*Tinospora smilacina, Cayratia trifolia.*

Epiphyte.—*Cymbidium canaliculatum.*

Shrubs.—*Calytrix* spp., *Verticordia cunninghamii, Jacksonia dilatata, Grewia* spp., *Distichostemon filamentosus*, and *Bossiaea phylloclada*.

Sub-shrubs.—*Desmodium* spp., *Galactia muelleri, Psoralea badocana, P. pustulata, Pachynema* spp. (including *P. dilatatum*), *Moghania parviflora*, and *Waltheria indica.*

Tall grasses (usually 5-10 ft.).—*Heteropogon triticeus, Sorghum plumosum, Coelorhachis rottboellioides, Chrysopogon latifolius, Eulalia mackinlayi, Sorghum intrans*, and *S. stipoideum.*

Grasses of medium height (usually 2-5 ft.).—*Themeda australis, Aristida browniana, A. ingrata, Sehima nervosum, Cymbopogon bombycinus, C. exaltatus, Alloteropsis semialata, Eriachne triseta, E. schultziana, Eragrostis schultzii, Plectrachne pungens*, and *Panicum* spp.

Low grasses (usually less than 2 ft.).—*Eriachne avenacea, E. obtusa, Panicum airoides, Ectrosia leporina*, and various annual grasses including *Schizachyrium* spp., *Setaria apiculata, Thaumastochloa* spp., and *Ichnanthus* spp.

Other species of the ground flora.—*Fimbristylis* spp., *Rhynchospora* spp., *Evolvulus alsinoides, Ipomoea erecta, Pycnospora lutescens, Philoxerus* spp., *Trichinium distans, Didiscus hemicarpus, Ampelocissus* spp., *Trichodesma zeylanicum, Euphorbia* spp., *Xyris elongata, Goodenia armstrongiana, Haemodorum corymbosum, Glossogyne tenuifolia, Blumea* spp., *Borreria* (*Spermacoce*) spp., *Crotalaria* spp., and *Tylophora erecta.*

Several phases of the *open forest* communities, differing in their composition, especially in the upper storeys of the formation, have been distinguished, but intergrading communities are common and extensive. The more open phases include communities somewhat similar to those described by some authors as savannah woodlands.

The major communities of the region are as follows:

(1) *Tall Open Forests* (Plate 14, Fig. 1).—Tall, straight trees of *Eucalyptus miniata* and *E. tetradonta* and an occasional *E. bleeseri*

* *Petalostigma quadriloculare* frequently occurs as a low shrub and in this state the name of *P. humile* has been applied to it.

† Taken in the broad sense; there are several forms which have been treated as varieties of *Melaleuca leucadendron* or as distinct allied species but it has not yet been possible to classify the numerous forms known in this area.

dominate this phase. The understorey is variable in expression and is sometimes nearly absent. In addition to the lower tree species, many of which are deciduous, it may include scattered trees of *Eucalyptus confertiflora, E. foelscheana, E. tectifica,* and less often *E. polycarpa,* forming an intermediate storey between the lower trees and the upper storey. In many places the understorey is dominated by *Livistona humilis* or *Cycas media,* the other tree species of the storey being very widely scattered. Some of these are of very occasional occurrence in this phase. *Gyrocarpus* and *Melaleuca* spp. are usually absent.

In general, the taller perennial grasses listed are dominant in the ground flora, but in some areas these are replaced by a very dense growth of the annual *Sorghum* spp.

(2) *Low Open Forests* (Plate 7, Fig. 1).—In these communities the dominant *Eucalyptus* species are those which are sometimes present in the understorey of the *tall open forests,* e.g. *Eucalyptus confertiflora, E. foelscheana, E. tectifica,* together with *E. grandifolia, E. latifolia,* occasionally *E. oligantha,* and, in the south-east, *E. terminalis* and *E. patellaris.* In the typical phase, the taller *E. miniata, E. tetradonta,* and *E. bleeseri* are excluded. The individual trees are often widely spaced and seldom exceed 35 ft. in height. They rarely have straight trunks and are branched low down.

The understorey is usually sparse, and of the trees and shrubs listed, the genera *Eugenia, Melaleuca, Cycas, Verticordia, Jacksonia,* and *Calytrix* do not occur, while *Erythrina* is very rare. The ground cover is rather similar in appearance to the *tall open forest,* but *Themeda, Sehima,* and *Chrysopogon latifolius* are much more prominent and the perennial grasses are frequently denser. *Plectrachne, Cymbopogon,* and *Aristida ingrata* do not appear.

(3) *"Orchard" Communities* (Plate 2, Fig. 2).—An extreme form of *low open forest* which occurs on some undulating yellow podsolic and shallow calcimorphic soils in the south-east section has been termed *"orchard"* community. The same species occur as in *low open forest,* but *Eucalyptus foelscheana* and *E. confertiflora* are usually dominant. The trees have a very stunted, pruned appearance, like orchard trees, and rarely exceed 15 ft. in height.

(4) *Mixed Open Forests* (Plate 5, Fig. 2).—The foregoing communities intergrade into one another, and the intermediate communities which occur over extensive regions are referred to as *mixed open forests.*

(5) *Scrubby Open Forests* (Plate 7, Fig. 2).—On some of the more sandy soils in the south-east section a form of *mixed open forest* with a prominent scrubby type of understorey occurs. The upper storey species are often very mixed and widely scattered. *Eucalyptus miniata, E. tetradonta, E. tectifica,* and *Erythrophleum chlorostachys* are most prominent, although *Eucalyptus confertiflora, E. foelscheana,* and *E. polycarpa* are often present.

The understorey is often dense and scrubby, and the most prominent species is *Petalostigma banksii*, which sometimes tends to form dense scrubs to the exclusion of other woody plants (*Petalostigma* scrubs). Other common species are *Alphitonia excelsa, Terminalia* spp. (including *T. ferdinandiana*), *Acacia* spp., *Brachychiton paradoxum, Grevillea heliosperma, G. pteridifolia, Gardenia megasperma, G. pyriformis, Persoonia falcata, Owenia vernicosa, Cochlospermum fraseri, Calytrix microphylla,* and *Melaleuca leucadendron.*

The dominant grasses are *Plectrachne pungens, Sorghum intrans, S. stipoideum, Aristida arenaria, A. ingrata, Panicum airoides, Eragrostis schultzii, Eriachne avenacea, E. obtusa,* and low annual grasses and Cyperaceae. Legumes are not common, but *Tephrosia* spp. and *Psoralea* spp. occur. Prominent low shrubs are *Petalostigma quadriloculare* and *Waltheria indica.*

(6) *Deciduous Open Forests* (Plate 2, Fig. 1).—Some species of eucalypts are characteristically deciduous during the dry season. These include *Eucalyptus alba, E. tectifica, E. dichromophloia, E. grandifolia, E. foelscheana,* and *E. confertiflora.* These species often enter into the composition of characteristic *low open forest* communities, especially under conditions of relatively poor moisture relationships. These *deciduous open forest* communities occur mainly on skeletal soils on stony slopes and crests.

Xanthostemon paradoxus is a prominent member of the understorey which also commonly includes the low-growing *Eucalyptus setosa, Terminalia canescens, Grevillea heliosperma, Hakea arborescens, Owenia vernicosa, Cochlospermum fraseri, Persoonia falcata,* and *Calytrix achaeta. Petalostigma quadriloculare* is abundant in its dwarf state as a low shrub.

The grass flora is dominated by annual *Sorghum* spp., *Heteropogon triticeus, Alloteropsis semialata, Sehima nervosum, Cymbopogon bombycinus,* and low annual grasses such as *Schizachyrium* spp., and *Plectrachne* may occur also.

(7) *Deciduous Low Mixed Open Forests.*—These are *low open forest* communities up to 20 ft. in height, in which some of the deciduous species of the understorey of the open forests dominate, particularly *Xanthostemon paradoxus, Cochlospermum fraseri, Buchanania obovata, Croton arnhemicus, Erythrophleum chlorostachys, Petalostigma quadriloculare, Gardenia megasperma, Grevillea* spp., low *Melaleuca leucadendron, Acacia* spp., *Verticordia cunninghamii,* and *Eugenia bleeseri.* Stunted eucalypts such as *E. foelscheana, E. clavigera, E. tectifica, E. confertiflora,* and *E. alba* occur. The dwarf *Petalostigma quadriloculare* is a prominent species of the ground flora, as also are low suckers of *Erythrophleum chlorostachys.*

The grass flora is dominated by annual *Sorghum* spp., *Heteropogon triticeus, Eriachne avenacea, Themeda australis,* with some *Plectrachne pungens,* low annual grasses, and Cyperaceae.

(8) Triodia *Communities of Barren Outcrops.*—Many of the barren and precipitous rocky outcrops carry a community characterized by an abundance of *Triodia,* particularly *T. microstachya.* Associated with the *Triodia* may be *Arundinella nepalensis, Eriachne mucronata,* and other grasses and grass-like plants. Through this herbaceous layer may arise a variety of trees and shrubs, sometimes gnarled and of low stature, including *Eucalyptus dichromophloia, E. phoenicea,* and less often *E. miniata, Calytrix* spp., and low *Acacia* spp.

(9) *Parkland* (Plate 3, Fig. 1; Plate 4, Fig. 1; Plate 18, Fig. 1).—On alluvial flats subject to brief seasonal flooding, the *Eucalyptus* spp. are less dense than in *open forests.* This, combined with the general absence of understorey trees, gives the communities a parklike appearance. The tree flora is often monospecific. Common species are *Eucalyptus alba* (to the north), *E. apodophylla, E. latifolia* (in the central portions), *E. papuana, E. grandifolia* (widespread), and in a few places other species of the *open forest. E. polycarpa* occurs sporadically at the edge of the *parkland. Erythrophleum chlorostachys* is associated with these eucalypts in some places.

The ground flora is predominantly grass, medium to tall in height, in which the perennials *Themeda australis, Chrysopogon latifolius, Alloteropsis semialata, Sorghum plumosum,* and *Coelorhachis rottboellioides* are the most common and occur in varying proportions. *Panicum trachyrhachis* is a characteristic tall annual, particularly in drainage channels and depressions.

(10) *Dwarf* Melaleuca *Communities.*—Communities dominated by *Melaleuca leucadendron* occur as scattered small areas on "acid" alluvial flats. The trees are small, usually stunted in appearance, 15-20 ft. high, and occur in dense to open stands. The ground flora consists mainly of grasses characteristic of the *parkland* and open *grassland* communities of the alluvial flats and plains. The *dwarf Melaleuca* communities could be regarded as intermediate stages between *parklands* and *grasslands.* In *open forest* areas they occur in similar situations to the *Tristania-Grevillea-Banksia* community.

(11) *Leguminous-Myrtaceous Scrub* (Plate 14, Fig. 2).—Communities dominated by shrubs such as *Jacksonia dilatata, Calytrix microphylla, Verticordia cunninghamii,* and *Acacia* spp., with or without scattered small trees such as *Grevillea pteridifolia,* occur on some of the Tertiary lateritic podsols in the northern part of the area. The ground flora is usually sparse with *Heteropogon triticeus* and *Eriachne avenacea* as the dominant perennials. Various annual grasses also occur.

(12) *Palm Scrubs* (Plate 6, Figs. 1 and 2).—The *palm scrub* communities grow to about 15 ft. in height and are dominated by *Livistona humilis* or *Pandanus spiralis,* or both, growing as isolated, somewhat scattered individuals or in small groups. Other trees that occur include

Grevillea pteridifolia, stunted *Xanthostemon paradoxus, Erythrophleum chlorostachys, Eugenia bleeseri,* and *Eucalyptus* spp. such as *E. grandifolia* and *E. confertiflora.*

The ground flora consists mainly of *Heteropogon triticeus, Sorghum intrans, Plectrachne pungens, Eriachne obtusa,* and *E. avenacea.* It is often sparse, but is somewhat dense where tall annuals are dominant. *Pachynema dilatatum* and *Didiscus hemicarpus* grow in the ground layer.

(13) Tristania-Grevillea-Banksia *Community* (Plate 19, Fig.1).—This community occurs as a narrow zone, usually on arenaceous soil at the edge of sandy flats that have restricted drainage and are seasonally flooded for long periods. The community may also be associated with the stream channels or permanent to semi-permanent billabongs. Although it occurs in the transition zone between the vegetation of the flats (frequently *grassland*) and the nearby *open forest* or *scrub* communities on higher ground it is quite distinctive and is not a transition community. It consists mainly of low-branched trees to 20 ft. in height, with a ground flora of grass and grass-like plants and a few small, broad-leaved herbaceous species.

The trees, which are often quite dense, include *Tristania lactiflua, Banksia dentata, Grevillea pteridifolia,* and *Acacia* spp. *Metrosideros eucalyptoides* often occurs as a co-dominant in the northern and western parts. *Eucalyptus papuana* and *E. polycarpa* may occur as scattered trees with, in the northern parts, *E. alba* and *Eugenia bleeseri.* There is often a change in associated species from the poorer-drained to better-drained fringes of the community. Often *Melaleuca* and *Pandanus spiralis* occur at the poorer-drained fringe and *Eucalyptus confertiflora* frequently appears at the better-drained fringe which adjoins the *open forest* communities.

There is a sparse to medium-dense ground flora, which includes *Sclerandrium grandiflorum, Eriachne triseta, Coelorhachis rottboellioides,* and low annual species such as *Pseudopogonatherum* spp. and *Setaria apiculata.* Associated with these are various sedges (chiefly *Fimbristylis* spp., *Tricostularia fimbristyloides,* and annual *Rhynchospora* spp.), *Leptocarpus schultzii, Xyris* spp., and small, low plants such as *Goodenia armstrongiana, Buchnera tetragona, Stylidium* spp., and *Drosera petiolaris.*

(14) Sclerandrium-Leptocarpus *Swamp Communities.*—These occur on sandy slopes and flats that have restricted drainage and remain wet by seepage for a considerable period. The vegetation is predominantly a low, mixed herbaceous community with occasional dwarf shrubs and tussocks of taller grasses such as *Sclerandrium grandiflorum, Ischaemum arundinaceum,* and *Eriachne burkittii.* The dominant lower species include various sedges (mostly *Fimbristylis* spp. and *Rhynchospora rubra*), *Leptocarpus schultzii,* and low plants such as *Eriocaulon* spp., *Cartonema parviflorum, Centrolepis exserta, Stylidium* spp., *Drosera indica, D. petiolaris, Byblis liniflora, Utricularia chrysantha* and other species,

Buchnera sp., and *Mitrasacme* spp. A very low shrub, *Osbeckia australiana,* grows in some localities.

(15) Pandanus *Scrubs.—Pandanus* (*P. spiralis* or perhaps a closely allied species) frequently forms almost pure stands at margins of *swampy grasslands* or along some of the drainage channels in heavy soil areas. The ground is usually covered with a litter of leaves, which suppresses the development of any permanent perennial ground flora. Annual species may occur, and in some places include rather dense communities of *Hyptis suaveolens.*

(16) *Deciduous Parkland* (Plate 18, Fig. 2).—Associated with some of the larger river systems are alluvial flats with heavy-textured soil which carry a vegetation consisting of a dense cover of grass of medium height through which may be scattered groups or individuals of trees, usually small and irregular, and usually deciduous in the dry season.

The grasses are mainly perennials dominated by *Dichanthium fecundum,* with *Chrysopogon fallax* and *Bothriochloa intermedia* prominent. In the damper places, taller grasses such as *Ophiuros exaltatus, Eulalia fulva,* and *Arundinella nepalensis* occur. Associated plants commonly include *Sorghum plumosum, Themeda australis, Alloteropsis semialata, Iseilema* spp., *Moghania* sp. (probably *M. pauciflora*), *Rhynchosia minima,* and *Goodenia gracilis,* together with a small species of the family Convolvulaceae.

The trees are commonly *Bauhinia* spp. (*B. cunninghamii* and *B. malabarica*), *Terminalia* sp., and *Acacia bidwillii. Eucalyptus microtheca* (coolabah) is prominent as an evergreen tree in many places. Scattered taller trees of *Eucalyptus papuana* and *Tristania grandiflora* occur occasionally, thus showing an approach to the *parkland* communities.

(17) Themeda-Eriachne *Grasslands* (Plate 3, Fig. 2).—*Grasslands,* almost or entirely treeless, occur on the broad plains and small flats of "Acid" Alluvia. The grasses are mainly of medium height and include as dominant species *Themeda australis, Eriachne burkittii,* and *Alloteropsis semialata,* with the lower *Eriachne avenacea, Ectrosia leporina,* and *Eragrostis bella* as common species. The taller *Sorghum plumosum* and *Coelorhachis rottboellioides* also occur. In some areas, these perennials are replaced by dense stands of the tall annual *Sorghum intrans.* A few small deciduous trees, chiefly *Eugenia bleeseri, Dolichandrone filifolia,* and *Vitex glabrata,* sometimes occur near the edges of the flats.

(18) Oryza-Eleocharis *Swamps and Swampy Grasslands.*—These are almost entirely restricted to the Sub-Coastal Plain and its associated flooded areas, but occasional and minor developments occur in depressions within the *open forest* areas. These plains are areas of heavy, sometimes peaty, soil, subject to long periods of inundation.

The drier parts of these plains are dominated by *Ischaemum arundinaceum* which often occurs in almost pure stands, but is sometimes mixed with *Imperata cylindrica* var. *major* (see Plate 11, Fig. 1). Both of these species are of medium height. *Xerochloa imberbis, Bothriochloa intermedia,* and *Eriochloa* sp. occur on small islands of shallower soils. Where the water-table is high, particularly when supplemented by drainage from surrounding areas, dense stands of *Phragmites karka* (up to 12 ft. high) or *Scleria poaeformis* (up to 8 ft. high) occur.

The main part of the plain has a dense growth of a perennial grass, *Oryza fatua,* and a tuberous, rush-like sedge, *Eleocharis dulcis.* In places, this sedge is replaced by other species, mainly *E. sphacelata* and *E. spiralis.* Other grasses associated with these are *Leersia hexandra, Hymenachne amplexicaulis, Pseudoraphis spinescens,* and *Panicum paludosum.* As the ground dries out, *Phyla nodiflora* (a small, creeping, herbaceous plant), *Polygonum* sp., and *Ipomoea aquatica* (*I. reptans*) sometimes form a rather close ground cover.

(19) *Communities of the Lagoons.*—On the plains and flats there are small to large expanses of water that persist well into or throughout the dry season. They carry a vegetation of broad-leaved waterlilies, *Nelumbo nucifera, Nymphaea gigantea, Limnanthemum indicum,* and *L. geminatum* and the submerged *Ceratophyllum demersum, Hydrilla verticillaris,* and *Utricularia flexuosa.* The free-floating plant, *Pistia stratiotes,* is abundant in places. In shallow water, *Eleocharis* spp. (mainly *E. sphacelata*), *Cyperus platystylis,* and sometimes *Polygonum* sp. form a more or less distinct zone. Most of the lagoons have a broken fringe of small trees of *Barringtonia gracilis,* sometimes with *Phyllanthus reticulatus, Pandanus aquaticus,* or low *Melaleuca.*

(20) *Tall* Melaleuca *Communities* (Plate 12, Fig. 1).—A tall species of *Melaleuca,* allied to *M. leucadendron,* frequently forms dense communities (up to 50 ft. high) with abrupt edges. The communities are mostly associated with the *Oryza-Eleocharis swampy grasslands* and occur at the edge of the heavy soil plains in places where water from the nearby uplands accumulates. The ground flora is often absent or may consist of small, annual, herbaceous species with some development of the *swampy grassland* species.

(21) *Fringing Forests* (Plate 17, Fig. 2).—These occur along most of the stream beds. In the permanent streams they are denser near the dry season water-level. They rarely extend far up the slopes of the stream bank. They vary from an almost single line of trees to a narrow, dense belt. Tall trees of *Melaleuca* sp., *Casuarina cunninghamiana,* and *Nauclea orientalis* (Leichhardt tree) are universally prominent above tidal waters on the major streams. Except in the far south-east, *Bambusa arnhemica* is often prominent (Plate 18, Fig. 1). *Metrosideros eucalyptoides* is fairly widely spread. *Eucalyptus camaldulensis* occurs along the streams of the Daly River system. *Tristania lactiflua, T. grandiflora, Barringtonia gracilis,* and *Pandanus aquaticus* are common smaller trees, while less widespread are *Eugenia eucalyptoides* and *Ficus* spp. (see Plate 5, Fig. 1).

Where the fringe attains any width, there is a tendency for the development of *monsoon forests* which include such trees as *Bombax* *malabaricum* (kapok). Towards the source of the smaller streams, this fringe tends to be dominated by *Bambusa* or by lower-storey members of the *monsoon forest* communities, of which *Strychnos lucida* and *Denhamia obscura* are most common. Where the source is a spring the community in that vicinity may be dense and often includes many of the species of the *Tristania-Grevillea-Banksia* community. Associated with these trees are a few characteristic grasses and grass-like plants, such as *Sclerandrium truncatiglume, Arundinella nepalensis, Eragrostis* sp., *Vetiveria intermedia, V. pauciflora, Paspalum orbiculare, Paspalidium distans,* and *Cynodon dactylon* with *Scleria zeylanica* and allied species in wet habitats. *Chionachne cyathopoda* occurs in dense masses immediately behind and sometimes within the *fringing forest* and in the gullies of the dissected levees. *Eucalyptus ptychocarpa* grows on the outside of the fringe near the headwaters of some of the smaller, more or less permanent streams.

Flagellaria indica, Opilia amentacea, Capparis umbellata, and *Passiflora foetida* are common lianas in the *fringing forest.* About the middle course of the Daly River, *Excoecaria parvifolia* (gutta-percha) forms pure stands on flooded flats behind the levee. In the region of tidal waters, the *fringing forest* is dominated by mangroves.

(22) *Monsoon Forests* (Plate 19, Fig. 2).—These occur sporadically as small patches at the headwaters of spring-fed creeks, on levees or in the *open forest,* sometimes on rocky outcrops, or as belts behind the vegetation of the littoral.

They are forests consisting of several storeys, the top one being composed of broad-leaved trees to 50 ft. in height, deciduous in the dry season, and somewhat widely spaced. There is a second storey of smaller trees, also mostly deciduous, while below this is a third storey of low trees and tall shrubs. The ground flora is sparse, consisting of small shrubs and a few herbaceous plants. Lianas are fairly frequent and of considerable variety.

The species listed below are the most constant in occurrence. This form of community varies considerably in composition, but it is not practicable to distinguish different types. Variations occur in which species of the first and sometimes also the second storey are absent, and a community of more shrubby species, sometimes dominated by *Strychnos lucida,* results.

The prominent top storey trees are *Bombax malabaricum, Sterculia quadrifida, Canarium australianum, Vitex glabrata, Alstonia actinophylla, Buchanania arborescens, Acacia aulacocarpa, Parinarium corymbosum, Terminalia sericocarpa, Eugenia* sp., *Peltophorum pterocarpum,* and the palm *Ptychosperma bleeseri.*

In the second storey, *Myristica insipida, Micromelum minutum, Cupaniopsis anacardioides, Pongamia pinnata* (*P. glabra*), *Cryptocarya cunninghamii, Litsea* sp., *Croton arnhemicus, Hemicyclia* sp., and others occur.

Of the third storey species, *Strychnos lucida, Exocarpus latifolius, Ixora* n. sp. (?), *Denhamia obscura, Wrightia pubescens, Canthium attenuatum, Trema aspera, Carallia brachiata, Leea sambucina, Diospyros hebecarpa* (ebony), and *Pithecellobium moniliforme* are common.

The lianas include *Tinospora smilacina, Malaisia tortuosa, Flagellaria indica, Passiflora foetida, Jasminum didymum, Parsonsia velutina, Capparis umbellata, Secamone elliptica, Smilax australis, Asparagus racemosus, Opilia amentacea, Pisonia aculeata,* and *Pachygone pubescens.*

The ground flora consists of a few grass-like plants such as *Panicum trichoides, Cyperus ramosii, Oplismenus compositus,* and the tuberous plants *Tacca leontopetaloides* (*T. pinnatifida*) and *Amorphophallus galbra.*

(23) *Communities of the Littoral.*—The foredunes are characterized by *Spinifex longifolius* and *Ipomoea pes-caprae.* On the more stable dunes there is developed *littoral forest* or *dune scrub,* in which *Celtis philippinensis, Guettarda speciosa, Dodonaea viscosa, Thespesia populnea, Hibiscus tiliaceus, Mallotus nesophila, Gyrocarpus americanus, Sterculia quadrifida,* and *Clerodendron floribundum* are the main species. This *dune scrub* may include many species of the *monsoon forest* and may occur as a relatively broad belt.

Mangroves occur on muddy or stony flats in more or less sheltered positions inundated by tidal waters, and extend up the rivers to tidal limit. Of the chief species, *Sonneratia caseolaris* faces the sea, *Rhizophora mucronata* is particularly abundant near the open water in quieter waters, *Avicennia resinifera* grows densely in the middle of the zone, while on the landward edge *Ceriops tagal,* sometimes with *Lumnitzera racemosa,* occurs commonly. Other species are *Bruguiera gymnorrhiza, B. parvifolia, Xylocarpus australasicus,* and *Aegiceras corniculatum. Aegialitis annulata* sometimes occurs as a small shrub further inland than *Ceriops.* Another small shrub is *Acanthus ilicifolius* which extends well up the rivers. *Phragmites karka* and *Hibiscus tiliaceus* are associated with the mangroves along the river banks.

Behind the mangroves, sometimes also behind the dunes, there may occur *salt meadows* consisting of a fairly close turf of *Sporobolus virginicus,* usually with *Fimbristylis ferruginea, F. cymosa,* and *Cyperus polystachyos,* often *Cyperus javanicus* (*C. pennatus*), and occasional plants of *Salicornia australis* and *Suaeda australis.* In other places this turf is partially replaced by *salt pan communities* which are very open communities of succulent species of Chenopodiaceae. *Arthrocnemum leiostachyum, Salicornia* sp., and *Tecticornia cinerea* are the most prominent. *Xerochloa* sometimes occurs on the inland edge of the salt pans (Plate 16, Fig. 2).

(*h*) *Pastures*

The monsoonal nature of rainfall in this region, drainage conditions, and liability to flooding are the major factors determining pasture type.

These appear to outweigh the influence of variation in soil fertility. Soil moisture is normally abundant during the well-defined wet season, which is, however, relatively short and accompanied by high temperatures. During the long dry season which follows, soil moisture is very low, except on areas subject to long periods of flooding or near springs and streams.

The dominant pasture type on upland areas under these conditions is composed of a mixture of fast-growing, rather coarse perennial grass species that are either tall (6-10 ft.) or of medium height (4-6 ft.). The pastures vary considerably in dominant species and in relative density of the species. Where the perennial species have been disturbed they are replaced by annual grasses, commonly tall species of *Sorghum,* or, where subjected to severe over-grazing or trampling, by the annual weed *Hyptis suaveolens.* Where soil moisture conditions are less favourable, such as on very light-textured soils, the tall perennial grasses are sparse and the tall annual grasses may dominate, or may be accompanied by xerophytic species such as *Plectrachne pungens.* On the rocky crests other types of spinifex, mainly *Triodia microstachya,* dominate.

Where flooding occurs for prolonged periods, characteristic grasses, including stoloniferous and semi-floating species, occur and are accompanied by various species of reeds.

Similar types of pastures may be found occurring in several land systems. Six major groups may be recognized:

(1) *Tall Grass Pastures of the Upland Areas*

These are by far the most extensive pastures in the region and occur in most areas not subject to flooding, except rocky crests, steep, rocky slopes, or on seepage slopes. They consist mainly of grasses that are tall or of medium height, with a small proportion of lower species. In general, perennial species dominate, but tall annual species are common, and in some areas occur almost to the exclusion of the perennials. This is particularly so on light-textured soils, but patches dominated by annuals also occur on other soils. The reasons for this have not been established, but possibly the effects of regular burning accompanied by local variations in soil type or in the incidence of grazing account for it. In such areas tall mounds, termitaria of *Eutermes,* are common and these insects may be a contributing factor.

The most common tall perennial species which assume dominance are *Heteropogon triticeus, Sorghum plumosum,* and *Chrysopogon latifolius. Coelorhachis rottboellioides* occurs spasmodically. The dominant perennials of medium height are *Themeda australis, Sehima nervosum, Alloteropsis semialata, Eriachne triseta,* and *Plectrachne pungens. Aristida browniana, A. ingrata,* and *Eragrostis schultzii* are common under some conditions.

Of the tall annual species, *Sorghum intrans* and *S. stipoideum* are by far the most common and widespread.* Numerous shorter annual species occur but assume prominence only where the ground flora is otherwise sparse.

The composition of the pastures varies considerably and it is not possible to enumerate all variations. The following are some of the more typical phases:

(i) On the better soils such as the Levees, Limestone Red soils, Amphibolite soils, and the Elliott Creek soils, dominance is shared by *Chrysopogon latifolius, Themeda australis, Sorghum plumosum, Alloteropsis semialata,* and *Sehima nervosum.*

(ii) On lighter-textured soils such as the Granite Podsols and Lateritic Podsols dominance is shared by both annual (chiefly *Sorghum intrans*) and perennial species (chiefly *Heteropogon triticeus*). In some places annual species alone may assume dominance.

(iii) On very light-textured soils *Plectrachne pungens* is common and may be dominant but rarely becomes so in the areas of higher rainfall.

(iv) In the major lateritic areas *Sorghum intrans* is prominent with a sparse perennial population which commonly includes *Heteropogon triticeus* but *Eriachne triseta* is abundant, particularly near the margins of the lateritic areas lying between the northern rivers, where it is the dominant grass species.

Because of the monsoonal nature of the climate of this region, and the generally good drainage conditions under which these pastures occur, growth is practically restricted to the short wet season of the year. The mature pastures are bulky but not heavy and are of low nutritional value. The latter varies slightly according to the botanical composition of the pastures. The tall annual species are particularly poor, but some of the perennials, such as *Sorghum plumosum, Heteropogon triticeus, Chrysopogon latifolius,* and *Themeda australis* maintain green leaves for a slightly longer period. *Plectrachne pungens* provides some fodder during the dry season and is a poor but useful standby, but areas where this species is dominant are usually not well supplied with stock water. In parts of the Daly River basin, *open forests* with *Plectrachne* sp. in the ground flora extend to near the rivers which provide good stock water.

Chemical analyses (Table 6) by Dr. Hallsworth of samples collected by F. W. Hely illustrate the low crude protein, calcium, and phosphorus contents of the taller grasses. The annual grass *Brachyachne convergens* and *Cyperus* sp. are superior but these are minor constituents and occur mainly on low-lying country. A satisfactory nutritional level occurs in

* When the area was visited, the plants were too dried out to allow discrimination between the several species of similar appearance now known to occur in the region.

these tall grass pastures only in the young stages of growth, e.g. at the beginning of the season or, in favourable seasons, following a fire at the end of the season.

Legumes are generally sparse and of little importance in these pastures. However, on some soils such as the Granite Podsols and Amphibolite Soils various small legumes are present and appear to make a good, although sparse growth following burning.

The burning of these pastures is a common feature. This is best practised at the end of the wet season as soon as the bulky growth is sufficiently dry to permit it. The new growth made possible by accumulated soil moisture, or in favourable seasons, by light showers of rain, provides

TABLE 6

CHEMICAL ANALYSES OF NORTHERN GRASSES*

Species	Stage of Growth	Crude Protein (%)	Calcium as CaO (%)	Phosphorus as P_2O_5 (%)
Dominant Species				
Chrysopogon sp.	Flowering	3.70	0.122	0.105
Chrysopogon sp.	Flowering	4.26	0.108	0.130
Themeda australis	Flowering	3.24	0.168	0.075
Themeda australis	Flowering	3.86	0.127	0.100
Sorghum sp.	Flowering	1.77	0.246	0.125
Sorghum sp.	Leafy	3.00	0.335	0.130
Minor Species				
Brachyachne convergens	Not recorded	8.11	0.214	0.084
Ichnanthus pauciflorus	Not recorded	6.70	0.243	0.200
Cyperus sp.	Not recorded	8.10	0.331	0.170
Cyperus sp.	Leafy	12.65	0.457	0.420

* Hely, F. W., and Hallsworth, E. G. (1947).—The nutritive value of some north Australian grasses. *J. Aust. Inst. Agric. Sci.* 13 (1-2).

a second short period of satisfactory nutrition. Burning is also of importance in controlling stock as they congregate on the burned areas and can therefore be more easily mustered. In unfavourable seasons or when not controlled, burning may be a serious disadvantage, as it removes the accumulated reserve which, as one grazier expressed it, does keep the animals full. Unfortunately, burning is not always controlled. Many fires are lit by natives while on "walkabout" and the fires lit by some graziers may extend far beyond their boundaries. Burning has been practised by natives for centuries before this region was occupied by white men. It has evidently played an important part in determining the present species composition of the pastures, but what effect the withholding of burning for long periods might have is not known. However, owing to the obvious dominating influence of climate, it is not likely to produce species changes of major importance.

Little is attempted by way of controlled grazing other than that enforced by climate through nutritional changes in pastures. When feed becomes unsatisfactory stock trek or are moved to more favourable portions of the run, if they exist. These include the sub-coastal plain and its extensions inland, stream frontages, lagoons, sheltered valleys, and some of the high hills (if springs are available for water supply). However, few fences exist, and the distribution of stock during the period of low nutrition, which lasts throughout the dry season, is determined by the occurrence of natural permanent water supplies.

It is doubtful if much can be done at present towards improving the utilization of these tall grass pastures. Growth is so rapid under the hot, humid conditions of the wet season that its control by the concentration of grazing or by other means is most difficult. Two graziers stated that in small areas which had been subjected to heavy intensive grazing they had observed marked vegetational changes and a development of "more desirable grasses of the couch type". However, the type of country was not defined. It is possible that the nutritional standard of these pastures could be maintained at a higher level throughout the wet season by better control of stock, but it is unlikely that such a system, even if desirable results were achieved, could be applied over wide areas. These pastures occur so extensively, relative to the area of pastures capable of providing better feed during the dry season, that only a small proportion could be so controlled. Further, any improvement in the nutritive level could not be expected to last long after the conclusion of the wet season, so that the major problem of the region, namely low nutrition during the long dry period, would be little affected.

There is no general evidence of any effect from over-grazing in these tall grass pastures. In the vicinity of stockyards and on the borders of the sub-coastal plains in the northern section, the perennials have been reduced, in the latter case as a result of the concentration of buffaloes, and the annual weed *Hyptis suaveolens* grows as dense dominating stands. The levees of the major streams are also subject to heavy grazing and in the Daly River basin some patches are dominated by *Aristida browniana.*

The possibility of introduction of other species into the pastures in order to prolong the period of better nutrition has not been fully examined, but, if successful, it would be the most practical method of improving their value. Because of the great extent of these pastures and the difficulties of management under the conditions of their present low economic return, this possibility should be fully investigated.

Sown pasture species in common use in Australia are unsatisfactory for this region, and the introduction of new plants from homoclimes in other countries would be necessary. A small clump of the introduced *Stylosanthes gracilis* was observed to be surviving and growing well on a lateritic soil in a protected garden at Koolpinyah Station, while the annual species *S. sundaica* occurs around Darwin on similar soils and is also established on one farm at Katherine. In the past, efforts to establish such plants have not been on an extensive scale, and many have failed because of the depredations of marsupials. These animals are abundant and are likely to seriously hinder any attempt at pasture improvement.

(2) *Pastures on "Acid" Alluvial Flats and Plains*

Pastures consisting mainly of perennial species of medium height with some shorter perennials, and tall and short annuals, occur on the small "Acid" Alluvial flats and the more extensive "Acid" Alluvial plains. The dominant perennials are *Themeda australis* and *Eriachne burkittii. Alloteropsis semialata, Sorghum plumosum, Coelorhachis rottboellioides,* and *Heteropogon triticeus* also occur. The shorter perennial species include *Ectrosia leporina* and *Eriachne avenacea.* The tall *Sorghum intrans* is the most common annual, but various shorter annuals also are found. Small developments of *Ischaemum* and *Oryza fatua* occur in flats of the Finniss Land System. On some flats the perennial species are absent and dense stands of *Sorghum intrans* are present.

These pastures are seasonally flooded for three to four months each year. By the time the flood waters have receded, the grasses are already near maturity. The plains and most of the flats dry rapidly and the pastures quickly deteriorate. Some of the small flats remain damp and produce sparse, short ground feed for part of the winter if burned early.

As with the tall grass pastures, grazing is not controlled and there appears to be little scope for pasture management. It is possible that introduced grasses such as Para grass (*Brachiaria mutica*) might persist on portions of the plains and on some flats. Such plantings would inevitably be subjected to over-grazing unless protected. On the extensive plains at present grazed mainly by buffaloes this would not be practicable owing to the extreme difficulty of construction and maintenance of fences strong enough to impede these animals.

(3) *Pastures of the Sub-Coastal Plain*

The Sub-Coastal Plain is flooded for six to eight months each year, when a dense growth occurs of water-loving grasses and reeds such as *Oryza fatua, Leersia hexandra, Pseudoraphis spinescens, Hymenachne amplexicaulis, Panicum paludosum,* and *Eleocharis* spp. When the waters recede these plants provide excellent succulent grazing extending for several months into the dry season, and, in damper places, if not over-grazed, throughout the dry season. In the northern sections of the sub-coastal plains, buffaloes exist in large numbers and most of the plains are well grazed by the middle of the dry season. The western sections, where buffaloes are absent, are not so completely utilized. The major part of that section south of the Daly River is set aside as an Aboriginal Reserve and does not appear to be stocked.

There are conflicting opinions regarding the suitability of the northern plains for cattle grazing. Undoubtedly buffaloes are better adapted as they thrive under swampy conditions and are able to forage for feed in the swampy waters. The possibilities of running cattle with buffaloes successfully are questioned by many stock men, and the loss from attacks on cattle by crocodiles is given as an important factor. With the existing restricted outlet for cattle from the region and the prevailing high prices for buffalo hides, the economic return from shooting buffaloes is probably greater than could be expected from grazing cattle. The return per animal varies from £1/10/- to £4 per hide. Should better markets for cattle be established in the future, the possibilities of using these plains in conjunction with the wet season upland pastures for cattle should be considered.

In the western section, where the existence of buffaloes is not a complicating factor, there would appear to be greater scope for the utilization of these pastures for cattle grazing. Cattle are grazed on the section just north of the Daly River and the practice appears to be to burn regularly the fringe of the plain as the waters recede. This fringe is dominated mainly by *Ischaemum arundinaceum* but *Imperata cylindrica* var. *major* (blady grass) grows in many places. Its development here may be a result of excessive burning.

Owing to the deep, annual flooding, the construction and maintenance of fences on an extensive scale on these plains would appear to be impracticable.

(4) *The Blue Grass Pastures*

The pastures of the *deciduous parkland* of the heavy alluvial river flats are dominated by various blue grasses (*Dichanthium* spp. and *Bothriochloa intermedia*) and *Chrysopogon fallax* with some *Ophiuros exaltatus, Eulalia fulva, Arundinella nepalensis,* and some of the grasses of the tall grass pastures. Several pasture legumes, *Moghania* sp. (probably *M. pauciflora*) and *Rhynchosia minima,* are a common feature but do not constitute a large proportion of the pasture. These pastures are not of great extent in the area surveyed, but are important to the properties on which they occur as they maintain their feeding qualities for a longer period and also because, associated with the pastures, are several small trees and shrubs that provide top feed.

(5) Triodia *and* Plectrachne *Pastures*

On the rocky hills, particularly of the Buldiva Land System, *Triodia*-dominant communities occur. Associated with some of these hills are small springs, and during the dry season cattle in small numbers proceed to the hill tops and gorges where they remain throughout the dry season, apparently surviving on the spinifex and the associated grasses. These pastures, however, are mostly rather inaccessible and can only be regarded as a minor form of reserve pasture. They would not warrant the provision of artificial water supplies.

On sandy soils, particularly in the south of the region, *Plectrachne* spp. are sometimes dominant. They form a harsh, sclerophyllous pasture that has value as dry season reserve if near water.

(6) *Miscellaneous Pastures*

In this group are included the small areas of pastures that surround lagoons and line the edges of streams or grow on the sandy seepage slopes and flats adjoining them. While they are not of great extent in comparison with the major pasture types, they have a special value in that, under the more favourable water conditions during the dry season, they continue to produce feed in small quantities when the pastures of the high areas are in poor condition. Many stock depend upon them to carry them through this period. They are of variable composition but *Dichanthium fecundum, Arundinella nepalensis, Pseudoraphis spinescens, Vetiveria pauciflora,* various members of the Cyperaceae, and a number of small annual species are important constituents. Various water plants and reeds occur in permanent water or where floods persist for most of the year.

On the sandy seepage areas *Sclerandrium grandiflorum, Ischaemum arundinaceum,* and *Eriachne burkittii* are associated with *Leptocarpus schultzii* and numerous low plants.

The areas surrounding permanent waters are subjected to heavy grazing and consequent deterioration. However, these pastures usually occur as small units and any attempt at controlled grazing on individual areas would be very difficult.

(*i*) *Timber Resources**

The natural timber resources of the Northern Territory have always been very limited. The trees in the very large areas of savannah woodland are generally unsound, and the occurrence of trees in forest is confined to comparatively small clumps. Before the 1939-45 war, the readily accessible stands of the most useful general-purpose structural timber, cypress pine, were heavily cut over. The concentrations of troops during the war made serious inroads on any timber stands close to the main camps, and even the sounder trees in the savannah woodland were taken. The vast majority of trees now remaining near centres of population are so badly damaged by white ants, fire, and other agencies as to be of little value for structural purposes. Any remaining good stands are situated in such inaccessible localities that the cost of exploiting them is likely to be far greater than the cost of importing suitably treated timber from outside. Nevertheless, against possible future emergencies, these stands have a value. Small communities such as station homesteads can still obtain limited supplies from local resources, but it is likely that the larger centres such as Darwin and Alice Springs will have to depend upon

* Prepared by Dr. M. Jacobs, Australian Forestry School, Canberra.

imported supplies of structural timbers for the time being. It should be possible to organize continuous firewood supplies, and this should be one of the important items in the forest policy of the Territory.

The main commercial timbers are:

(i) *Cypress Pine* (Callitris intratropica).—The wood of this tree is very durable and fairly light and because of this fact it is the most generally useful wood in the Territory. Little remains near centres of population.

The tree occurs naturally in scattered groups on sandy soils over a wide range of elevations. On Bathurst and Melville Islands it occurs near sea-level. On the mainland it is sometimes found on the higher plateaux. It is not clear why the distribution should be so irregular as many soil types in the region look like soils that could support such a non-exacting tree. It may be that its occurrence has been controlled by the regular firing of the savannah by the native population. There is every indication that cypress pine could be grown in the Territory as a forest crop provided the forest could be protected from fire.

(ii) *Ironwood* (Erythrophleum chlorostachys).—This tree produces the main sleeper timber of the Territory. It is a high class hardwood, but very hard and very heavy. Unfortunately, the tree is thinly scattered through the savannah forest. In 1933 it was estimated that this species would have to be completely exploited in the savannah woodland for three miles on each side of a railway line to supply one set of sleepers for the line.

Ironwood trees are usually sound. There is good reason to experiment with the production of this valuable tree as a crop. It is a legume. The seed is large and easily collected. From its appearance, the tree should grow in plantations. The only indication of rate of growth obtained in a reconnaissance in 1933 was that trees 12 inches in diameter on the ramparts of Fort Dundas must be less than 110 years old.

(iii) *Paper Bark* (Melaleuca leucadendron).—Fairly extensive forests of *Melaleuca* occur on the coastal flood plains of the major rivers, especially between the Adelaide and the three Alligator Rivers. Should an extensive emergency timber supply be required in the Territory regardless of cost, paper bark represents the most likely supply. Expense of working the forests is likely to limit exploitation in normal times.

Paper bark trees are usually sound. The wood tends to twist during seasoning but otherwise it is a useful hardwood. It is the only timber in the Northern Territory that could be supplied in millions of super feet if the problem of access and extraction could be overcome.

(iv) *Red Gum* (Eucalyptus camaldulensis).—This tree grows along the watercourses of inland streams from and including the Daly River system. It is a useful inland hardwood which should be judiciously protected, exploited, and regenerated. If the inland watercourses are kept well lined with red gums a useful emergency timber supply will be maintained in difficult country.

(v) *Savannah Eucalypts.*—Although the eucalypts are such a feature of the vegetation of the Northern Territory, they are disappointing as a source of structural timber owing to the ravages of white ants. When sound the wood of any species is useful. Sound wood is most commonly obtained from the following species: *E. nesophila* (Bathurst and Melville Islands), *E. alba, E. tetradonta, E. bleeseri, E. confertiflora, E. patellaris,* and *E. microtheca.*

(vi) *Jungle Trees.*—During the 1939-45 war most of the tree species mentioned under "monsoon forests" in the section on plant communities were exploited in a mill established at the Black Jungle near the Adelaide River. Before the war the most prized jungle timber was Leichhardt pine (*Nauclea orientalis*), which was used for pearl shell crates. Little jungle remains in accessible areas.

(vii) *Sandalwood.*—The sandalwood trade was one of the earliest trades between north Australia and the countries around it. The trade was prohibited in the Northern Territory during the depression. A small trade in sandalwood could be developed.

(viii) *Lancewood* (Acacia *sp.*).—Thickets of lancewood in the Daly Waters area proved a useful source of poles for constructional work during the 1939-45 war. These thickets should be preserved and if possible treated to provide a continuous supply of poles in this area.

Forest Policy.—Extensive forest operations cannot be envisaged in the Northern Territory. However, skilled attention should be given to the following points:

(1) Even in the tropics, firewood is usually an essential commodity for human comfort. If continuous supplies are to be assured, organized work on the production of wood for fuel will be necessary near the larger centres of population.

(2) Cultivation of cypress pine.

(3) Experiments with the growth of ironwood and useful jungle timbers such as Leichhardt pine.

(4) A study of the possible utilization of paper bark as this represents the most likely immediate source of local timber supply on an extensive scale.

(5) Perpetuation of red gum on inland rivers.

(6) A study of lancewood thickets, sandalwood, and fodder trees.

III. Description and Potentialities of the Land Systems

(*a*) *General*

The seven Geomorphological Units of the region have been divided into 19 land systems differentiated according to the definition given in Section I (*g*). A map showing the distribution of the Land Systems accompanies this report and a summary of their main characteristics is given on page 151. Table 7 summarizes the land form characteristics of each land system.

TABLE 7

LAND FORM CHARACTERISTICS OF THE LAND SYSTEMS

Geomorphological Division	Land System	Area (sq. miles)	Geology	General Topography
Northern Lateritic Plain	1. Charles Pt.	335	Lateritic formation on shales, some sandstones, and limestones (Mullaman and Port Keats Groups)	Gently undulating plains
	2. Koolpinyah	3,810	Lateritic formations on shales (Mullaman Group), metamorphics (Brocks Creek Group), and granite	Gently undulating plains
	3. Bynoe	280	Lateritic formations on shales (Mullaman Group), metamorphics (Brocks Creek Group), and granite	Variable
Elevated Lateritic Residual	4. Mullaman	415	Lateritic formations on shales (Mullaman Group); underlying geology variable	Flat-topped tableland, bordered by steep dissection slopes
Elevated Backbone	5. Brocks Creek Ridge	1,560	Metamorphics of Brocks Creek Group	Sharp ridges and hills
	6. Brocks Creek Foothill	2,340	Metamorphics of Brocks Creek Group	Low hills and small flats
	7. Brocks Creek Undulating	300	Metamorphics of Brocks Creek Group	Undulating with scattered hills and flats
	8. Batchelor	300	Metamorphics of Brocks Creek Group	Hills, undulating, and small flats
	9. Cullen	1,360	Granite	Hills and undulating plain
	10. Buldiva	2,750	Sandstones, quartzites, conglomerates (Buldiva Quartzite)	Rocky hills, gorges, scarps, some gentle slopes and alluvial washes

TABLE 7 (*Continued*)

Geomorphological Division	Land System	Area (sq. miles)	Geology	General Topography
Elevated Backbone	11. Volcanics	42	Basic volcanics, probably Lower Cambrian	Low hills and gentle slopes
Daly River Basin	12. Tipperary	6,890	Sandstones, limestones, some shales (Daly River Group)	Undulating with stony outcrops
Western Fault Block Plains	13. Litchfield	830	Granite	Mostly gently undulating with few scattered hills
	14. Elliott Creek	400	Interbedded shales, limestones, sandstones (Elliott Creek Formation)	Gently undulating plains
	15. Moyle	190	Sandstones, limestones, shales of Port Keats Group	Gently undulating plains
Flood Plain Alluvia of Northern Rivers	16. Marrakai	680	Quaternary flood plain alluvia with occasional residual rises derived mainly from metamorphics (Brocks Creek Group) and granites	Nearly flat, liable to shallow seasonal flooding, with scattered ridges
	17. Finniss	360	Quaternary flood plain alluvia as above mixed with considerable areas of residual rises of metamorphics of Brocks Creek Group	Low hills interspersed with flats
Estuarine Alluvia	18. Sub-Coastal Plain	2,650	Quaternary estuarine alluvia	Flat plains liable to deep seasonal flooding
	19. Littoral	840	Estuarine alluvia still liable to tidal inundation with minor areas of resorted beach deposits and laterite-capped cliffs	Beaches, and salt and mud flats liable to tidal flooding with small areas of sand dunes and laterite-capped cliffs

In addition, there are 850 sq. miles of mixed Brocks Creek Foothill and Marrakai Land Systems.

The boundaries of a land system are determined by the pattern of topography, soils, and vegetation. One geomorphological unit may be subdivided into several land systems, but a land system boundary will rarely extend beyond the boundaries of a single geomorphological unit. There is no such instance in this region. Thus the country enclosed by a land system has a common origin and the soil and vegetation characteristic of the topographic units which combine to form the land system are likely to remain reasonably constant throughout its area.

It is possible, therefore, to construct a typical cross section of a land system showing the major topographic units it includes, together with details of their soils, vegetation, etc. Such a cross section summarizes the character of the country within the land system. Cross sections of this nature (Figs. 5-22) are included for 18 land systems and can be used as a quick guide to their general characteristics. The topographic units commonly occur in the order shown but *not* necessarily so. Summary information is given for each unit with respect to relative area, geomorphology and geology, soils, and vegetation. In some cases a unit may be repeated in a cross section to show its relationships to a number of other units. In such cases the relative area is indicated once only. A cross section for the very small Volcanics Land System (No. 11) is not included.

For each land system, information is given under the following headings: Location, Extent, Topography, Geology and Geomorphology, Soils, Vegetation, Rainfall, Natural Water Supply, Accessibility, Present Land Use, Agricultural Prospects, and Pastoral Prospects. The first eight describe the origin and nature of the inherent land characteristics which, with the possible exception of the vegetation (which may be subject to change in normal occupation), can be expected to be of reasonably permanent nature. The remaining headings concern land utilization and development possibilities which depend upon the inherent land characteristics (natural resources), stage of regional development with respect to such things as communications, etc., present knowledge of crop, pasture, and animal production, and economic factors. The last three are factors liable to change, hence it is impossible to give a precise final assessment of development possibilities. For example, all the more extensive natural pasture types within this region surveyed are of low nutritive value for a large part of the year and the development of the cattle industry is primarily limited by this factor. At the present time, there is no method whereby these pastures can be practically and economically improved over large areas, and the present assessment of potentialities is influenced by this fact. It is not inconceivable, however, that investigation could find superior exotic species which could be economically established and maintained by suitable management, even under these extensive methods of land use. Should this prove to be the case, the practical potentialities of the cattle industry could be materially altered.

This possibility of change in use of resources resulting from advances in our knowledge, together with the facts that there have been little previous agricultural investigation and development in this region, and that there are few, if any, places in the world where similar resources have been developed by white labour, means that potentialities can be described only in broad terms. Fields of investigation that might lead to an increase in potential productivity are indicated in Sections V and VI, but no special attention has been paid to the changeable economic factors that might influence their application.

For uniformity, the names adopted for the land systems follow geological nomenclature wherever possible, but this has not been practicable in all cases, especially where one geological group has been subdivided. In such cases, the appropriate locality names have been adopted for the systems with the exception of two widely dispersed systems, namely the Sub-Coastal Plain and Littoral Land Systems.

(*b*) *The Land Systems*

(1) *Charles Point Land System* (Fig. 5)

Location.—This system forms a broken strip occupying some of the north-west coastal portion of the region, and an isolated area to the west of the Wildman River estuary.

Extent.—335 square miles.

Topography.—A gently undulating plain, up to 200 ft. above sea-level which, where it extends to the coast, forms a low laterite-capped cliff (Plate 15, Fig. 2). The widely spaced watercourses are generally small and have a broad dendritic pattern. They traverse irregular flats liable to seasonal flooding which themselves probably constitute the major drainage outlet. Occasionally these flats have lagoons which are the focal points of small internal drainage areas.

Geology and geomorphology.—This land system is part of the Northern Lateritic Plain, and, as such, is a relic of the Tertiary land surface with little apparent modification. The underlying rocks are shales of the Mullaman Group and mixed sediments of the Port Keats Group. The low elevation of these plains, the permeable nature of the soils, and existence of a senile Tertiary drainage system of broad flats have permitted adequate drainage without active erosion except at the margins. Where dissection has encroached laterally, resistant lateritic horizons have delayed it and given rise to the short, steep dissection slopes of the Bynoe Land System.

Soils.—The Point Blaze occurrence is almost exclusively Tertiary Lateritic Red Earth soil. In the remaining areas, the major soils of the upper undulations are Tertiary Lateritic Red Earths with smaller areas of Tertiary Lateritic Podsols. Minor areas of flats have Tertiary Lateritic Flat soils.

Vegetation.—With the exception of the flats and the small portion of the system near the Wildman River, the Lateritic Red Earths are covered with *tall open forest,* dominated by *Eucalyptus miniata* and *E. tetradonta* with *Cycas media* prominent in the understorey. In the Wildman River section, the tall forest species are less common and there occurs a community consisting mostly of lower trees such as *Eugenia suborbicularis, Livistona humilis, Acacia* spp., *Gardenia* spp., with scattered trees of *Eucalyptus papuana; E. porrecta,* and *Alstonia actinophylla.*

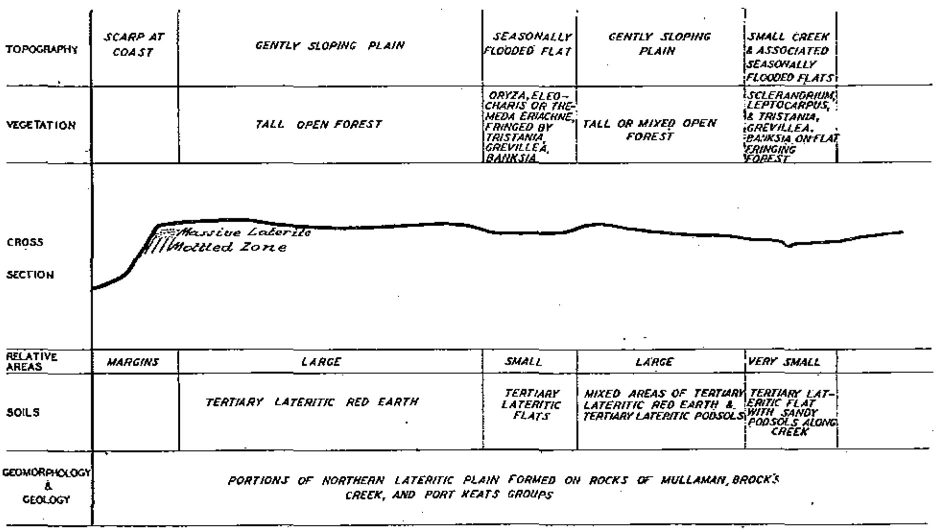


Fig. 5.—Cross section and summary of characteristics of Charles Point Land System.

The vegetation of the flats is similar to those of the Koolpinyah Land System, in which they are more common.

Rainfall.—Mean annual rainfall—60 in.

Mean length of season of adequate rainfall—20 weeks.

Mean time of commencement—November 21.

Natural water supply.—Apart from a few isolated lagoons and creeks, this system lacks surface water supplies during the dry season, and there are no prospects for other than very small-scale irrigation. Those portions near Fog Bay and Anson Bay are reasonably accessible from portions of the Sub-Coastal Plain Land System and its lagoons.

Accessibility.—The portions of this system on Cox's Peninsula and those near Darwin are accessible by all-weather roads. The distance by road from Darwin to Charles Point is approximately 100 miles. The sea route, however, is much shorter. The areas near Fog Bay and north of Anson Bay are inaccessible by road at present but could be served by sea transport. The small portion of this system near the Wildman River is not accessible during the wet season.

Present land use.—With the exception of the Wildman River section, where buffaloes graze, this system carries very few stock at the present time. In the Berrimah area there have recently been started a few small market gardens irrigated from the Manton Dam pipe line, and at Charles Point crops of peanuts have been produced in the past on a very small area near the lighthouse.

Agricultural prospects.—The low fertility of these soils, together with the relatively high costs that would be involved in clearing, will discourage any major agricultural development. However, as these areas occur in the region of higher rainfall, and some of the soils are reasonably deep, they could be used for special purposes that warrant the costs of clearing and application of adequate fertilizer. At the present time there does not appear to be any exportable product justifying special attention.

Pastoral prospects.—The tall grass pastures common to this land system are rank and of low nutritive value for the greater part of the year. Their natural carrying capacity is low and is not likely to be materially increased other than by the introduction of exotic species. At present there are no proved species available for this purpose but the possibilities of *Stylosanthes* spp. and *Arachis* spp. should be examined and the search for others continued. The suspected poisonous plant *Cycas* occurs commonly in this land system.

(2) *Koolpinyah Land System* (Fig. 6)

Location.—This system occurs across the northern part of the region as four main areas separated by the four major northern rivers, the Adelaide, Mary, and South and East Alligator.

Extent.—3,810 square miles.

Topography.—The topography is gently undulating like the Charles Point Land System but the flats liable to seasonal flooding form a larger proportion of the total area.

Geology and geomorphology.—This system is also part of the Northern Lateritic Plains but has been formed mostly on metamorphics of the Brocks Creek Group with only a small area formed on shales of the Mullaman Group. The general lack of dissection can be attributed to the same factors as operate in the Charles Point Land System. Dissection is encroaching from the south but as with the Charles Point Land System it is being delayed by resistant lateritic horizons.

Soils.—Whereas in the Charles Point Land System the major soils of the gentle undulations are Tertiary Lateritic Red Earths, in this system the most extensive soils are Tertiary Lateritic Podsols with smaller areas of Tertiary Lateritic Red Earths and, in the depressions liable to seasonal flooding, Tertiary Lateritic Flat soils (Plate 15, Fig. 1). The boundary between these two land systems is not sharp.

Vegetation.—Except for the depressions and their margins, the whole of this system is covered by rather dense *tall open forest* of *Eucalyptus* *miniata* and *E. tetradonta* in which the understorey commonly includes *Eucalyptus porrecta, Livistona humilis, Cycas media, Eugenia suborbicularis,* and *Erythrophleum chlorostachys.* The perennial grass flora, which includes *Heteropogon triticeus, Alloteropsis semialata,* and *Eriachne triseta,* is not dense. The tall *Sorghum intrans* and numerous small annual grasses are common.

The depressions in this system more usually carry permanent or semi-permanent lagoons in which *Eleocharis dulcis* and *Pseudoraphis spinescens* are the dominant species. In some places the lagoons are fringed by *Pandanus* and sometimes by rather dense communities of *Melaleuca symphyocarpa.*

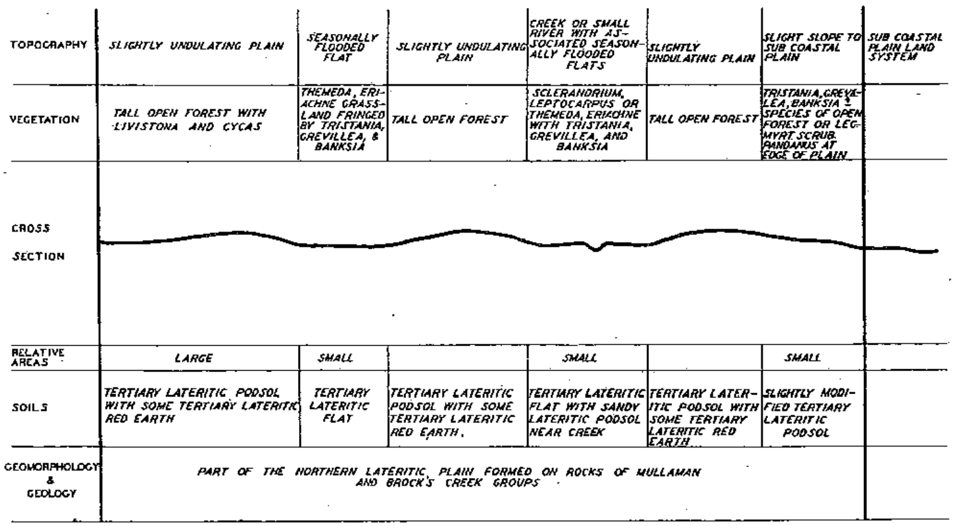


Fig. 6.—Cross section and summary of characteristics of Koolpınyah Land System.

Surrounding the permanent water are grassed flats carrying *Pseudoraphis spinescens* and tussocks of *Vetiveria pauciflora.* In some places these are replaced by annual *Sorghum intrans.* On the more sandy phases *Leptocarpus* and *Sclerandrium* dominate.

Between these grassy flats and the *open forest* of the lateritic soils is a narrow modified soil zone which carries various phases of the *Tristania-Grevillea-Banksia* community. Within this, *Metrosideros eucalyptoides, Eucalyptus papuana, E. alba, Eugenia suborbicularis,* and *Melaleuca* spp. (often dense *M. symphyocarpa*) also occur. The dominant grass is *Eriachne triseta,* sometimes replaced by the annual weed *Hyptis suaveolens.* On some larger occurrences of this modified lateritic soil the vegetation consists mainly of the *Leguminous-Myrtaceous scrub.*

In those sections where the lateritic plain protrudes into the Sub-Coastal Plain a narrow fringe of *Pandanus* occurs at the edge, backed by a narrow belt of the *Tristania-Grevillea-Banksia* community.

Small patches of *monsoon forest* may occur at the head of spring-fed streams and occasionally on modified lateritic soils.

Rainfall.—Mean annual rainfall—55-60 in.

Mean length of season of adequate rainfall—20 weeks.

Mean time of commencement—November 21.

Natural water supply.—The southern portion of the western section is well supplied with small streams and scattered lagoons, but in the north of this section there are lagoons only. The remaining sections have a few isolated lagoons and, very infrequently, small spring-fed creeks around the margins. The northern undulating portions are supplied with stock water from sources on the Sub-Coastal Plain. All the flats within the system are seasonally flooded.

Accessibility.—The western section, which lies between Darwin River and the mouth of the Adelaide River, is readily accessible, although the northern sections may be cut off by road for periods during the wet season. The portions between the northern rivers are inaccessible except during the dry season.

Present land use.—The major portions of this system adjoin the Sub-Coastal Plains and are grazed with them either by buffaloes or cattle.

Agricultural prospects.—The soils are generally of low fertility, and are fairly heavily timbered. Although in areas of higher rainfall, the extremely leached soils make this land system even less attractive agriculturally than the Charles Point Land System.

Pastoral prospects.—These are similar to those of the Charles Point Land System.

(3) *Bynoe Land System* (Fig. 7)

Location.—The largest area occurs east of Fog Bay, but there are smaller areas along the coastal fringe as far north as Darwin.

Extent.—280 square miles.

Topography.—East of Fog Bay there are sections of a much broken plain, up to 200 ft. above sea-level, intersected by narrow valleys edged by steep breakaway slopes, and draining to the estuarine plain or directly to the sea. In the northern occurrence the topography consists of broken dissection slopes leading from the laterite "breakaway" down towards sea-level.

Only small streams occur. They are usually steeply graded but, near the lower margins of the land system where they approach base level, some alluvial flats occur. The generally dendritic stream patterns are of moderate intensity.

Geology and geomorphology.—This land system consists of parts of the Northern Lateritic Plain that have suffered some dissection. The underlying rocks vary and may be shales of the Mullaman Group, metamorphics of Brocks Creek Group, or Litchfield Granite. In general, dissection has not gone below the lateritic profile except in the northern parts near Darwin, where the underlying rocks have been exposed in many places.

Soils.—The soils of dissected lateritic areas are described in Section II (*f*). They may be grouped as:

(*a*) Tertiary lateritic soils of residuals.
(*b*) Gravelly soils with massive laterite of the breakaway.
(*c*) Gravelly soils of lateritic dissection slope.
(*d*) Soils formed on exposed underlying rocks.

Vegetation.—On the residual lateritic areas the common plant community is *palm scrub,* with various modifications intermediate between this and *open forest,* but with a concentration of the second storey species rather than the taller trees. Some of these communities are extremely stunted in appearance, sometimes with *Acacia* spp. dominant. Small scattered patches of *monsoon forest* occur.

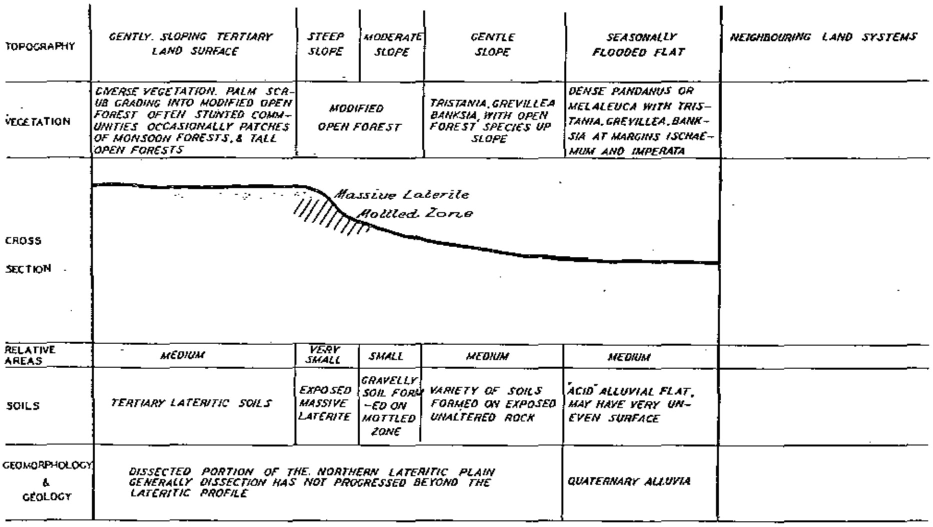


Fig. 7.—Cross section and summary of characteristics of Bynoe Land System.

In the valley floors, belts of *Pandanus,* or less often, tall *Melaleuca* occur, lining the drainage channels. Sometimes these grade into *mixed fringing forest.* Bordering this there usually are rather open phases of the *Tristania-Grevillea-Banksia* community with *Ischaemum arundinaceum* and *Imperata cylindrica* var. *major* occurring more commonly than is usual in this community.

On the slopes of the dissection areas various modifications of the vegetation of the residual areas occur.

Rainfall.—Mean annual rainfall—55-60 in.

Mean length of season of adequate rainfall—20 weeks.

Mean time of commencement—November 21.

Natural water supply.—The lower-lying sections of the system are liable to flooding during the wet season and some portions have small, semi-permanent creeks with scattered permanent or semi-permanent lagoons. Some sections are close to portions of the Sub-Coastal Plain on which surface water persists in some areas throughout the year. The higher portions of the system have no water supply.

Accessibility.—The major portion of this area between Mt. Finniss and the west coast is inaccessible during the wet season, and can be reached only by traversing rough country without roads in the dry season. The smaller northern portions occur at the edge of the Northern Lateritic Plain, and are easily accessible.

Present land use.—These areas are virtually not used except for spasmodic grazing. Parts of the Fog Bay section are included in the Wangites Aboriginal Reserve.

Agricultural prospects.—Except for small, isolated areas of alluvial soils in the valleys or flats where small creeks occur, the soils are not suited to agriculture.

Pastoral prospects.—This system is of very minor pastoral value, which is not likely to be materially modified.

(4) *Mullaman Land System* (Fig. 8; Plate 10, Figs. 1 and 2)

Location.—Scattered small occurrences along the north-west-south-east diagonal divide, with some areas in the south and south-west of the region.

Extent.—415 square miles.

Topography.—Flat-top tablelands edged by vertical breakaways and steep slopes. Small depressions with lagoons occur in some places on the larger tablelands only.

Geology and geomorphology.—These mesa-like Elevated Lateritic Residuals are formed on shales of the Mullaman Group. Resistant lateritic horizons form the cap-rock, which has been the major factor in preserving these tablelands in spite of considerable dissection in the surrounding country. On the lower part of the dissection slopes, underlying arenaceous sediments of the Mullaman Group, or rocks of the Brocks Creek Group, Buldiva Quartzite, Daly River Group, or Cullen Granite, may be exposed.

Soils.—On small table-tops the soils are shallow, very gravelly, sandy loams. Mt. Tolmer Tableland and possibly other larger table-tops have extensive areas of Tertiary Lateritic Red Earth and minor areas of Tertiary Lateritic Flat soil as in the Charles Point Land System. Dissection slopes have many outcrops and shallow skeletal soils which vary with the nature of the parent rock.

Vegetation.—The flat table-tops are mainly covered with *tall open forest* in which *Livistona humilis* and sometimes *Calytrix* spp. are prominent. On the slopes *mixed open forest* occurs, with some communities which tend towards *deciduous open forest* on the steeper portions.

The flats which may occur at the base of these tablelands sometimes have small running streams lined with *Pandanus aquaticus.* They sometimes pass through small patches of *monsoon forest.* The gentle slopes from the streams carry *parkland.* The *monsoon forests* also develop to a small extent on some of the sheltered slopes of the tablelands just below the cap rock.

Rainfall.—This system is widely distributed throughout the whole range of rainfall conditions of the region. As individual sections are of small extent and are not considered to have any great developmental prospects, details of rainfall are not given.

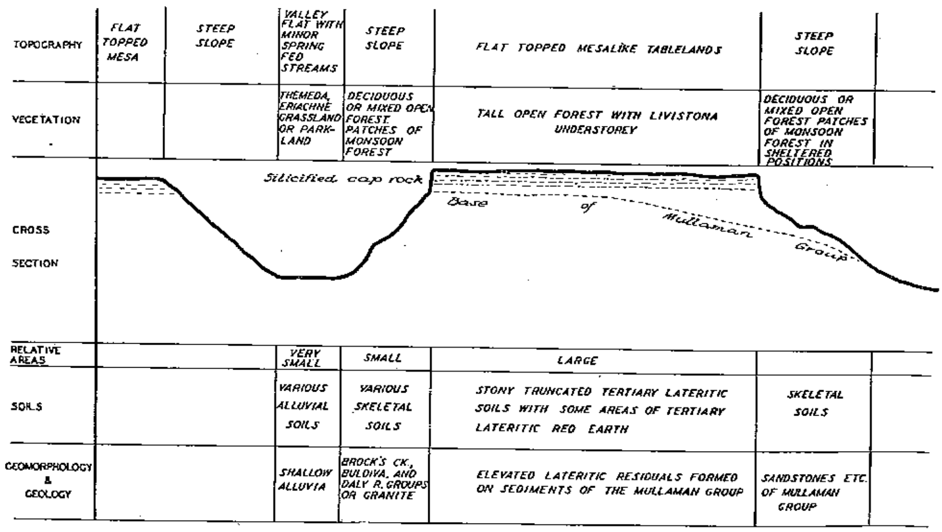


Fig. 8.—Cross section and summary of characteristics of Mullaman Land System.

Natural water supply.—The flat tops rarely have any form of permanent surface water and most of the streams rising at the base of the steep slopes are seasonal. In a few of them permanent flow is maintained by small springs.

Accessibility.—The table-tops can generally be reached only by a steep climb of over 100 ft. Accessibility to the slopes and undulating portions is relatively easy, as they are nearly all within 15 miles of good roads, except those in the very isolated area south of the mouth of the Daly River.

Present land use.—Many of these tablelands are not used for any purpose but cattle may graze on the more accessible ones.

Agricultural prospects.—This system offers no agricultural prospects. The soils of the small table-tops and slopes are shallow and very stony, and the lateritic soils of the undulating areas and larger flat tops are of low fertility. Combined with their inaccessibility this renders them unsuitable for agriculture.

Pastoral prospects.—The table-tops carry poor quality medium tall and tall pasture which could be put to only minor pastoral uses.

(5) *Brocks Creek Ridge Land System* (Fig. 9; Plate 1, Fig. 1)

Location.—This land system comprises units scattered throughout the diagonal divide extending from Edith River to the north-west coast with an extension south over the Daly River.

Extent.—1,560 square miles.

Topography.—Mainly north-south ridges up to 600 ft. or more in height with steep slopes and generally sharp crests, dissected by numerous small, immature creeks showing marked structural control in steep valleys with small, narrow alluvial flats associated with local changes in grade.

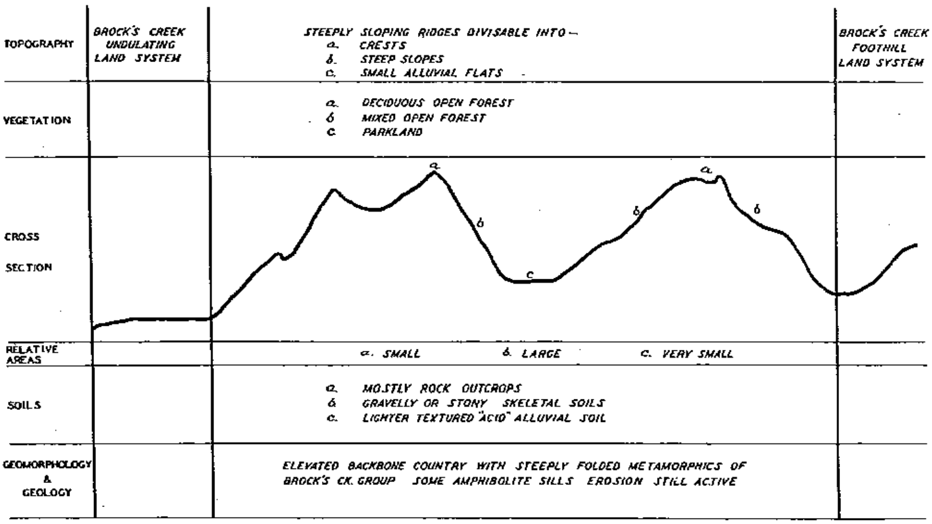


Fig. 9.—Cross section and summary of characteristics of Brocks Creek Ridge Land System.

Geology and geomorphology.—The system is formed on metamorphics of the Brocks Creek Group in the Elevated Backbone Country. Dissection of the uplifted peneplain formed on folded rocks has produced these ridges, their north-south orientation being due to selective erosion of softer beds along the strike of these folds. Erosion is active and there is little or no accumulation of soil on slopes. This land system is differentiated from the following two land systems by reason of its steep topography, active erosion, and lack of soil accumulation.

Soils.—The major soils are very gravelly sandy loam and skeletal soils formed on metamorphics of the Brocks Creek Group. Minor areas of amphibolite give stony brown loam skeletal soils. The small alluvial flats have soils similar to the flats described in Brocks Creek Undulating Land System.

Vegetation.—On the highest ridges *deciduous open forest* develops while the lower ridges and slopes are covered by *mixed open forest.* The understorey is rarely prominent, but ironwood (*Erythrophleum chlorostachys*) occurs commonly on the slopes. *Scrubby open forest* does not occur.

Rainfall.—As this system extends for a distance of over 100 miles from north to south, rainfall conditions vary considerably.

Mean total annual rainfall—40-60 in.

Mean length of season of adequate rainfall—16-20 weeks.

Mean time of commencement—November 20 to November 31.

Natural water supply.—Flooding during the wet season is confined to the narrow flats. In the dry season the surface water supply is poor and consists only of small isolated lagoons in the flats and, very rarely, springs. The Manton Dam, which supplies Darwin, is situated in this ridge country. Other small catchment areas could probably be found if necessary.

Accessibility.—As the various sections of ridge country are distributed over wide areas, it is not possible to generalize on accessibility but the country is very difficult to traverse by motor vehicle except along the broad valleys or when roads have been prepared.

Present land use.—This type of country is either not utilized or carries cattle at low rates of stocking and is used for this purpose in conjunction with land of other systems. Agriculture is restricted to the use of very small areas of alluvial soil along the main north-south road for vegetable growing, and to the small settlement on the levee of the Daly River near the Daly River Police Station. Peanuts are the main crop but vegetables are also grown and one farmer grows and manufactures tobacco.

Agricultural prospects.—Because of the steep slopes and shallow, stony soils, the ridges themselves are useless for agriculture. The flats associated with them may possibly be cultivated, but are generally small and isolated and the soils are of low-moderate fertility, liable to irregular flooding, and lack water for irrigation. A quite atypical development is the small area of deep alluvial soil on Hayes Creek near the main road. This area was a successful Army farm during the war and a portion of it is now being used for vegetable production. At Coomalie Creek, 18 miles north of Adelaide River, the stream cuts through a narrow ridge. Above and below the gap are other small areas of alluvial soils which were also used as a vegetable farm. Such areas are not common and are due to fortuitous topographic features.

The limited areas of soils not liable to flooding on the levee of the small section of the Daly River passing through this land system are almost fully occupied in a low-standard agriculture.

Pastoral prospects.—The tall grass pastures of this land system are naturally low in stock carrying capacity and in particular provide little feed during the dry season, other than on some protected slopes and gullies and near springs.

There does not appear to be much prospect at the present for the economic improvement in the potential stock carrying capacity of this type of country. Better pasture species might be introduced into some of the flats but as these are small and isolated, they could not be protected from over-grazing and the species are unlikely to survive. For these reasons, together with the rough nature of the country and the general lack of permanent natural waters, its total carrying capacity is not likely to be high.

(6) *Brocks Creek Foothill Land System* (Fig. 10; Plate 3, Fig. 1)

Location.—Extensive areas of this land system occur in the central and north-central part of the region.

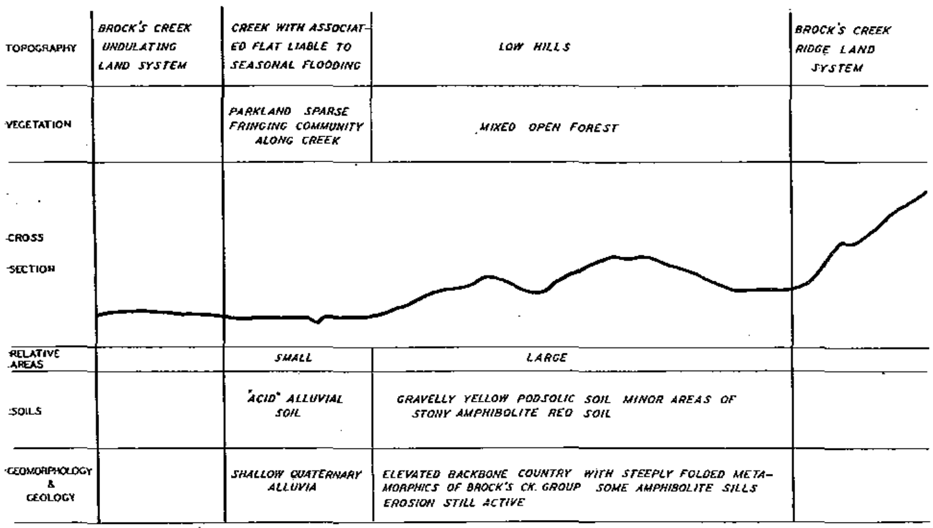


Fig. 10.—Cross section and summary of characteristics of Brocks Creek Foothill Land System.

Extent.—2,340 square miles.

Topography.—Low hills up to 50 ft. in height above the surrounding terrain, with steep to moderate slopes but more rounded than the ridges. They are similarly dissected by numerous structure-controlled creeks with small alluvial flats.

Geology and geomorphology.—As for Brocks Creek Ridge Land System, but erosion has reached a more advanced stage. The range of relief is less and there has been greater accumulation of soil on the more gentle slopes.

Soils.—Gravelly Yellow Podsols are the dominant soils of the slopes with minor areas of stony Amphibolite Red soil. Soils of the alluvial flats are similar to those in Brocks Creek Undulating Land System.

Vegetation.—The hills and slopes are covered with *mixed open forest.* The vegetation of the flats is described under Undulating Country.

Rainfall.—As for Brocks Creek Ridge Land System.

Natural water supply.—As for the Brocks Creek Ridge Land System.

Accessibility.—This unit also covers widely separated areas. While it is more easy to travel through than the ridge country, it is in many places associated with the ridges and therefore accessibility is governed by their occurrences to a great extent.

Present land use.—Cattle are grazed at a low rate of stocking. The section associated with the "bull-dust" plains is grazed partly by buffaloes.

Agricultural prospects.—The shallow, stony podsols of the foothills are unsatisfactory for agriculture. The small flats associated with them, like those of the ridge country, may be flooded for short periods, and their agricultural possibilities are slight. The Amphibolite soils of this land system are more attractive, but do not occur as large areas and usually lack water for irrigation.

Pastoral prospects.—Apart from the fact that this country is slightly less difficult to manage, the pastoral prospects are no better than those of the Brocks Creek Ridge Land System.

(7) *Brocks Creek Undulating Country* (Fig. 11)

Location.—Two small areas near and south of Fountain Head, a smaller area east of the Mary River, and another near the Reynolds River.

Extent.—300 square miles.

Topography.—Undulating or gently undulating, adjacent to and partially surrounded by foothill or ridge country. Up to 10 per cent. of the total area is occupied by alluvial flats associated with the moderately intense dendritic drainage system. Very low hills and gravelly rises occur infrequently throughout. Tall termitaria of *Eutermes* are a common feature of the lower undulating country.

Geology and geomorphology.—In these parts of the Elevated Backbone Country formed on the metamorphics of the Brocks Creek Group the geomorphic cycle has reached a stage where, in general, soil formation is in equilibrium with erosion, thus much of the influence of geological structure on stream pattern is lost. Erosion is still active on the stony rises and there is some alluvial deposition on the flats.

Soils.—Yellow Podsolic soils occupy the greater part of this land system. Flats have light-textured "Acid" Alluvial soils, and the low hills have immature, stony Yellow Podsolic soils. Minor areas of Amphibolite Red soil and Heavy-Textured Grey Pedocals occur where basic intrusive rocks are the parent material.

Vegetation.—On the Yellow Podsolic soil of the undulating country the "Orchard" type of *low open forest* predominates with small patches of *mixed open forest* on the Gravelly Yellow Podsolic soils of the low rises. The grass flora consists of rather dense stands of mixed tall and medium tall perennial grasses with *Themeda* and *Sehima* prominent.

The alluvial flats carry *parkland* with either *Eucalyptus papuana* or *E. apodophylla* and occasionally *E. grandifolia* dominant, and with *Themeda australis* as the dominant grass.

Rainfall.—Mean total annual rainfall—45-55 in.

Mean length of season of adequate rainfall—18 weeks.

Mean time of commencement—November 26.

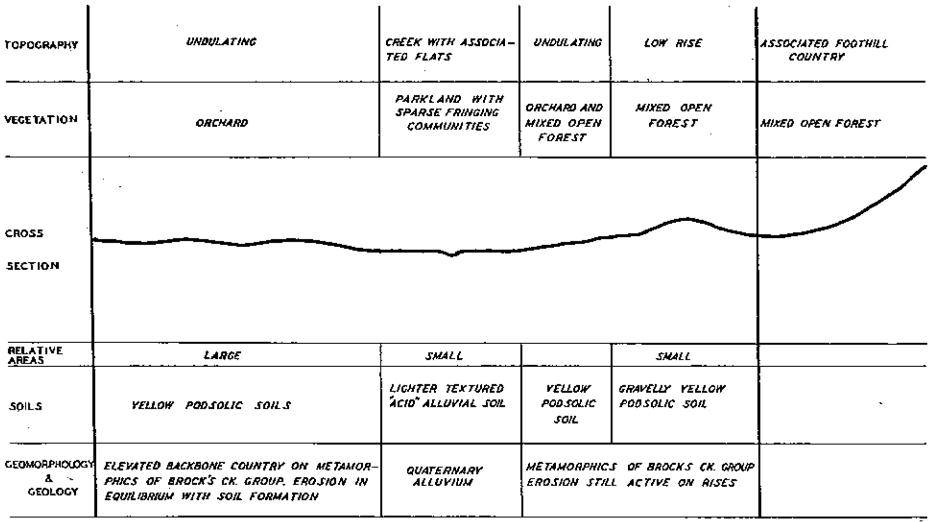


Fig. 11.—Cross section and summary of characteristics of Brocks Creek Undulating Country.

Natural water supply.—The undulating country is traversed by small creeks, most of which cease to flow during the dry season. Some permanent or semi-permanent billabongs occur in these creeks.

Accessibility.—This country is quite easy to traverse and lies mostly near the north-south highway.

Present land use.—Cattle are grazed at low stocking rates in conjunction with other systems.

Agricultural prospects.—The Yellow Podsolics and Gravelly Yellow Podsolics of low to low-moderate fertility examined are not attractive agriculturally. Amphibolite Red soils occur only as small, scattered areas. The flats associated with the creeks and drainage areas are slightly more extensive than in the ridges and foothills, but are subject also to slightly heavier flooding. Near Grove Hill a small area of Levee soil occurs on Yam Creek and was once cultivated. Such occurrences are rare.

Pastoral prospects.—Although the pastures of this undulating country are generally denser than those of the ridges and foothills, their value as stock feed is even lower. Topographically, this land system is better suited to improved management than the two preceding ones but the poor nature of the soils and the lack of better pasture species of proved value make pasture improvement impractical at present and are major obstacles to increased production.

(8) *Batchelor Land System* (Fig. 12)

Location.—This constitutes an irregular area west of the main road extending north from Adelaide River beyond the Manton Dam, with a small area 20 miles south of Adelaide River township.

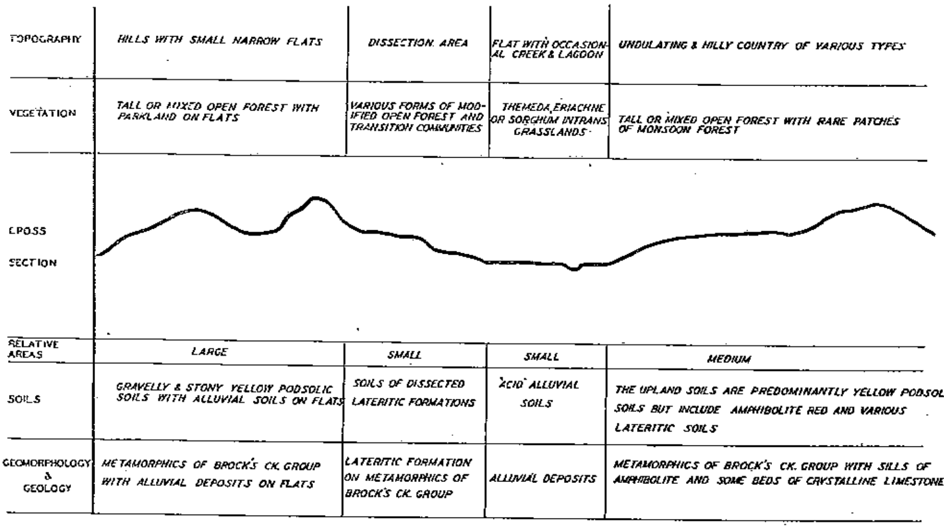


Fig. 12.—Cross section and summary of characteristics of the Batchelor Land System.

Extent.—300 square miles.

Topography.—Mixed undulating country and low hills with some flats. The type and intensity of drainage pattern varies but most of the streams are small.

Geology and geomorphology.—This is a variable area in which several of the major land systems are intimately intermixed, and of which the separate units are too small or too irregular to be mapped separately by a reconnaissance survey.

Most of the area consists of various metamorphics of the Brocks Creek Group with some small amphibolite intrusions and hard crystallized limestone, but remnants of the Tertiary lateritic land surface also occur in this irregularly dissected region.

Soils.—The system contains a wide range of soils. Stony Yellow Podsolic soils on low hills appear to be most extensive. Yellow Podsolic soils, Amphibolite Red soils, Tertiary Lateritic Red Earths, Tertiary Lateritic Podsols, Soils of Dissected Lateritic Formations, and "Acid" Alluvial soils also occur, but none in areas of large extent.

Vegetation.—For the reasons indicated above the vegetation of this land system is variable. It consists mostly of types of *open forest* on the higher ground with practically no development of *scrubby open forest.* The flats within the land system in general correspond to the smaller flats of the Brocks Creek Systems. Small patches of *monsoon forest* occur, e.g. at Rum Jungle.

Rainfall.—Mean annual rainfall—55 in.

Mean length of season of adequate rainfall—20 weeks.

Mean time of commencement—November 21.

Natural water supply.—Several small creeks rise in or flow through this land system. A few are permanent but otherwise most of the system lacks surface water except for scattered lagoons on the flats between the hills.

Accessibility.—This system occurs mainly near the main north-south road and is generally accessible, although portions of it include rough hills, difficult to traverse.

Present land use.—There are two small vegetable farms in this system, one on the site of the old Batchelor Demonstration Farm. The remainder of the land system is not used or is grazed by cattle spasmodically.

Agricultural prospects.—The hills and steep slopes of the system have no agricultural prospects. The very variable soils are mostly of low fertility, but some areas of the flats and isolated areas of soil formed on basic rocks might be used for small-scale agriculture.

Pastoral prospects.—The pastoral value of this system is low. Any change is mainly dependent upon finding suitable exotic pasture species.

(9) *Cullen Land System* (Fig. 13; Plate 5, Fig. 2)

Location.—This system includes numerous scattered and isolated units, extending from Darwin generally south-east to the Edith River and eastward to the Arnhem Land Tableland. The largest unit is to the east of Pine Creek, extending north and south.

Extent.—1,360 square miles.

Topography.—The topography varies from rough, rocky outcrops to gently undulating country with flats of small area. The drainage pattern is dendritic except where jointing exercises structural control in some areas of steep topography. Such areas have a relatively intense drainage pattern but in the gently undulating areas the intensity is only moderate.

Geology and geomorphology.—This land system is part of the Elevated Backbone Country and has as its base rock the Cullen Granite intruding the Brocks Creek Group and now in contact with these and rocks of the Mullaman and Daly River groups.

In consequence of this and the fact that the granites themselves differ in structure and mineral composition, and therefore in resistance to erosion, their present topographic form is variable.

Soils.—Large rounded boulders and very gritty, sandy skeletal soils are characteristic of steep topography. On undulating topography Granite Sandy Yellow Podsolic soils are formed. Granite Lateritic Podsols occur on gentle slopes. The minor areas of flats have "Acid" Alluvial soils. The skeletal soils and Granite Sandy Yellow Podsolic soils are the most extensive within this land system.

Vegetation.—The most widespread vegetation on this granite country is a *mixed open forest* or *scrubby open forest,* typically on sandy surface soils, and *deciduous open forest* on the steeper and higher slopes. Tall annual *Sorghum* dominates the ground flora but sparse perennial grasses such as *Heteropogon triticeus, Eriachne avenacea, Plectrachne pungens,* and sometimes *Themeda australis,* also occur.

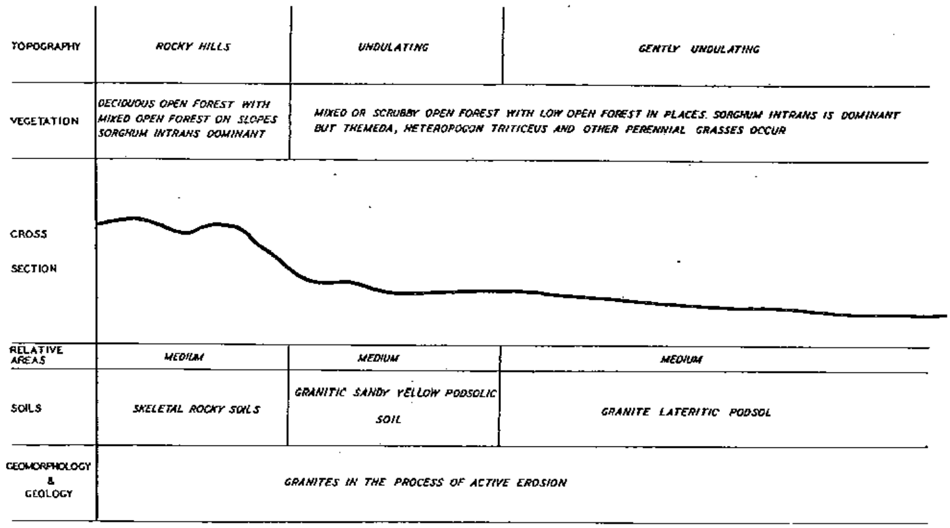


Fig. 13.—Cross section and summary of characteristics of the Cullen Land System.

Rainfall.—As areas of this system are dispersed widely throughout the Brocks Creek Land Systems, rainfall conditions vary considerably.

Mean annual rainfall—45-55 in.

Mean length of season of adequate rainfall—16-20 weeks.

Mean time of commencement—November 21-30.

Natural water supply.—Most of the granite areas of this system have no permanent surface water supply, but small lagoons may occur in nearby flats of the associated land systems.

Accessibility.—As the units of this system occur within the Brocks Creek and Marrakai Land Systems, accessibility is governed partly by those systems. The main north-south road passes through a large part of the granite area near Pine Creek and also close to the smaller area north of Rum Jungle. The rocky, hilly portions of the system are difficult to cross by motor transport, but the undulating portions are reasonably easy to traverse.

Present land use.—As these areas of granite country occur within the Brocks Creek Land Systems they are used in conjunction with them for cattle grazing at low rates of stocking. Minor attempts at agriculture may have been made on these soils in the past, but agriculture has not persisted.

Agricultural prospects.—Agricultural prospects are limited to the undulating and gently sloping portions, mainly to the west of the main road, south and north of Pine Creek. Soils are low-moderate to low fertility, and irrigation prospects are restricted to small-scale schemes from springs or small creeks. These soils do not occur in extensive areas of unbroken country, but some portions would be cultivable and are worth examining from the point of view of specialized crop production, e.g. tobacco and peanuts. The application of fertilizer would be almost certainly necessary for satisfactory crop production.

Pastoral prospects.—The present low rate of stocking is not likely to be improved until further advances are made in methods of pasture improvement.

(10) *Buldiva Land System* (Fig. 14)

Location.—The major units are the Arnhem Land Tableland in the east of the region, extending beyond the boundary of the area surveyed, the slopes of the Mt. Tolmer Tableland, and the north-south range from Buldiva towards Stapleton. There are also a number of smaller, more isolated units.

Extent.—2,750 square miles.

Topography.—This system comprises rough, rocky hills or dissected tablelands, deeply cleft along joint lines (see Plate 9, Fig. 1). In the Buldiva-Stapleton and Mt. Tolmer Sections, there are some areas with long, gentle dip slopes and short, rocky strike slopes. At the foot of steep slopes, there occur sandy fan delta formations not always distinguishable on aerial photos from neighbouring land systems. The drainage pattern is largely controlled by the jointed structure characteristic of these rocks but, on the areas of more gentle slopes, a dendritic pattern of moderate intensity is developed.

Geology and geomorphology.—This system is portion of the Elevated Backbone Country formed on the sandstones, quartzites, and conglomerates grouped under the Buldiva Quartzite. Erosion is still active. The strongly developed joint pattern gives strong structural control of drainage in outcrop areas. On very gentle slopes the low relief and permeable sandy soils are responsible for the dendritic drainage pattern of moderate intensity.

Soils.—Bare rock outcrops with small sand accumulations in fissures are common. Small areas of gentle slopes have stony, sandy skeletal soils while Sandstone Lateritic Podsols occur on very gentle slopes. The fan delta formations consist of Deep Sandy Light Grey soils.

Vegetation.—Many of the rocky outcrops are bare or carry a more or less dense stand of *Triodia,* commonly of *T. microstachya,* with a few, often stunted, trees and shrubs and annual grasses and sedges.

On the gentle slopes developed within the system some form of *open forest* occurs, usually *mixed open forest* with *Eucalyptus phoenicea, E. miniata,* or *E. dichromophloia* prominent. In some of the gorges and at the foot of some of the tablelands, small patches of *monsoon forest* occur.

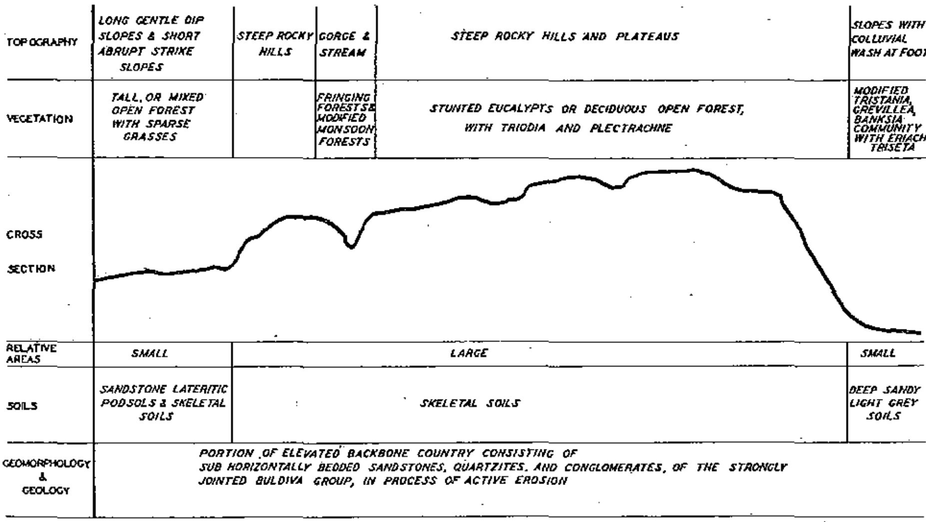


Fig. 14.—Cross section and summary of characteristics of Buldiva Land System.

On flat, sandy, fan delta soils below the steep slopes are modifications of the *Tristania-Grevillea-Banksia* community. Where these soils occur on slopes, the trees are less frequent and *Eriachne avenacea* and *Leptocarpus schultzii* become prominent. *Pandanus spiralis* is common on some of these soils in areas of higher rainfall.

Rainfall.—The two main areas of this system have different rainfall conditions:

	Buldiva-Stapleton	Area East of Katherine
Mean annual rainfall	45-55 in.	35-50 in.
Mean length of season of adequate rainfall	18 weeks	13-16 weeks
Mean time of commencement	November 26	November 26 to December 10

Natural water supply.—In the Mt. Tolmer section and the large section in the east of the area, there are numerous springs and small permanent streams, but the remainder is poorly provided with permanent water. Flooding during the wet season is restricted to some of the lower sandy fan deltas. The gorges developed within the system may offer sites for dams for water storage, but the strongly developed jointing may be a feature of importance.

Accessibility.—The Stapleton-Daly River-Buldiva road runs close to or through portion of the Buldiva System. The Mt. Tolmer section is also accessible by road.

The three isolated sections across the centre of the region consist of rough, stony hills, with poor accessibility. The edge of the large extent of Buldiva along the eastern margin of the area can be reached by road from a number of points, but the system itself is extremely difficult to traverse.

Present land use.—Small parts of this system are grazed in conjunction with adjoining systems, but only as dry season refuge country.

Agricultural prospects.—The only areas with any possibility of agriculture are the Deep Sandy Light Grey soils at the edges of the system. It may be possible to grow tobacco and some other specialized crops, perhaps under small-scale irrigation from the springs and permanent streams but, as the soils are rather isolated and in an irregular, narrow band at the foot of the steep hills, this had not been included in the list of primary recommendations.

Pastoral prospects.—Apart from their use as very low production areas for dry season reserve, the sections of this system have no prospects of development.

(11) *Volcanics Land System*

Two small areas totalling 42 square miles, with base rocks of volcanic origin, occur to the north and east of Katherine and constitute a distinct land system. When aerial photographs were available for laboratory interpretation, these areas proved to be larger than had been expected in the field. In consequence, land traverses crossed only one short section and information on this land system is incomplete.

The base rocks are basic volcanics which have been correlated with the Lower Cambrian volcanics of the Kimberleys. They are exposed near the margin of the Daly River Basin and the Elevated Backbone Country. The topography includes low hills and gentle slopes with skeletal and deep Heavy Grey Pedocal soils respectively. The vegetation includes species characteristic of basic and heavy soils elsewhere in the region. The gentle slopes carry *deciduous parkland* with short and medium tall grass species in the ground flora (e.g. *Dichanthium* spp., *Aristida* spp., *Brachyachne convergens*).

Rainfall conditions are similar to those at Katherine. The Edith River, which cuts the northern tip of one portion of this land system, is the only permanent stream and there does not appear to be any possibility of irrigation.

Both areas are reasonably accessible from Katherine. At present they are lightly grazed by cattle in conjunction with adjacent country, and this is likely to remain their main use. It is possible that agriculture could be developed under dry-land conditions on some small areas of deeper soil with cotton as one of the crops which might be investigated.

(12) *Tipperary Land System* (Fig. 15; Plate 8, Fig. 1)

Location.—This system lies to the north and south of the middle section of the Daly River, and extends southwards beyond the Katherine and Flora Rivers.

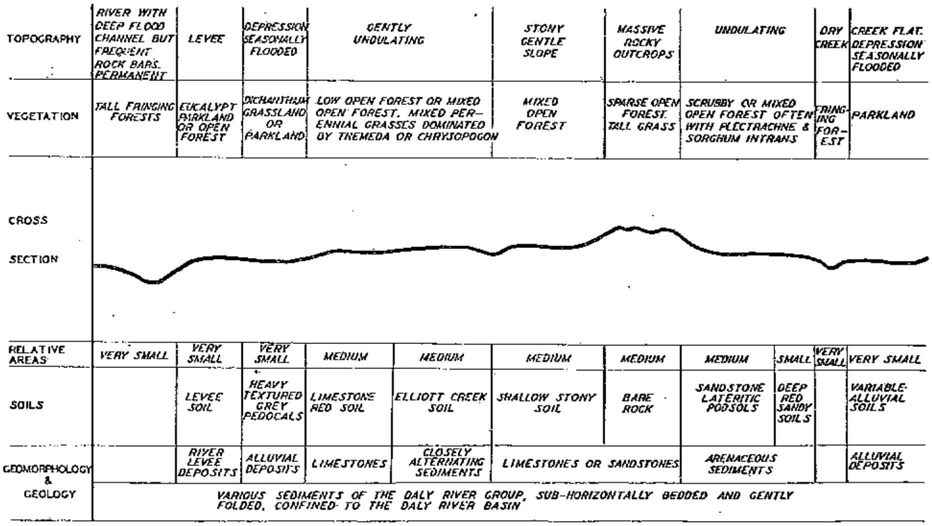


Fig. 15.—Cross section and summary of characteristics of Tipperary Land System.

Extent.—6,890 square miles.

Topography.—The land surface is mainly undulating to gently undulating with some low, rough, rocky hills. It is drained by one major system, the Daly River and its several major tributaries. These are fed by infrequent small creeks, with which are associated scattered broad flat areas flooded during the wet period. The drainage pattern is irregular, being of less intensity where these flats and swamps are most numerous, but becoming more intense in the hilly sections.

Geology and geomorphology.—This is the only land system within the Daly River Basin geomorphological unit. The geology and geomorphology have already been described in Section II.

Soils.—The low hills are composed almost entirely of rock outcrops with very little soil. Stony soils are formed on both sandstone and limestone and occur on undulating topography. In some places such limestone areas are characterized by platey boulders scattered over the surface. There are also very small areas of a grey rendzina-like soil in the vicinity of Katherine. On the gently undulating areas, Limestone Red soils, Sandstone Lateritic Podsols, and Elliott Creek soils are most extensive. Smaller areas of Deep Red Sandy soils occur only in the southern portion.

There are small areas of Heavy-Textured Grey Pedocals, generally on the calcic flood plain alluvia behind the levees of the lower Katherine and Flora Rivers and along the Daly River. There are also smaller areas of these soils, sometimes crabholey, formed where drainage is poor on limestones. The larger streams have narrow bands of Levee soils. These bands are generally less than 20 chains wide and may be broken and dissected by tributaries.

Vegetation.—The major soils of this system carry a *mixed open forest* and sometimes *low open forest* on the Limestone Red soils and the "Elliott Creek" soils, and *scrubby open forest* on the sandstone Lateritic Podsols. On the Deep Red Sandy soils a type of *mixed open forest* is common in which *Plectrachne pungens* and annual *Sorghum* spp. are prominent in the grass flora.

On the alluvial Heavy-Textured Grey Pedocals of this system, which are sometimes crabholey, a variable type of *parkland* occurs in which *Eucalyptus papuana, E. microtheca, Bauhinia cunninghamii, Tristania grandiflora, Erythrina vespertilio, Terminalia volucris, Erythrophleum chlorostachys, Acacia bidwillii, Carissa lanceolata, Pandanus spiralis,* low *Melaleuca* spp., and *Hakea arborescens* may all occur (Plate 18, Fig. 2). The deciduous lower species sometimes assume dominance, particularly in areas subject to severe cracking, and such communities have been termed *deciduous parkland.* The grasses of these flats include *Bothriochloa intermedia, Dichanthium fecundum, D. superciliatum,* and *D. annulatum,* with *Ophiuros exaltatus* and several of the common species of the *open forest,* e.g. *Themeda australis, Sehima nervosum,* and *Chrysopogon* spp. A low leguminous shrub, *Desmodium* sp., is common.

In the lower sections, swampy patches dominated by *Arundinella nepalensis* with *Ophiuros exaltatus* and annual Cyperaceae occur. Where there is extensive deep seasonal flooding, dense stands of *Excoecaria parvifolia* grow with or without *Eucalyptus microtheca* in association.

On the small areas of rendzina and Grey Heavy-Textured Pedocals formed on limestone, species common to the *deciduous parkland* dominate and in some places form closed formations. The ground flora consists mainly of rather sparse tussocky grass of medium height (chiefly *Themeda australis, Sehima nervosum, Chrysopogon fallax,* and *Aristida latifolia*) through which occur annual species such as *Brachyachne convergens* and, less commonly, *Iseilema* spp.

The levee communities vary from *parkland* to *mixed open forest* in which the ground flora is dominated by tall grasses such as *Sorghum* spp., *Chrysopogon latifolius,* and *Themeda australis.* Where these grasses have been reduced by excessive grazing, fire, or flood, *Aristida browniana* is a common pioneer annual species.

Fringing forests are dense along major streams and include tall species such as *Eucalyptus camaldulensis, Melaleuca* spp., *Casuarina cunninghamiana,* and occasionally *Nauclea* (*Sarcocephalus*) *orientalis* with the lower *Barringtonia gracilis* and *Pandanus aquaticus* in and near the water's edge. These communities are less dense along minor streams and may be reduced to sparse *Eucalyptus camaldulensis* or lower storey species only.

Rainfall.—This system extends for a distance of over 100 miles in a north-west to south-east direction along the Daly River basin. There is thus a considerable range in rainfall conditions, which may be of significance in relation to land utilization in this area. The range is indicated below:

	SE Section	NW Section
Mean annual rainfall	35 in.	50 in.
Mean length of season of adequate rainfall	13 weeks	18 weeks
Mean time of commencement	December 20	November 26

Natural water supply.—This system is traversed by the Daly, Flora, Katherine, Ferguson, and Douglas Rivers and their tributaries. The major rivers flow permanently. These supply good sources of stock water and, by pumping, also water for irrigation of the levees and other soils close to the rivers. Scattered lagoons occur behind the levees, but the portions of the system away from the streams are generally dry owing to the excellent internal drainage of the soils. Geological information suggests possibilities of artesian water in small sections of the central portion of the Daly River Basin.

Accessibility.—The section south of the Katherine and Flora Rivers and to the north of the Katherine River is generally accessible from the main road and railway, although the numerous creeks isolate some areas for periods in the wet season. The portion south of the Daly River and west of the Flora River is inaccessible for long periods during the wet season, and could only be made accessible by the construction of high-level bridges. Those portions north of the Daly River are accessible from the main road. Roads lead to Tipperary, Douglas, Jindare, and Claravale Stations and these could be made all-weather roads except for short periods at flood peaks.

Present land use.—The pastures of this system provide somewhat better grazing than areas farther north. Scattered areas of *deciduous parkland* with shorter, blue-grass-dominant pastures and carrying some top feed species occur on alluvial flats near the rivers and along drainage channels away from the rivers. River levees occur more extensively within this system than elsewhere in the region and these also carry somewhat more feed with some top feed in the associated gullies and *fringing forests* of the streams. In addition, *open forests* carrying *Plectrachne* in the ground flora extend to near the rivers and provide an inferior but useful dry season reserve.

With the exception of a small herd in the north-west of the system, buffaloes do not occur and the cattle industry is somewhat better established than in other systems. However, carrying capacity remains low and the industry is by no means well developed.

Agriculture is practised on a small scale on the levee soils of the rivers that traverse the system. The main area is the Katherine River settlement near the township of Katherine. Isolated areas of cultivation occur along the Daly River area west of the Ferguson River. Peanuts are the main crop cultivated but vegetables and fruits are also produced. Cotton has been grown but has not become a stable industry. The total number of farmers at the present time is less than 20.

Agricultural prospects.—On the river levees there is room for a more efficient agriculture based on intensive mixed farming.

Physically and topographically some of the soils away from the rivers are suitable for agriculture, e.g. Limestone Red soil and "Elliott Creek" soil, although their fertility is only moderate or low-moderate. In the absence of any prospects for extensive irrigation, agricultural production from these must depend upon natural rainfall and hence crops most suitable for this purpose must be selected if the area is to be cultivated. It is considered that, because of its accessibility and general suitability, the possibilities of dry-land agriculture and associated animal industries in this area should be fully explored. If successful, there will be opportunity for the establishment of a community sufficiently large to permit the provision of facilities and amenities so necessary to attract and maintain a population in this region. However, neither soil fertility nor the characteristics of the rainfall during the growing season are sufficiently satisfactory to encourage development until field trials have been conducted.

Pastoral prospects.—If agriculture is developed within this system, there should be scope for some cattle fattening and this in turn could influence cattle breeding in that a supply of store cattle would be in demand. Apart from this it does not seem practicable to increase materially the potential carrying capacity at present, although some areas could be more effectively used by the provision of additional stock water supplies.

(13) *Litchfield Land System* (Fig. 16)

Location.—Three main areas occur, viz.:

(*a*) Between the Mt. Tolmer Tableland and the west coast;

(*b*) Surrounding Mt. Litchfield, north of the Daly River;

(*c*) In the Hermit Hill-Dilke Range region, south of the Daly River.

Extent.—830 square miles.

Topography.—The topography is undulating to nearly flat with occasional higher rocky outcrops, e.g. Mt. Litchfield, Hermit Hill, and Dilke Range. Alluvial flats are associated with the lower sections of the rather poorly defined dendritic creek systems, and sometimes extend directly to the Sub-Coastal Plain. These flats are best developed in the Hermit Hill section, and occur to a lesser degree west of the Mt. Tolmer Tableland.

Geology and geomorphology.—Granites are the base rocks of these portions of the Western Fault Block Plains; they have been somewhat altered in the Hermit Hill-Dilke Range section. The area occupied by this system has reached an advanced stage of erosion and the low relief and

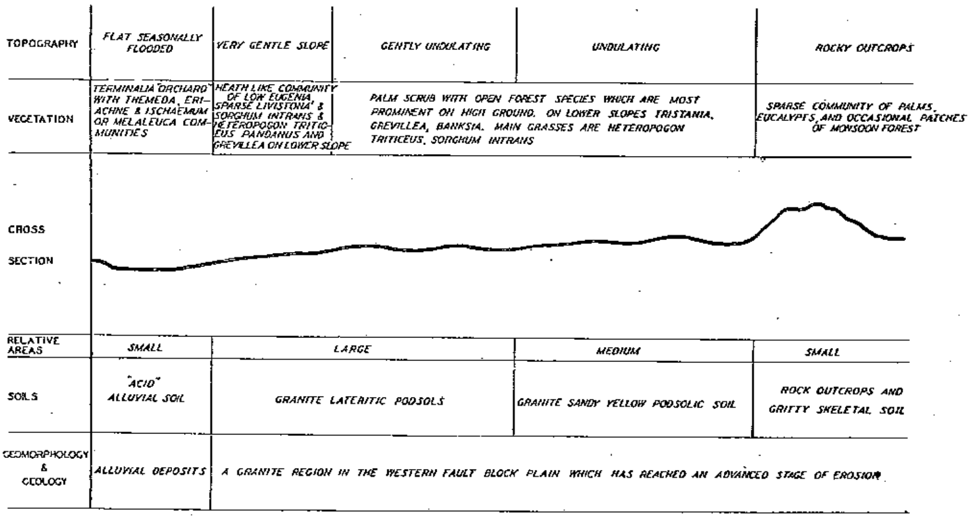


Fig. 16.—Cross section and summary of characteristics of Litchfield Land System.

deep, sandy, permeable soils are responsible for a broad, poorly defined drainage pattern. The alluvial flats most probably represent the original drainage systems which, as a result of the submergence of that area which is now the sub-coastal plain and the consequent reduction in grade of the streams, have been filled with alluvial deposits.

Soils.—The soils are similar to those of the Cullen Land System but differ in relative extent. Granite Lateritic Podsols cover large areas, generally mixed with lesser areas of Granite Sandy Yellow Podsolic soils. The areas of "Acid" Alluvial soil, and skeletal rocky soils are relatively small.

Vegetation.—The dominant vegetation is some form of *palm scrub* with *Livistona* and *Pandanus* prominent. Scattered *Eucalyptus* spp., particularly *E. grandifolia*, occur on the higher ground and in places form a mixed *palm scrub* and *open forest* community. In the portion east of Hermit Hill a low form of *scrubby open forest* occurs extensively. In this, second-storey species of the *open forest* such as *Grevillea*, *Terminalia*, *Petalostigma, Owenia vernicosa, Persoonia falcata, Cochlospermum fraseri,* and *Eugenia bleeseri* are associated with *Livistona, Pandanus,* and *Eucalyptus* spp. such as *E. grandifolia.* On a plain west of Hermit Hill there is a low heath-like vegetation consisting of dwarf *Eugenia bleeseri, Melaleuca* sp., and sparse *Livistona humilis.*

On the lower slopes of the system the *Tristania-Grevillea-Banksia* community is usually present. The alluvial flats carry either a *Terminalia* "orchard", or a sparse tall *Melaleuca* community with a dense grass ground flora somewhat similar to the *Themeda-Eriachne* community but sometimes with *Ischaemum arundinaceum* and *Arundinella nepalensis* also present.

On the rocky outcrops and the steeper slopes a sparse *Eucalyptus-Livistona* community occurs with minor areas of *monsoon forest.* Tall annual *Sorghum* spp. dominate the ground flora of all the better-drained portions of the system with thin stands of perennial grasses such as *Heteropogon triticeus.* Minor legumes are fairly abundant in the ground flora in places.

Rainfall.—Mean annual rainfall—40-60 in.

Mean length of season of adequate rainfall—18-20 weeks.

Mean time of commencement—November 21-26.

Natural water supply.—The system is not well supplied with surface water, but scattered small lagoons usually associated with small, non-permanent streams occur.

Accessibility.—The portion west of Mt. Tolmer Tableland is relatively inaccessible, being isolated from present communications by this tableland and the Finniss Land System. The area around Mt. Litchfield is easily reached in the dry season, but is isolated for periods during the wet season by creeks and wet flats. The area south of the Daly River in the vicinity of Hermit Hill is isolated by the Daly River for long periods during the wet season.

Present land use.—Cattle are grazed at low stocking rates in association with the Tipperary and Elliott Creek Land Systems and the Sub-Coastal Plains near the Daly River. The northern section is virtually unstocked.

Agricultural prospects.—This system occurs in an area of relatively high rainfall and has a season of adequate rainfall of 18-20 weeks. The soils of the more accessible Mt. Litchfield area warrant agricultural investigation, particularly for tobacco and peanuts. As with most soils in this region the application of fertilizer will most probably be required for satisfactory crop production.

Pastoral prospects.—Should agricultural development occur there may be a place for small-scale cattle fattening associated with it, otherwise there is little immediate hope of improving the present stock-carrying capacity.

(14) *Elliott Creek Land System* (Fig. 17)

Location.—This system covers an area which extends to the west, north, and east of the granite area in the vicinity of Mount Litchfield.

Extent.—400 square miles.

Topography.—This is gently undulating with a small proportion of flats subject to flooding, and only minor rock outcrops. Drainage is by small creeks forming a broad dendritic pattern, and flowing on to the adjacent Sub-Coastal Plains.

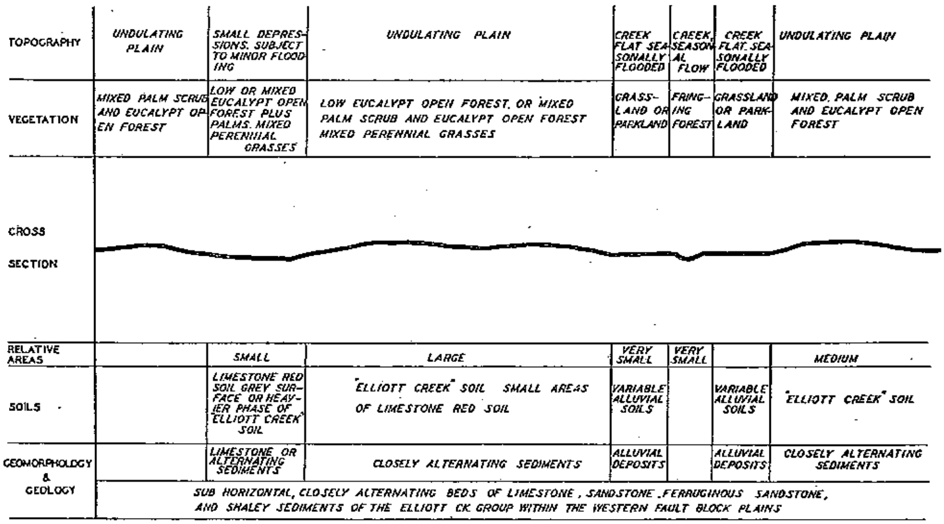


Fig. 17.—Cross section and summary of characteristics of Elliott Creek Land System.

Geology and geomorphology.—In this section of the Western Fault Block Plain, the base rocks are sub-horizontally bedded limestones, sandstones, ferruginous sandstones, and shaley sediments of the Elliott Creek Formation of undetermined age. These beds alternate in such a way that distinctive soils have rarely been developed on each rock form individually. Erosion has reached an advanced stage. The sub-horizontal fairly soft strata outcrop only as scattered beds of sandstone or limestone boulders. The gently undulating topography and the soils of moderate permeability are factors responsible for a dendritic drainage pattern of fairly low intensity.

Soils.—The soils of the extensive gently undulating areas are almost exclusively "Elliott Creek" soil. In shallow depressions and flats there are minor areas of heavier-textured "Elliott Creek" soil and grey-surfaced Limestone Red soil.

Vegetation.—The most common type of vegetation is *low open forest* with *Eucalyptus foelscheana, E. grandifolia, E. tectifica,* and *E. confertiflora* most prominent. *Livistona* is abundant and there is a wide variety of other second storey species. The ground flora is uniformly dense and consists mainly of perennial grasses of the *open forest.* Minor legumes are relatively abundant.

To the south-west, *Livistona* sp. becomes dominant and the community grades into *palm scrub.* In other places a taller type of *open forest* occurs with *Eucalyptus miniata* as a prominent species.

On some of the creek frontages, the trees become more scattered and the community approaches *parkland* in appearance.

Rainfall.—Mean annual rainfall—50 in.

Mean length of season of adequate rainfall—18-19 weeks.

Mean time of commencement—November 21.

Natural water supply.—There are some permanent creeks and waterholes, but not sufficient surface water for extensive irrigation. There are only minor flats liable to irregular flooding.

Accessibility.—The area is readily accessible from the Daly River road in the dry season, but the present track is impassable during flooded periods. The area abuts the Daly River estuary in two places, and sea transport may have advantages over present long hauls by road, e.g. to the railway, which is 50 miles away at Stapleton, or to Darwin 120 miles distant.

Present land use.—This area is used in conjunction with the surrounding systems for cattle grazing at low rates of stocking.

Agricultural prospects.—The soils are almost exclusively Elliott Creek soil. They are of low-moderate to moderate fertility and suited topographically and physically for cultivation. No agriculture is practised in the area, but it is recommended that it be investigated for agriculture under natural rainfall with particular attention to tobacco and peanut production. The length of season with adequate rainfall is slightly longer than that of the Tipperary Land System.

Pastoral prospects.—As with the Tipperary Land System, improving of potential stock-carrying capacity does not appear feasible at present except in relation to possible agricultural development.

(15) *Moyle Land System* (Fig. 18).

Location.—This system occurs south of the lower reaches of the Daly River. It is named after a native tribe as no locality names are mapped in this area.

Extent.—190 square miles.

Topography.—This land system is a gently undulating or undulating plain broken only by isolated mesa-like hills of the Mullaman Land System. The system is drained by small, mature creeks, some of which are spring-fed, with flats liable to seasonal flooding.

Geology and geomorphology.—This portion of the Western Fault Block Plains is based on sediments of the Port Keats Group. They are sub-horizontally bedded calcareous and arenaceous sediments. The only outcrops observed were on the lower slopes of mesas capped with sediments of the Mullaman Group. Elsewhere, these soft rocks have weathered to form deep soils of moderate to high permeability, giving a dendritic drainage pattern of fairly low intensity. Small springs and soaks are common features.

Soils.—On the undulating and gently undulating areas, the major soils are Sandstone Lateritic Podsols and "Moyle" soils with smaller areas of Deep Light Grey Sandy soils. In the moist flats, the soils are similar to the Sandstone Lateritic Podsols and Deep Light Grey Sandy Soils and where permanently moist they may have three or four inches of peaty surface soil.

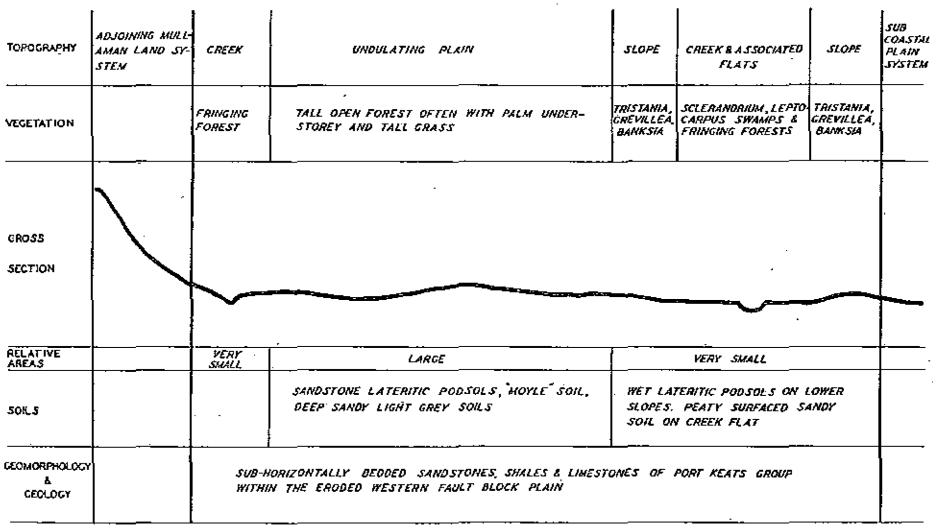


Fig. 18.—Cross section and summary of characteristics of the Moyle Land System.

Vegetation.—The dominant vegetation throughout the plain is *tall open forest,* with a rather dense understorey of *Livistona humilis* which, however, is sometimes absent. The annual *Sorghum intrans* is especially abundant in the ground flora, and at times is almost exclusive. The flats associated with the creeks are usually damp and carry *Sclerandrium-Leptocarpus* swamp. Between these and the *open forest* there commonly occurs a narrow *Tristania-Grevillea-Banksia* zone. The creeks are lined with a *Melaleuca*-dominant, bamboo-free, narrow fringing forest which in places passes into dense *tall Melaleuca* stands of the swampy Sub-Coastal Plains.

Near the coastward edge of the plain, instead of the *tall open forest* there is a community with low *Pandanus spiralis* as the dominant species, and dwarf scattered *Eucalyptus grandifolia* as the major eucalypt. In the dense perennial ground flora, tall grasses such as *Coelorhachis rottboellioides, Capillipedium parviflorum, Eulalia mackinlayi,* and *Heteropogon triticeus* are prominent, together with *Themeda australis* and *Heteropogon contortus.*

Rainfall.—No data are available for this locality and the following are only extrapolations:

Mean annual rainfall—45-50 in.

Mean length of season of adequate rainfall—19 weeks.

Mean time of commencement—November 21.

Natural water supply.—The area is fairly well supplied by small perennial creeks and by waterholes on the flats or on the adjacent Sub-Coastal Plain Land System. No extensive irrigation appears possible.

Accessibility.—The system is not served by any roads and is isolated by the Daly River and numerous flooded areas during the wet season. It can be reached in the dry season from the Daly River Police Station Crossing by a route proceeding south of Hermit Hill. The construction of an all-weather road would be difficult. Two narrow necks of land belonging to this system extend to the coast through the seasonally flooded sub-coastal plain and the area could possibly be served by sea transport.

Present land use.—This system is included in an Aboriginal Reserve.

Agricultural prospects.—The soils of this system are all of low to low-moderate fertility. Because of its isolation and the fact that it carries very heavy timber, any investigation of its prospects is not warranted at the present time.

Pastoral prospects.—The area is not stocked at present, but its carrying capacity would be low. However, it adjoins extensive areas of the Sub-Coastal Plains Land System and could be used in conjunction with these for cattle. The area is isolated and only store cattle could be moved by road. Fat cattle would have to be transported by sea.

(16) *Marrakai Land System* (Fig. 19)

Location.—This system occurs as irregularly shaped areas along the middle courses of the Adelaide, Margaret, McKinlay, and Mary Rivers, with an isolated area on the South Alligator River.

Extent.—680 square miles.

Topography.—Generally level to slightly sloping plains, intersected by large mature water-courses with low levees, and interspersed with low gravelly or stony rises. Widely dispersed lagoons occur throughout the plains. Isolated hills and ridges of Brocks Creek Land System occur, and, in the portion between the McKinlay and Margaret Rivers, there is an extensive section in which the plains of this system and the Brocks Creek Foothill Land System are intimately mixed.

Geology and geomorphology.—This system occupies a region that had reached an advanced stage of maturity at the time of the Quaternary rise in sea-level. The consequent rise in base level caused alluviation of the broad river valleys; these now form the extensive "bull-dust" plains lying between gravelly rises that are island residuals of a dissected area of the metamorphics of the Brocks Creek Group. The alluvia are derived from these rocks and from the Cullen Granite.

Soils.—The "bull-dust" plains are "Acid" Alluvial soils. The gravelly rises, which are covered by gravelly Yellow Podsolic or skeletal soils, are surrounded at their base by a belt of transition soils of variable width. Narrow bands of Levee soils fringe the larger streams that flow through the plains.

Vegetation.—The most characteristic vegetation of the low rises is *deciduous low mixed open forest* with a sparse to moderately dense grass flora. *Mixed open forest* also occurs, especially on the slopes. Communities of low *Eugenia bleeseri* occur on some very low residuals. The vegetation of the major plains and flats consists mainly of *Themeda-Eriachne grassland* with patches of *dwarf Melaleuca* and of *Eucalyptus latifolia-Themeda parkland* towards the transition zone between the plains and rises.

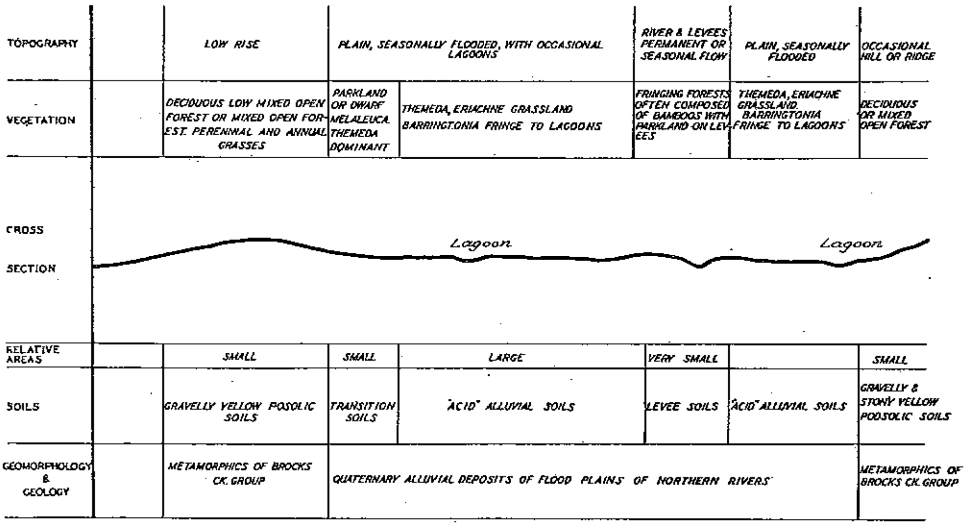


Fig. 19.—Cross section and summary of characteristics of the Marrakai Land System.

On these transition zones fringing the plains or flats, *parkland* is common and is dominated by one of the following species, viz. *Eucalyptus apodophylla, E. bigalerita, E. papuana, E. grandifolia,* and sometimes *Tristania grandiflora.* This *parkland* is often restricted to a very narrow zone, but occasionally occurs irregularly distributed throughout large flats or small plains.

In the tall *fringing forests* which line the larger rivers, bamboo is a prominent feature. The levees are covered with *Eucalyptus parkland* with a mixed tall and medium grass ground flora. Sparse fringing communities of *Barringtonia gracilis* sometimes fringe the lagoons of this system, but are often absent. *Nelumbo nucifera, Nymphaea* sp., and *Eleocharis* spp. are prominent in the water.

Rainfall.—Mean annual rainfall—50-60 in.

Mean length of season of adequate rainfall—19 weeks.

Mean time of commencement—November 21.

Natural water supply.—The alluvial plains are annually flooded to a shallow depth during the wet season by the five major rivers and the numerous minor streams which flow through this system. Flooding may occur over a period of three to five months, the continuity of flooding depending upon seasonal rainfall conditions.

In the dry season all except the Adelaide River cease flowing. The Mary and South Alligator become series of large waterholes, and the remainder have only isolated holes. Permanent billabongs occur behind the river levees and lagoons at the base of surrounding hills.

Accessibility.—Except the western fringe and the southern extremities of these plains, which are approachable over higher ground, most of this system is inaccessible during the wet season because of the impassable wet plains. The section west of the Margaret River could be made accessible relatively easily but to give access to the larger sections to the east it would be necessary to build elevated roads across the flats and high-level bridges over the rivers.

Present land use.—Buffaloes probably outnumber cattle throughout this system and shooting buffaloes for their hides is the major industry. Some cattle are grazed on this country in conjunction with the Brocks Creek Land Systems, but only at low rates of stocking.

Agricultural prospects—Many sections of the alluvial plain are naturally flooded for two to four months during the wet season. If flooding could be controlled, this offers possibilities for rice production, but the "Acid" Alluvial soils are of low-moderate fertility only. Many of the plains are treeless. Clearing costs would be very low, but the necessity to apply fertilizers may be a limiting factor. Should this development prove to be practicable and economic, small-scale intensive mixed farming of the narrow levees of the Mary, McKinlay, and middle Adelaide Rivers would be an accompanying feature. The low stony rises are not suitable for any form of agriculture.

Pastoral prospects.—The seasonal flooding of the natural pastures of these plains during their main growth period makes them inaccessible to cattle. At the conclusion of the wet season sparse short feed is produced following a burn, but this persists for only a short period and during the dry season much of the ground surface is bare. The wet season growth is more readily grazed by buffaloes which, during the dry season, appear to migrate to the Sub-Coastal Plain. The pastures of the stony rises are of only minor significance.

(17) *Finniss Land System* (Fig. 20)

Location.—This system includes the middle and upper sections of the Finniss River basin and area north of it.

Extent.—360 square miles.

Topography.—In this area, large stony rises are interspersed with gently sloping alluvial flats, often with long, finger-like projections protruding into the adjacent hills. The southern portion is drained by the Finniss River, the northern by the Darwin, Blackmore, and Charlotte Rivers. The flats themselves constitute the major parts of the contributing drainage systems. They receive drainage from the hills by small creeks, and in turn discharge their seasonal flood waters into creeks which may empty directly into the major drainage outlets or indirectly through other flats.

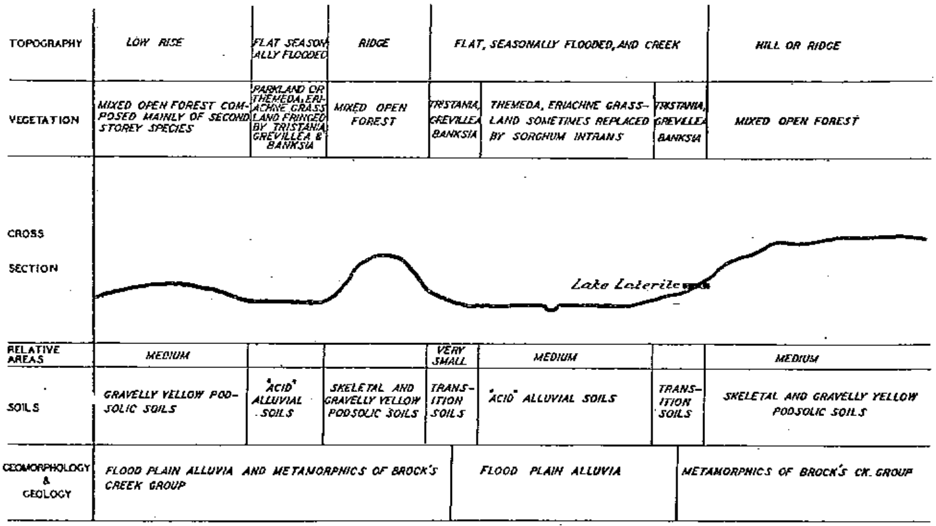


Fig. 20.—Cross section and summary of characteristics of the Finniss Land System.

Features which distinguish this system from the Marrakai Land System are:

(*a*) The flats are less extensive,

(*b*) The vegetation of both the rises and the fringes of the flats is different, and

(*c*) Lake laterite occurs near the base of stony hills.

Geology and geomorphology.—The stony rises consist of metamorphic rocks of the Brocks Creek Group intruded in places by dykes of pegmatite and greisen bearing tinstone and tantalite. They are aligned in a north-south direction, conforming to the strike of the metamorphics.

The flats are Quaternary Flood Plain Alluvia derived from these metamorphics and are similar in origin and nature to those of the Marrakai System. The alluviation appears to be due to the considerable rise in sea-level in Quaternary time, which consequently raised the base level of erosion. Slight rejuvenation of the stream system brought about by the subsequent fall in base level following sea recession in Recent time is responsible for the present extension of creek channels up the flats.

Soils.—The soils of the land system are the same as those of the Marrakai System, viz. "Acid" Alluvial soils on the flats, gravelly Yellow Podsolic and skeletal soils on the rises, transition soils, and Levee soils. The "Acid" Alluvial soils form a smaller proportion of this land system. "Lake Laterite" occurs on the lower slopes of the hills, in a band which probably represents the zone of fluctuating water-level during the period of deposition of the alluvial flats.

Vegetation.—The vegetation of the flats consists mainly of *Themeda-Eriachne grassland,* with scattered small communities of *Ischaemum arundinaceum* and *Oryza fatua.* These species are replaced in some flats by dense stands of annual *Sorghum* spp. Smaller flats may carry *parkland,* including *Tristania* and clumps of *Pandanus,* especially near drainage channels, and in some places *Eucalyptus alba.*

At the edge of the flats where the ground rises, there is a narrow transition zone of the *Tristania-Grevillea-Banksia* community, with *Eugenia bleeseri* and *Pandanus* at the edge of the grassland.

A *mixed open forest* occurs on the rises. This is characterized by a fairly high concentration of second storey species, particularly *Grevillea pteridifolia, Eugenia bleeseri, Xanthostemon paradoxus,* and *Livistona humilis.* On some of the quartz gravelly rises; the eucalypts are less abundant and a stunted community consisting mainly of second storey species occurs. In general, the ground flora consists of sparsely distributed perennial grasses, mainly *Heteropogon triticeus,* with tall and low annuals.

On the sandy rises which are apparently part of the river levee system, there occurs a development of the *Leguminous-Myrtaceous* scrub in which species of the *open forest* and of the *Tristania-Grevillea-Banksia* community also occur. The *fringing forest* is variable in character and contains a relatively large number of species, but in places consists of dense stands of bamboo.

Rainfall.—Mean annual rainfall—50-60 in.

Mean length of season of adequate rainfall—19-20 weeks.

Mean time of commencement—November 21.

Accessibility.—An all-weather road connects the north of the system with the main road, and the railway line runs just beyond the eastern boundary of the system but the major portion is at present inaccessible during the wet season because of impassable wet flats.

Present land use.—A very small number of cattle are grazed on this land system. Buffaloes, which are common in the related Marrakai Land System, are not present.

Agricultural prospects.—The gravelly soils of the rises are not suitable for agriculture but the flats, like those of the Marrakai Land

System, may be suitable for rice cultivation. However, as the areas of the latter near the Adelaide River are the more extensive and more accessible they are recommended for initial investigation. No immediate agricultural investigation or initiation in this system is proposed.

Pastoral prospects.—Apart from the presence of a larger proportion of stony rises, the pastoral characteristics of this land system are very similar to those of the Marrakai Land System.

(18) *Sub-coastal Plain Land System* (Fig. 21; Plate 11; Plate 12)

Location.—The plains of this system include two major sections, one on the north coast and one on the west coast; from the littoral they extend inland along the major rivers for up to 60 miles. These plains are not represented in the north-western corner of the region, where the lateritic plains extend to the much indented coastline.

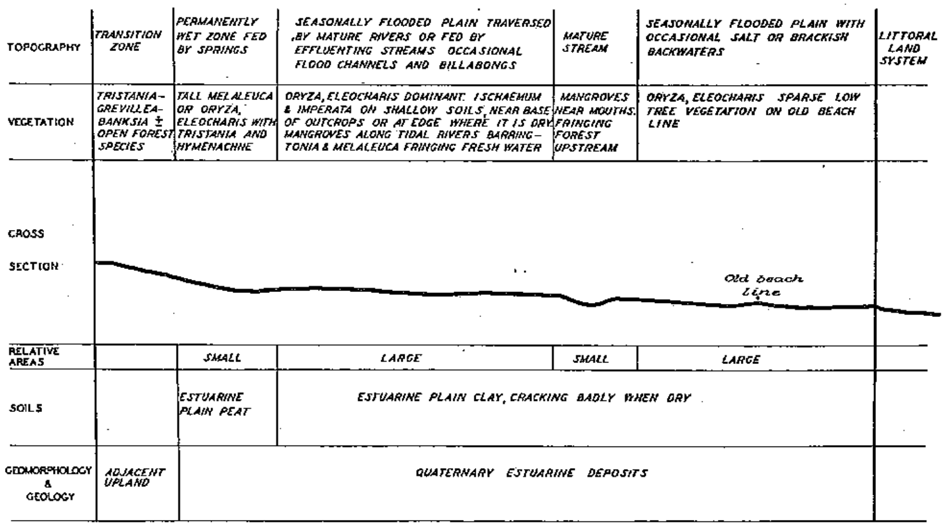


Fig. 21.—Cross section and summary of characteristics of the Sub-Coastal Plain Land System.

Extent.—2,650 square miles, with additional areas on the west coast south of the region surveyed.

Topography.—Flat, or nearly flat plains, at low level not exceeding 20 ft. above sea-level, traversed by meandering tidal mature streams, in part replaced by a system of distributaries and flat channels. Billabongs and salt water back-waters, locally termed "stringers", are characteristic features.

Geology and geomorphology.—This system is composed of a discontinuous and irregular coastal plain formed in Quaternary times. A Pleistocene rise in sea-level, drowning the lower river valleys, provided a shallow sea in which fine sediments were deposited. A subsequent fall in sea-level exposed large areas of these deposits which now lie just above sea-level. On the northern part of the plain between the Adelaide and the Wildman Rivers behind the present littoral at distances of half a mile to two miles apart, there is a series of narrow, more or less parallel, raised beaches, consisting of low sandy rises bearing sea shells.

The streams which traverse these plains are fed by large catchment areas in the centre and south of the region. In consequence of the high, seasonal rainfall, and the low grade of the streams traversing these plains, they regularly overflow their banks each wet season. The plains are flooded to a depth of several feet and water remains on them for a period of 6-8 months. Where spring-fed streams effluent on to the plain, permanent swamps occur. These are more numerous in the west coast section.

Soils.—The plains of the northern section are almost exclusively Estuarine Plain Clays with small areas of Estuarine Plain Peats in the swamps. In the western section the swamp areas are much larger and Estuarine Plain Peats are probably as extensive as the Estuarine Plain Clays.

Vegetation.—The open plains are covered with *Oryza-Eleocharis swampy grasslands* with *Phragmites karka, Scleria poaeformis,* or *tall Melaleuca* communities in low areas, especially those at the margin fed by small streams. On the shallow soil around the margin of the plain and in small patches within it, where flooding is less prolonged, there occur communities dominated by *Ischaemum arundinaceum,* sometimes with *Imperata cylindrica* var. *major, Xerochloa imberbis,* and *Bothriochloa intermedia.* At the inland edge of the plains occurs a narrow fringe of *Pandanus,* leading to the *Tristania-Grevillea-Banksia* zone, at the edge of the *scrub* or *open forest* communities on the rising ground.

On the old beach-lines occur scattered *Pandanus* and occasionally *Sterculia quadrifida, Clerodendron floribundum,* and *Celtis philippinensis* with clumps of *Cyperus javanicus* (*C. pennatus*) at the edges. Some small patches of the plain, particularly along the salt water "stringers", are devoid of vegetation.

Rainfall.—This is distributed approximately as follows:

	Northern Sections	Western Sections
Mean annual rainfall	55-60 in.	45-60 in.
Mean length of season of adequate rainfall	20 weeks	Probably 19-20 weeks
Mean time of commencement	November 21	Probably November 21

Natural water supply.—These plains are flooded for periods of six to eight months of each year. During the dry season, scattered lagoons and distributaries of the major rivers provide good stock water supplies although some of these are brackish.

Accessibility.—During the wet season the plains are flooded by several feet of water. Buffalo shooters have constructed tracks (impassable in the wet season) to the plains in the northern section and the plains themselves can be traversed when the surface has dried. The surface, however, cracks badly and becomes very rough.

The western portions of the plains are less accessible, as buffaloes do not occur in that area and tracks have not been made, but they could readily be reached by travelling stock during the dry season. The portion south of the Daly River is least accessible by road transport, but could also be reached by travelling stock. Much of this area, however, is set aside as an Aboriginal Reserve.

All sections are approachable by sea, and small craft transport is used in the northern section to carry supplies and buffalo hides.

Present land use.—The northern plains, east of the Adelaide River, are occupied by buffaloes, with only a small population of cattle concentrated mainly to the west. Cattle are grazed more intensively on Koolpinyah and Humpty Doo Stations, which are west of the Adelaide River, and are worked in conjunction with the Darwin meat supply. The plains along the western coast do not carry buffaloes. Cattle are grazed along the lower course of the Daly River and on the eastern extensions of these plains in the Reynolds and Finniss River sections.

Agricultural prospects.—There does not appear to be any prospect of preventing the flooding of these plains and, owing to the heavy texture of the plain and the wetness of the swamps, agriculture in the dry season is impracticable. The plains carry a perennial species of *Oryza* (rice), but even rice cultivation under conditions of white labour and mechanized farming does not appear practicable. The construction and maintenance of fences are very difficult.

Pastoral prospects.—The plains in the west could be more extensively used for cattle grazing, provided sea transport was available for marketing fat stock. In the north the return per unit area from buffalo hides is probably as great at the present time as could be expected from cattle under existing conditions. Should the outlet for cattle be improved, there may be a case for the replacement of the buffaloes by cattle. However, buffaloes are much better adapted to the swampy conditions and can better utilize the available wet season feed.

(19) *Littoral Land System* (Fig. 22; Plate 17, Fig. 1)

Location.—A narrow littoral, frequently no more than one-half mile in width, except in the estuarine areas, extends around most of the coast and for some distance up the rivers. At those points where the low lateritic plateau extends to the beach the littoral is absent or represented by scattered patches of the mangrove community only.

Topography.—Five major units in the topography may be recognized:

(*a*) Mangrove mud flats below high tide level but exposed at low tide.

(*b*) Salt flats, inundated irregularly at very high tides, behind the mangroves.

(*c*) Sand dunes, always low, either immediately behind the mangrove flats or with a mangrove fringe or above the beaches. The sand dunes in some places on the west coast, e.g. Fog Bay and Red Cliffs, may extend for a distance of one-quarter mile in a series of parallel rises. It is in the depressions between these that the natives find fresh water at shallow depths.

(*d*) Cliff faces and the associated detrital deposits.

(*e*) Littoral laterites on gentle slopes, less than 35 ft. above sea-level, behind cliff faces, e.g. Fanny Bay.

(*f*) Sand beaches.

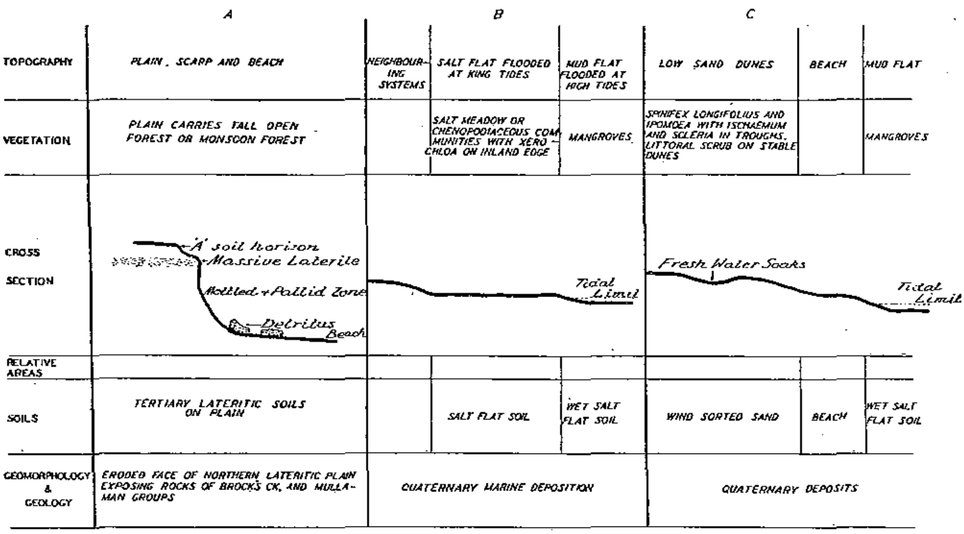


Fig. 22.—Cross section and summary of characteristics of the Littoral Land System.

Geology and geomorphology.—The present configuration of the littoral was determined by the coastal topography at the time of the more recent sea recession. Thus, the present littoral consists in some places of low cliffs, at the foot of which new marine benches are now being cut, in part of raised beach deposits such as the sand dunes at Fog Bay and Red Cliffs, and in part of partially submerged Estuarine Alluvia of the salt and mangrove flats.

Units (*a*) and (*b*) above are recent salt water deposits;

(*c*) are windblown marine depositions;

(*d*) consist of the eroded edge of the low Northern Lateritic Plains, exposing lower lateritic horizons;

(*e*) are Tertiary lateritic soils modified by exposure to the sea before the Recent fall in sea-level; and

(*f*) are recent coarse marine deposits.

Soils.—The salt flats have Salt Flat soils and the mangrove areas have Wet Salt Flat soils. The sand dunes are arenaceous and calcareous (shells) sand, often fairly coarse, in which no soil profile is developed. The minor areas of modified Tertiary lateritic soils have a gravelly grey loam surface with a mottled subsoil over massive laterite at two feet. The lower lateritic horizons are the same as other lateritic soils.

Vegetation.—The vegetation communities of the littoral have been described in Section II (*g*).

Rainfall.—Mean annual rainfall—50-60 in.

Mean length of season of adequate rainfall—20 weeks.

Mean time of commencement—November 21.

Natural water supply.—Fresh water supply is very irregular. Soaks behind the dunes provide small supplies. The mangrove areas are regularly flooded at high tides and the salt pans at king tides.

Accessibility.—Only the littoral near Darwin is readily accessible by road, but the remainder is accessible by sea.

Present land use.—The littoral is not used for agricultural or pastoral purposes. Small-scale salt production has been conducted in the past.

Agricultural prospects.—Apart from a few very small areas of the modified Tertiary Lateritic soil, e.g. at Fanny Bay, the littoral has no agricultural prospects, and even these areas can be utilized only for small-scale intensive production.

Pastoral prospects.—Very minor.

IV. A Review of Past and Present Forms of Production and Discussion of Future Possibilities

(*a*) *Agricultural Industries*

The available records concerning past crop production in the northern portion of the Northern Territory have been examined. The following notes give a brief summary of these records. The possibilities of commercial production are discussed, but economic factors such as present or future demands and costs of production are not considered in this report.

(i) *Peanuts* (Arachis hypogaea)

Peanuts were grown by Chinese in Darwin as early as 1884. Between then and 1908 Botanic Gardens records report several small crops that produced well. In 1914-15, production commenced on the Daly River Settlement (see Plate 20, Fig. 1). By 1929, 70 settlers in the Northern Territory were engaged in peanut production, but the number was reduced to 28 in 1935, and to no more than a dozen at the time this survey was conducted.

This reduction in the number of settlers was due to several factors:

(1) Discouragement due to periods of low prices, and adverse seasons;

(2) Low production as a result of poor husbandry on many farms;

(3) The enthusiasm engendered by the early successes encouraged some settlers to attempt production on unsuitable land. Many of these were only part-time farmers.

Continuous records of acreages planted and yields are not available, but figures in Table 8 have been extracted from official reports.

TABLE 8

ACREAGES PLANTED AND YIELDS OF PEANUTS

Year	Acreage Planted	Average Yield per Acre (estimated) (bags)
1926	180	7.7
1930	976	6.8
1932	1400	11.7
1936	1000	16.9
1937	1250	8.9
1938	1500	5.9
1940	1040	8.3
	Mean Average	9.2

Yields of 40 bags per acre have been obtained by some settlers under favourable conditions and this compares favourably with other peanut-growing districts. It can be expected that the average yield per acre can be substantially raised under improved husbandry conditions on suitable soils. The value of the crop has exceeded £10,000 in several years and has been as much as £15,000. It could be considerably more.

TABLE 9

ACREAGE OF PEANUTS PLANTED IN INDIVIDUAL LOCALITIES

Locality	1931	1934
Katherine	398	633
Mataranka	57	
Adelaide River	81	
Grove Hill	20	
Daly River	270	416
Edith River	50	
Others	100	113

Peanuts have been grown commercially mainly on the levees of the Katherine and Daly Rivers but smaller acreages have been planted in many other localities. The acreages for individual localities are recorded in Table 9 for 1931 and 1934.

Because of their higher market value, varieties for the wholenut trade are grown, and the most popular is Virginia Bunch, although Chinese Jumbo also does well. In 1934, an attempt was made to improve production by the importation of seed from Rhodesia. This appears to have had some effect temporarily but there is now need for a reliable source of good seed.

The type of land husbandry under which peanuts are grown is frequently very poor. Most growers produce only peanuts. In consequence, their continuous one-crop system has caused deterioration of soil structure which, under the intensive rainfall of the region, has led to soil erosion on some farms. Two settlers reported increased yields following the resting of land and the ploughing in of native grasses. The use of fertilizers has been discouraged by high transport costs but one settler has obtained a response following the application of superphosphate. There are, however, no records of adequate fertilizer trials to indicate the correct procedure.

The crop is undoubtedly adapted to the lighter, well-drained soils of the region, although production is affected in some years by unfavourable incidence of rainfall. Because of the relatively short wet period, seed is often planted in dry soil before the rains. Crops have failed following excessive rainfall in the young stages of growth and also following the early cessation of rains. Some of these failures could be avoided by irrigation but it is doubtful if the installation and operation of pumping plants, and the lifting of water to a height of 40-60 feet from the rivers for this one-crop system would be a payable proposition.

As the peanut is the only crop of which production and export have persisted over a long period in spite of fluctuating markets, poor husbandry, lack of organized transport and marketing, and variable seasons, it warrants thorough investigation to establish it as a more stable industry.

There are extensive areas of soil in the Tipperary, Elliott Creek, and Litchfield Land Systems that are worth investigating for this purpose. An essential feature of a stable development of peanut production, however, must be the establishment of some form of mixed farming. Investigations concerning peanuts should be closely associated with the proposed investigations of the possibilities of dry-land farming in the areas mentioned.

Immediate contributions towards the improvement of peanut cultivation would be:

(1) Well-conducted variety trials, and the establishment of a source of pure seed of the most suitable variety;

(2) Seed treatment investigations to reduce losses under wet conditions in the seedling stage;

(3) Experiments to determine a system of crop rotation to replace the existing one-crop system;

(4) Fertilizer experiments;

(5) Improved grading of the product and organized transport and marketing.

(ii) *Tobacco* (Nicotiana tabacum)

The first attempts at growing this crop were made by Chinese in 1884 when a smoking tobacco was manufactured. Between 1884 and 1894, reports indicate successful crops at the Darwin Botanic Gardens and at Shoal Bay. A comparison of varieties at the Botanic Gardens during this period indicated that Manila and Havana tobaccos were more satisfactory than those from cold climates. No information is available for the next ten years, but between 1904 and 1932 numerous trial crops were grown. The success of cigar varieties is emphasized but insect pests caused considerable trouble amongst young plants, and the lack of knowledge concerning curing is evident. In spite of many recommendations by the Curator of the Botanic Gardens commercial production was not achieved.

In 1932 a more serious attempt was made to encourage production and 30 oz. of seed was obtained from the Federal Tobacco Investigation. Leaf-eating insects destroyed most of the seedlings grown during the wet season, but six acres were successfully established on Verburg's farm at Adelaide River by irrigation during the dry season. The tobacco produced from this crop appears to have been badly cured and was very adversely criticized by the British Australian Tobacco Company to whom the produce was sent. This and similar experiences, mainly relating to the handling of the harvested crop, discouraged further effort for the time being.

Several acres of the variety Cash were successfully grown on the Daly River levee by Mr. Ridgdale in 1936. Seedlings planted out in mid season matured to a good amber colour but plantings made later in the season to escape insect damage were affected by dry season conditions.

Experimental work was assisted in 1937-38 by a grant of £200 from the Council for Scientific and Industrial Research. Seeds of the varieties Cash, Gold Dollar, and Hickory Pryor were sown at Darwin and seedlings were planted at the Botanic Gardens. Seed was planted on December 7 and 21. In spite of applications of sulphate of ammonia, growth in one seedbed was so poor that it had to be replanted on January 6. Seedlings were ready for planting nine weeks after sowing and plantings were made on fertilized ground on February 10. A large number of plants were killed by the sun and later by heavy flood rains (13 in. in 36 hours). Stem borer cut 40 per cent. of the survivors. Leaf was ready for curing 12 weeks after planting out and it was all harvested by June 20. Curing was done under difficulties. Samples of the leaf were reported to give a fairly good burn and fairly good to good aroma. The following yields of graded leaf per acre were recorded: Cash, 412 lb.; Gold Dollar, 363 lb.; and Hickory Pryor, 142 lb.

Further trials with these varieties were conducted in 1938 at the Botanic Gardens with exploratory plots at the Bagot Compound and at

Katherine. Seed beds were sown on October 24 and plants were ready seven weeks later.

Botanic Gardens.—Monsoonal rains caused water-logging and stunting in mid January. Harvesting commenced on April 5 and was completed in four pickings by May 7. The leaf was fine in texture and cured to a bright mahogany.

Bagot Compound.—Plantings were made on red lateritic soil. Growth was coarse and yield was potentially high but high winds flattened the maturing crop. Harvesting commenced on April 21 and was completed in three pickings by May 22. Cured leaf was darker than at the Gardens. Grasshoppers were the major insect pest, and a leaf spot (like *Cercospora*) damaged much leaf.

Katherine.—Even growth and uniform maturing of the leaf was a feature of this planting on levee soil. Harvesting commenced 12 weeks after planting and was completed four weeks later. Cured leaf was a good bright mahogany or better. The yields in pounds per acre obtained are set out in Table 10.

TABLE 10
YIELDS OF TOBACCO (LB. PER ACRE)

Location	Variety		
	Cash	Hickory Pryor	Gold Dollar
Botanic Gardens			
Fertilized, av.	352	272	250
Fertilized, best plot	563	312	289
Katherine			
Fertilized, av.	840	Not sown	422
Bagot Compound			
Fertilized, av.	318	333	448
Not fertilized, av.	132	231	180

In view of the much reduced stands and the fact that the product was reported to be of very good quality, these yields are encouraging, especially at Katherine. The response to fertilizer at the Bagot Compound is clear and it is evident that there is scope for more complete fertilizer trials with this crop.

In 1940 experiments at Katherine and Darwin suggested that seedlings must be raised in time for planting not later than mid January. In this year samples of cured leaf from the Northern Territory sold in Brisbane at 33d. per lb. Trial plantings were continued by the Army at Katherine during the war, but yield records are not available. One sample of cured leaf was reported to be of good quality, but no details are recorded.

In the meantime, Ridgdale of the Daly River had continued tobacco growing and produced quantities of plug tobacco from air-cured leaf for local consumption, mainly by the natives. However, this tobacco seems to have been of fair quality and was preferred by white consumers to some brands at least of fine cut tobacco. Ridgdale grows tobacco crops both during the wet season and under irrigation during the dry season. The Assistant Curator of the Botanic Gardens has advised that wet season crops are of better texture.

The available evidence suggests that tobacco is a crop well worth thorough investigation, especially in the Katherine region. Examination of the climatic data also supports this view. Production under natural rainfall conditions appears to be quite feasible, but partial irrigation may be desirable, especially during the establishment period, to permit sufficiently early plantings. The effect of climatic conditions on the maturing leaf requires further investigation and it is possible that the effects of adverse seasons might be reduced by controlled irrigation during this period, suitable fertilizer treatment, or the selection of most suitable varieties. Curing of the leaf requires attention and a local advisory service would be necessary before the production of good quality leaf could be increased.

The only commercial crops grown in recent years have been on the Daly River levee. If production under natural rainfall conditions proves sufficiently reliable it is likely that at least some portions of the Tipperary, Elliott Creek, and Litchfield Land Systems could be utilized. If successful, this high-return crop would prove a very useful basis for the establishment of an agricultural community and its possibilities should be thoroughly explored by adequate and sustained investigations on all likely soil types. It will be seen from the data presented that yields up to 840 lb. of dried leaf per acre have been obtained at Katherine. If this can be raised to 1,000 lb. per acre of good quality leaf there should be a sound basis for the establishment of a tobacco growing industry.

(iii) *Cotton* (Gossypium *spp.*)

From 1882, when cotton was first grown at Fanny Bay near Darwin, until 1903, no records of cotton growing are available. From then until 1920, cotton growing was mainly restricted to small trials at the Botanic Gardens, although crops were grown at Oenpelli, Daly River, and Batchelor. In 1921 and 1922 crops planted on the Daly River were lost by flooding and a small crop at Stapleton was badly affected by the insect pest *Earias huegeli* Rog. In 1922 a Government guarantee of 5½d. per lb. and assistance for freight charges became operative.

The Mataranka Experiment Station grew a small acreage in 1923 and this yielded 1,300 lb. seed cotton per acre under a 35 in. rainfall. The soil has been described as a red to grey loam with some stone. A crop of 5½ acres at Stapleton (sown in mid November) failed because of dry weather following sowing, which resulted in stunted plants unable to compete with weed growth that followed later rains. A later crop of 4½ acres (planted in mid December) produced 2,100 lb. from the first picking but insect pests later seriously affected the crop and the final yield was only 600 lb. per acre. Other crops were grown in this year by Messrs. Vakharron, Daly River (1,100 lb.); Pruen, Shoal Bay (258 lb.); Milton, Stapleton (215 lb.); Parry, Daly River (506 lb.); and Nobley, Roper River (1,904 lb.).

A small ginnery was established in Darwin in 1924. This temporarily encouraged production and in 1925 crops totalling 7,000 lb. seed cotton were grown at Stapleton, Grove Hill, Daly River, Pine Creek, Katherine, Mataranka, Booroloola, and on the lower reaches of the Roper River.

A cotton pool was established in Darwin in 1926 but the failure of the ginnery to handle the cotton produced and the comparative success of peanut cultivation discouraged further cotton growing, and apart from small trials at the Botanic Gardens there are no further records of production until 1940 when three farmers at Katherine grew a total of 175 acres. Throughout the history of cotton growing in the Northern Territory, Upland Sea Island and Acala have each been successful at times.

The failure of cotton growing to become more prominent in the Northern Territory has been largely determined by the very small rural population interested in its production. When peanut growing proved comparatively more successful the available farmers turned their efforts to this crop and forsook cotton. Apart from small plantings at the Botanic Gardens and trials by growers, experimental work with cotton in this region has been negligible.

Other problems have, however, also been apparent, namely the effects of adverse seasons and the depredations of various insect pests. Of the latter, the major ones appear to be the pink bollworm (*Pectinophora gossypiella* Saunders), the rough bollworm (*Earias huegeli* Rog.), the maize moth (*Heliothis armigera* (Hubn.)), the red cotton stainer (*Dysdercus cingulatus* Fabr.), and the small black cotton stainer (*Oxycarenus luctuosus* Montr.). A wild cotton population and native species of *Hibiscus* no doubt favour the abundance of these pests.

Cotton requires a soil with good water-holding capacity, or very even climatic conditions to permit uninterrupted growth. The deeper and heavier soils within the Tipperary and Elliott Creek Systems may prove suitable.

With adequate investigation, particularly with regard to choice of soils and varieties, time of planting, and control of insect pests, much more successful crops can be expected. However, the extent of the production of cotton will always be controlled by the importance of varying seasonal conditions, labour required for harvesting, ginning, and marketing facilities. There does not appear to be any scope for extensive irrigation of cotton and consequently if the crop is to be greatly extended it will be dependent upon natural rainfall. It may be possible to choose, or breed, a variety of cotton better adapted to the seasonal conditions of this region, while harvesting difficulties might be removed by the use of mechanical pickers, possibly combined with a pre-harvest spray to promote leaf fall.

It is evident that much investigation is required before cotton growing can become a major industry in this region, but it is one of the possible crops which might fit into a system of mixed farming under dry-land conditions and for this reason its possibilities should be further examined.

(iv) *Rice* (Oryza sativa)

In 1884, five acres of rice at Darwin produced eight tons of uncleaned rice. In 1886, Chinese on the Margaret River produced a ton of rice reported to be the first harvest from 30 lb. of seed. It is also reported that other Chinese paid two shillings a bag more for this rice than for the grain imported from China. Since then small crops have been grown by Chinese and others at various locations, and numerous trials have been planted at the Botanic Gardens. These small trials have rarely failed to give encouraging, although not good, results. A yield of 64 bushels per acre is recorded for Fanny Bay in 1909.

Numerous varieties have been grown. Earlier reports indicate that upland varieties were superior but later reports tend to favour the lowland or swamp varieties. In 1937, several varieties were imported from Malaya. The swamp varieties Radin Siak, Radin 2, Radin 13, Kelantan, and Nichin 66 grew successfully, the highest yields being obtained from Kelantan and Radin 2.

Extensive commercial production has not been encouraged, apparently owing to a Government agreement with the rice growers of the Murrumbidgee area. However, in view of the fact that some concern is now being expressed regarding the use of water for this crop in that area, the possibilities of the crop in the Northern Territory should be further examined. If the crop can be grown by natural flooding this would represent a far more economic use of water and land.

There are numerous areas in the region subjected to seasonal flooding for varying periods. As rice is not particularly specific in respect to soil requirements provided artificial fertilizer can be applied, it would appear certain that some areas suitable for its production can be found. However, the economics of production would need to be carefully considered.

At various times observers have commented upon the suitability of the flooded plains of the sub-coastal region for rice production. The soils of these plains are heavy clays which crack badly when dry and would be extremely difficult to cultivate in this condition. Under conditions of white labour, and with existing farm machinery, it is very doubtful if these plains could be successfully cultivated when wet.

The most extensive areas suitable for mechanization are the "bull-dust" plains of the Marrakai Land System, and similar flats of the Finniss

Land Systems. By the construction of low banks it is likely that some control of flooding can be exercised and the period of flooding can be sustained and prolonged. The most extensive areas occur in the Marrakai Land System and because of the greater accessibility of portions of this near the Adelaide River township, it is recommended elsewhere in this report that initial investigations should be commenced in this area.

(v) *Summer Cereals*

Sorghums.—Grain varieties of sorghums have not been extensively grown in this region, but should be well adapted to the summer rainfall conditions. The length of growing season should be adequate at least for earlier-maturing varieties. Little is known about insect or other pests, or of yields of grain. With a choice of suitable varieties, however, there is a possibility that this summer cereal could be grown extensively with natural rainfall on the better soil types.

The absence of this crop plant from past agriculture is probably due to the facts that it has become popular elsewhere in Australia only in recent years, and that the grain is not used here for human consumption but must be utilized in established animal industries. The extent to which it will be grown in the Northern Territory will depend upon development in these industries. The grain could provide a useful source of carbohydrates for both the pig and poultry industries, and for this purpose it may become a major item in the use of soils such as those of the Tipperary and Elliott Creek Land Systems under natural rainfall. It is one of the most promising crops from the point of view of production possibilities.

Maize (Zea mays).—From 1884 to 1925 occasional reports of crops are available. Crops were grown mainly at Darwin, Batchelor, and Daly River, and yields recorded vary from 15 to 35 bushels per acre, but total failures are also reported. Maize is a crop which is very susceptible to interrupted growing conditions and to adverse atmospheric conditions at the time of pollination. This probably explains the reported failures. Sorghum is a much more reliable crop under such conditions and there seems to be little reason for intensive investigations concerning maize.

(vi) *Winter Cereals*

Wheat and oats.—In 1911, the wheat variety Pusa was grown at Adelaide River, Pine Creek, and Booroloola. The crop failed at Booroloola but at Adelaide River, planted April 12 and harvested at the end of July, a yield of 15 bushels per acre was obtained. Crops planted in autumn at Batchelor Farm in 1912 and 1914 failed during the dry season after successful establishment. The Adelaide River crop apparently matured without additional rain following heavy rains in the month of establishment.

Climatic conditions in this region are not suitable for wheat cultivation on an extended scale but the result at Adelaide River indicated that, in favourable seasons, a crop planted at the end of the wet season can produce a reasonable yield. This result is important not for what it indicates concerning wheat production, but in relation to other crops with somewhat similar requirements. Grazing oats have been successfully grown at Katherine and these two cereal crops may have an occasional place for fodder purposes in a system of intensive mixed farming on river levees.

(vii) *Legumes (excluding Peanuts)*

Cowpeas (Vigna sinensis).—These are well adapted to the region and grow very well at Katherine. They should play an important part in any system of mixed farming, either as a green manure crop or as a fodder plant.

Soya beans (Glycine max).—Trials in 1937 and 1938 at Katherine and Darwin failed. Further trials are being conducted at Katherine by the C.S.I.R.O.

Mauritius bean (Mucuna aterrima).—This species is well adapted to the region and is used to a minor extent as a cover crop between orange trees. There is a market for seed of this crop, but harvesting presents considerable difficulties.

Pigeon pea (Cajanus indicus).—This species has been grown successfully at Katherine and also in similar latitudes on the Ord River in the East Kimberleys. It offers a possible source not only for leguminous green fodder but also for a high-protein seed, but its utilization presents difficulties.

Lucerne (Medicago sativa).—Lucerne has persisted on the levees of the Katherine and Ord Rivers with dry season irrigation. Atmospheric conditions are too humid during the wet season for satisfactory growth but good cuts are obtained during the dry season. On the Ord River levee, lucerne has persisted better when mixed with Rhodes grass (*Chloris gayana*) than when planted alone. At Katherine, spaced rows have given better results than broadcast stands. This crop can be grown usefully only where irrigation is possible. It may prove of value in a system of crop rotation under intensive mixed farming conditions along the river levees, but cannot be considered on a very extensive scale.

Townsville lucerne (Stylosanthes sundaica).—This pasture legume is established in and around Darwin and at Katherine, where it is highly spoken of by one settler. Wider distribution of this species would contribute to better animal nutrition at least for a short period after the wet season. Investigations concerning the range of conditions to which it is adapted and methods of establishment and maintenance are warranted.

Stylo (S. gracilis).—This pasture species has not been widely grown but appears to be adapted to some soils of the region. The Katherine Research Station is building up increased seed supplies for wider distribution. Its value should be investigated.

Alysicarpus *spp.*—*A. rugosus* is reported to have grown well at Darwin and it is understood that other species of the genus occur in that locality although the survey party did not observe them during the dry season. Species of this genus may be of value for introduction to natural pastures.

(viii) *Summer-Growing Pasture and Fodder Grasses*

Perennial grass species.—In spite of trials of numerous grass species in the Botanic Gardens in Darwin, little has been achieved with respect to the establishment of introduced pasture or fodder grasses on station properties.

Many of the species tried are obviously unsuitable for these conditions while others are of doubtful value. The outstanding introductions are Para grass (*Brachiaria mutica*) (Plate 13, Fig. 1), Guinea grass (*Panicum maximum*), and elephant grass (*Pennisetum purpureum*). In addition, molasses grass (*Melinis minutiflora*), teosinte (*Euchlaena mexicana*), and Buffel grass (*Cenchrus biflorus*) have proved adaptable to certain conditions. The survey observed persisting stands of Para grass (*Brachiaria mutica*) on the East Alligator River plain near Cannon Hill (see Plate 9, Fig. 1; Plate 13, Fig. 1), on the Adelaide River plain on Koolpinyah Station, and on low-lying land in Darwin.

The major factor inhibiting the use of introduced pasture grasses is the fact that cattle are almost entirely uncontrolled so that palatable introductions are subjected to selective and over-grazing. The persistence of Para grass is therefore all the more meritorious. A second factor on higher country is the presence of large numbers of marsupials which are completely uncontrolled.

Under the existing methods of property management it is questionable whether extensive use can be made of the better introduced grasses. With control of stock some of the above species could be more widely used. For example, it is likely that Para grass could be successfully established on some of the "bull-dust" plains. Conditions on these plains are less satisfactory for the grass than on the sub-coastal plains and the grass would be more susceptible to over-grazing. Under present conditions of grazing, therefore, the grass is unlikely to persist, but with some degree of protection it might well prove a very useful introduction.

Small patches of elephant grass are growing very well on the river levee at Katherine, especially where it receives soakage from irrigation ditches. The possibilities of this grass and Guinea grass should be more widely examined as it is this type of deep-rooted perennial grass that is able to continue growth into the dry season in favourable locations.

Some caution should be exercised in the distribution of Buffel grass and other species of the genus as they may prove a pest of cultivated land.

Annual fodder grass species.—Sorghums (*S. vulgare*) have not been grown extensively in the region. Plantings are reported from the Botanic

Gardens, Batchelor, the Daly River, and Katherine. The results have been variable, but from more recent trials at Katherine and on the Ord River there appears to be no reason why this crop cannot be grown under natural rainfall conditions. Apart from wet season crops, plantings made on deep soils at the end of the wet season also mature satisfactorily. The crop must be used in conjunction with the animal industries, and the production of both fodder and grain sorghums, planted near the end of the wet season, could be of major importance in extending the period of satisfactory nutrition for fattening stock. Planted mixed with a compatible leguminous crop species, a standing crop with good fattening properties could be available for several months at a time when natural pastures are in poor condition. The use of fodder crops in this way will depend upon a satisfactory outlet for fat cattle in the region, but given this, farm fattening of store animals may prove a payable proposition and sorghums should become a prominent crop if a mixed farming system under natural rainfall conditions can be established.

Sudan grass (*S. sudanensis*) has been grown successfully at Darwin, Katherine, and Grove Hill. As with other sorghum species its production has been limited by the lack of demand for such a crop in past agriculture. With development of mixed farming this fodder species would deserve further attention.

(ix) *Fibre Plants (excluding Cotton)*

Numerous fibre species have been planted at the Botanic Gardens. These include ramie (*Boehmeria nivea*), jute (*Corchorus capsularis*), sun hemp (*Crotalaria juncea*), kapok (*Ceiba pentandra*), Mauritius hemp (*Furcraea* spp.), bowstring hemp (*Sansevieria* spp.), Manila hemp (*Musa textilis*), Peta fibre (*Bromelia magdalense*), *Abroma augusta*, Deccan hemp (*Hibiscus cannabinus*), sisal hemp (*Agave sisalana*), rozelle (*Hibiscus sabdariffa altissima*), and broom corn (*S. vulgare*).

Of these, the best-adapted species appear to be sisal hemp, broom corn, roselle fibre, jute, sun hemp, Deccan hemp, and bowstring hemp. At one time the commercial production of sisal hemp was envisaged but the unsuitability of a machine purchased to treat the fibre and a report by the Administrator that the Northern Territory would find it difficult to compete against the cheap labour of Java and Malaya discouraged it. It is also reported that the variety used tended to "pole" before a sufficient crop of leaves could be harvested.

Broom corn is probably the only crop in this class that has any prospects of economic commercial production, trial samples forwarded south having been favourably reported upon. It is worth consideration as a sideline crop for mixed farms.

(x) *Oil Plants*

The reports of the Botanic Gardens refer to occasional trials of a number of special oil plants including coconuts (*Cocos nucifera*), African oil palm (*Elaeis guineensis*), Sesame (*Sesamum* spp.), castor oil (*Ricinus communis*), tung oil (*Aleurites cordata*), candlenut (*A. moluccana*), croton oil (*Croton* sp.), jatropha (*J. curas*), linseed (*Linum usitatissimum*), and sunflower (*Helianthus* sp.).

These trials were not very extensive and no efforts seem to have been made to encourage production of any of these species other than coconuts. The most favourable reports concern sesame and castor oil. Coconuts have been planted in the gardens and at other localities such as near the mouth of the Daly River and at Shoal Bay. Trees have grown well but termites have attacked most of them. Reports indicate that the coastal fringe is generally unsuitable and suggest that plantings should be made on light alluvial soils with fresh, non-stagnant water at shallow depths. Such areas are very limited in extent and it is unlikely that any large quantity of coconuts will ever be produced.

The cultivation of peanuts for oil production has not been practised because of the higher return from edible peanuts. Recently a trial of several varieties of rape seed has been conducted at Katherine by the C.S.I.R.O. Plant Introduction Section and initial results have been quite promising. Further investigation is warranted.

The reports concerning wheat crops suggest that there may be a possibility of growing linseed on suitable soil types by planting late in the wet season. As this crop has similar requirements to wheat, can be handled under extensive farming conditions, and does not require excessive labour, its possibilities should be determined, especially in view of the present shortage of linseed oil.

(xi) *Starches Other Than Cereals*

Cassava (Manihot utilissima).—This crop is adapted to the region but commercial production is not likely to be achieved in face of overseas competition unless greater demands for the product arise.

Arrowroot (Cana edulis).—Arrowroot has been successfully grown at Darwin where it has escaped from cultivation. Like cassava, production is restricted by the demand for the product.

(xii) *Rubber* (Hevea brasiliensis)

Climatic conditions do not seem to be satisfactory for extensive rubber production in this region. Plants have been successfully grown at Darwin and at Beatrice Hill near the Adelaide River but are likely to succeed only in isolated areas with favourable moisture relations, and no large-scale production can be visualized.

(xiii) *Sugar Cane* (Saccharum officinarum)

Large sums of money were expended in attempts to grow this crop on Cox Peninsula between 1884 and 1889, but these failed owing to unsuitable soils. More success was achieved at Shoal Bay, but repeated accidents over a number of years prevented much of the crop being milled. The grower subsequently left and little interest has since been taken in the crop except for minor attempts at Stapleton and Beatrice Hill. As the subsidized Queensland industry supplies Australia's requirements and labour would present a major problem in the Northern Territory, there appears no justification for further attention to this crop at this stage.

(xiv) *Fruits*

The most successful fruits grown in this region are bananas, mangoes, pineapples, papaws (Plate 21), and citrus fruits. Darwin has always offered a market for these fruits, but with the exception of pineapples during the years 1922 to 1930, when Verburg of Adelaide River produced large crops, the demand does not appear to have been fully met. Investigation of the problems affecting production of these crops would almost certainly lead to higher returns.

At Adelaide River and Katherine, there are indications in citrus of what appears to be a trace element deficiency disease (possibly zinc), while a disease of the lower portion of the trunk occurs at Katherine. The appearance of the pineapple crops at Katherine would suggest that fertilizer trials might indicate means of improving production, and the investigation of methods of inducing flowering would also be worth while. A blackening of the fruit of bananas (possibly physiological) was observed on the Daly River Settlement and this disease was responsible for the loss of much fruit on one farm. Many of the problems could, no doubt, be solved relatively easily, but in the absence of any advisory service growers are apt to become discouraged.

Production of these fruits will be restricted to irrigable areas, and thus mainly to the levees and nearby soils and to spring-fed alluvial flats. Increased production for local consumption should be encouraged, and if a better transport service to Adelaide is developed, there would be a place for limited production for southern markets.

Other fruits which might be grown for local consumption but with little scope for export because of their poor carrying characteristics are custard apple, mangosteen, sweet sop, avocado pear, and loquats.

(xv) *Vegetable Crops* (Plate 20, Fig. 2)

There has been ample demonstration both by private growers and by the Army vegetable farms that a wide range of vegetables can be grown in this area, especially during the winter season by irrigation. The huge output achieved by the Army farm has caused many observers to see therein vast potentialities for this region. While it is true that large quantities of vegetables could be grown, it is equally clear that this form of production cannot be the basis for extensive development. Northern markets accessible to this region are limited and could be supplied by a very few efficiently run farms. There is scope for some export of winter crops, e.g. tomatoes, to the south if satisfactory transport facilities are developed, but with keen competition from other sources even this outlet cannot be expected to induce any major increase in the rural population of the Northern Territory.

The most successful vegetable crops are produced under irrigation during the winter months. The most important crop is the tomato, which grows very well under these conditions and gives high yields. Other vegetables that grow well are cabbages, lettuce and other greens, cucurbits, and various root crops, including carrots, beetroot, radish, sweet potato, and, to a lesser extent, English potatoes.

Very few of these crops can be produced during the summer months. The major wet season vegetable crops are the cucurbits, sweet potatoes, egg fruit, and possibly sweet corn. There is need for further investigation, including plant introduction, to increase the range of acceptable vegetable crops suitable for summer production.

The production of vegetables throughout the year will always be an important factor in maintaining the health of the population of this region. For this reason alone this industry, like fruit production, deserves the help of an advisory service in order that growers may be assisted to overcome the many problems that will arise relating to soil fertility, insect and other pests, choice of suitable varieties, and the handling of the crop for marketing.

(xvi) *Palms*

A wide variety of palms have been grown at the Botanic Gardens at one time or another, including date palm, Chinese fan palm, toddy palm, Areeka palm, Palmyra palm, sago palm, Kettool palm, Gamuta palm, cabbage palm, bastard sago palm, Talipot palm, and betel nut palms. None of these species has shown sufficient promise to warrant agronomic investigation.

(xvii) *Miscellaneous Plant Species*

Numerous miscellaneous species of plants have been planted at one time or another in the Botanic Gardens, Darwin. They include Annatto,* gambier, patchouli,* divi-divi, cinnamon,* ginger, vanilla, nutmeg, pepper, citronella grass, turmeric, galangal root, tea, Liberian coffee,* robusta coffee, pyrethrum, tuba root,* Indian teak tree, vegetable wax, Carob tree, canary seed, rape.

Reports concerning these are very spasmodic. The species marked with an asterisk are the only ones about which favourable reports have been made, but none has been sufficiently enthusiastic or sustained to suggest that commercial production might be commenced. Material of the tuba root was distributed to peanut farmers in recent years. There is no indication at present that any of these crops could constitute a major industry in the region.

(*b*) *Animal Industries*

(i) *The Beef Cattle Industry*

Since the Advance Report of this survey was published, a survey of the beef cattle industry of Australia has been made by Mr. W. Beattie (Division of Animal Health and Production, C.S.I.R.O., Div. Rep. No. 5). Part I of this report deals with northern Australia. Some material that appeared in this section of the Advance Report has, therefore, been deleted and the reader is referred to Mr. Beattie's report for greater detail.

The total number of cattle in the region surveyed is approximately 50,000. Of these, half are concentrated in the Daly River basin and the country immediately west and north of it. There are 10,000 head on the "bull-dust" plains and the hills and ridges to their west and south, and another 10,000 on the northern sub-coastal plains and associated laterite areas. More than three-quarters of these are on one property west of the Adelaide River so that the bulk of the northern plains carry very few cattle. This area and the "bull-dust" plains country are well stocked by buffaloes. The cattle stocking regulations attached to leases in the "Buffalo Country", an area defined by Ordinance No. 19, 1935, were waived in that year.

The cattle industry is still in a primitive stage of development. The variable nature and the low carrying capacity of most of the country have led to properties of large size which, under these conditions, are difficult to manage and develop. During the wet season, flooded streams and flats limit the attention that can be paid to stock while the poor condition of pastures during the dry season restricts the movement of stock to a short period. As a result, cattle are to a large extent out of control.

Although economic factors have been important in limiting the development of the industry, an equally important factor is the annual long period of inadequate nutrition towards the end of the wet season and throughout the dry season.

The tall grass pastures occupying most of the cattle country deteriorate in nutritive value to such an extent during the dry season that they do not provide even a maintenance ration. At this time, apart from some sections of the sub-coastal plains, stock depend mainly upon feed provided by flooded flats, small spring-fed areas, the margins of water-courses, and the areas adjacent to lagoons and billabongs. Such areas occupy only a small proportion of properties and are often widely scattered. In general, stock are raised on a low and fluctuating level of nutrition, and this is reflected in high mortality, low carcase weights, poor quality beef, and late maturity. In consequence, not only is the average return per unit area low, but station development costs are high, and much of the country is not fully utilized. At present there is no proved method whereby the nutritive level of the pastures of the region can be raised economically over large areas.

The cattle industry occupies and will probably continue to occupy the major part of this region. The problem of seasonal starvation is common throughout. It warrants intensive investigation. Irrespective of what may be done with regard to transport or markets it is this which limits carrying capacity, delays the maturity of animals, and prevents full returns being gained from efforts to improve the quality of the herds.

If there should be developed a stable market accessible from this region, an increase in total stock numbers within the region can be expected and the percentage of the herd marketed each year should rise. The latter figure is at present very low and probably does not exceed five per cent. Any estimate of the numbers of cattle that could be carried can be only approximate. In the absence of any major forms of pasture improvement but assuming a reasonable standard of property development the number of stock from this region available for killing is likely to vary from 5,000 to 10,000 per annum, depending upon the extent to which the margins of the sub-coastal plains are utilized, and upon the demand from within the region. If an agricultural development of any great magnitude is achieved within the region, it should provide scope for fattening at least a proportion of the available store stock.

In the absence of any revolutionary change in the pastures, it is unlikely that the number of stock within this region could alone maintain adequate supplies to a killing works of an economic size. Hence, if it is intended to develop the cattle industry in this portion of northern Australia to the full, it would appear axiomatic that with it must be linked, in a broader development plan, the production potential from other regions within reasonable proximity.

(ii) *The Dairying Industry*

Dairy cattle were introduced into this region following the transfer of the Northern Territory to the Commonwealth and animals were distributed to the Daly River Settlement, Oenpelli, and Stapleton. Herds were subsequently established at the last two locations and in Darwin. A milk supply was available to Darwin for a period and butter was manufactured both at Oenpelli and Stapleton. The industry, however, did not persist.

There appears to be no fundamental reason why a small dairying industry should not be established and maintained if the supply of fresh milk to Darwin is considered a worth-while objective. As with the beef cattle industry, the provision of adequate nutrition throughout the year will be a major problem. Available evidence concerning crops suggests that, with conservation of fodder, an adequate diet can be provided, but particular attention will need to be paid to the production of high-protein crops.

There are several small scattered areas adjacent to the main road on which dairy farms might be established, but it would be wise to concentrate the industry in one area to facilitate supervision and organization.

Five to ten small, efficient farms should supply Darwin's initial requirements. The most satisfactory location for these would be on the levees of the Katherine or Adelaide Rivers where dairying could be run in conjunction with mixed farming, including irrigated crops. In either location, a quick transport service to Darwin would need to be organized.

In considering the provision of milk supplies to stations or small settlements, attention should also be drawn to the possibility of using higher milk-producing strains of goats than those in common use. For station properties and also on many farms, these animals are likely to prove more satisfactory than dairy cattle. A source of good quality animals in northern Australia could have widely felt benefits.

(iii) *The Buffalo Industry* (Plate 13, Fig. 2)

Buffaloes are the main grazing animals in the region between the Adelaide and East Alligator Rivers. Introduced to Melville Island in 1824 from Timor, they were left behind when the Military Post was abandoned, and have since extended to the mainland and multiplied considerably. They once occupied a much larger area, but very few buffaloes now exist west of the railway line. The total number of buffaloes in the region can only be estimated but it probably equals the total number of cattle.

The animals are shot for their hides and the average number of hides exported annually during the period 1914-41 was approximately 6,500. The view has been expressed at various times that their numbers were being rapidly reduced. However, the number of hides shot shows no marked downward trend and it is reasonable to suppose that their numbers have been maintained. Two periods when hunting practically ceased have no doubt contributed to this. The first was after the First World War, when prices of hides fell so low that hunting was not profitable. The second was during the recent war years when manpower was not available.

Holders of pastoral leases and grazing licences in the "Buffalo Country" make buffalo shooting their major occupation and this provides a payable alternative or addition to the cattle industry. In fact, it has been the means by which some cattle properties have been financially maintained. When prices for hides are high it is probably the most prosperous industry in the region.

The suggestion that these animals should be tamed and the industry run along lines similar to the cattle industry does not appear to be practicable. The domestication of small groups is no doubt feasible, but to maintain them in this condition, and to develop from them large herds of controlled animals, would be fraught with difficulties both practical and economic. While wild buffaloes existed, domesticated animals would tend to revert to their wild condition. The construction and maintenance of fences on the flooded heavy clay plains to control the animals would almost certainly prove an insurmountable difficulty.

The buffalo is ideally adapted to the swampy Sub-Coastal Plains. It is prolific, mortality appears to be low, and reports indicate that the animal is relatively free of disease and pests. However, an extension of this industry would not appear to have an important place in plans for further development of the region.

(iv) *The Horse Industry*

This industry is of importance only because of its relationship with the cattle and buffalo industries. In both industries the use of horses is largely confined to the dry season when natural fodder is at a very low nutritional level. In consequence, the period over which horses remain in sufficiently strong condition is short. Buffalo shooters have imported fodder from southern States to maintain their shooting horses in better condition, but otherwise no effort has been made in this region to supplement the natural pastures. Elsewhere in northern Australia, e.g. on the Fitzroy River of Western Australia, sheep stations have found conserved natural hay to be useful to maintain horses in condition for a longer period. Supplementary feeding is not generally favoured by cattle stations because of the difficulty of transporting the feed to outlying mustering camps. Instead, they rely on a number of "plants" of horses which are each worked and rested alternately for short periods during the mustering season. On portions of the Sub-Coastal Plain dry-season fodder is of much better nutritive value and horses can be worked for longer periods.

Draught animals are not common in the region and their use for heavy farm work would require special attention to feeding. However, farms on which they were to be used could grow quite satisfactory crops for this purpose.

(v) *The Pig Industry*

There are no extensive records concerning pig production in this part of the Northern Territory. Pigs have been raised on a small scale and appear to be well adapted to the region. In many localities they now run wild.

If a killing works equipped for the slaughtering and processing of pigs was established in the region this industry might develop considerably, not only as an alternative source of income for farmers supplying the local market but also as an export trade.

Apart from the health of the animals, about which few records are available, the most important factor requiring investigation is the provision of an adequate diet for the production of good quality carcases. If the growing of grain sorghums on an extensive scale proves feasible this cereal could provide a satisfactory source of carbohydrates. In addition, adequate animal protein must be available to supplement this diet. It is doubtful if this could be imported economically but it could be supplied locally if there were killing works within the region. These components, combined with other crops, should constitute a satisfactory nutritional basis. Whether or not exportable carcases can be produced from existing breeds under these climatic conditions needs to be determined.

(vi) *The Poultry Industry*

The poultry farms run by the Army during the war years demonstrated that fowls can lay satisfactorily within this region if an adequate diet is maintained. As with the pig industry, if there were killing works in the region supplying a source of animal protein, it may be possible to supply a satisfactory diet from locally grown products, with grain sorghums supplying the main carbohydrate requirements. Under these conditions the local demands should be easily met. The possibility of an export trade should not be overlooked but the economics of production are factors that require examination.

(vii) *The Bee Industry*

The Army Experiment Farm at Katherine successfully maintained a healthy and productive apiary for several years. Heat, ants, and predatory birds were initial problems, but these were successfully overcome and there appears no reason why local requirements of honey could not be supplied from within the region.

(viii) *General*

The under-developed nature of the animal industries in this region is a direct consequence of the natural difficulties of the environment. Added to this is a lack of knowledge concerning animal husbandry and production under these conditions. The quality of the product is poor and this, in combination with the absence of adequate communications and transport facilities, has prevented the satisfactory disposal of the product. In consequence, the returns are low.

The animal industry, particularly beef cattle, theoretically occupies this and related portions of northern Australia and is likely to remain in possession for many years to come. If this occupancy is to be stable and profitable, steps should be taken to place the industry on a much sounder basis. In order to do this, two groups of interrelated problems require thorough investigation. They concern the provision of:

(i) An adequate diet for the animals; and
(ii) A satisfactory type of animal to use it efficiently.

V. Future Development of Land Industries

The region surveyed does not present any possibilities of easy development. A review of the history of this portion of the Northern Territory indicates that, in spite of many efforts on the part of both governments and individuals over a long period of years, no prosperous industry of any magnitude has developed. There is no reason to believe that the individuals who were concerned with these attempts were in any way less sincere or less able than those who made a success of pioneer ventures in other parts of Australia. In fact, a perusal of past records indicates a most valiant spirit on the part of many of the early occupants.

Nor is it true that the financial support provided was any less than that for other areas at a comparable stage of development. In many respects money has been wasted. Carried away by the rapidity of growth during the wet season, and the illusion of tropical splendour, many of the early inhabitants painted a false picture of fertile lands of great potentialities. The inevitable failures led to disappointment, discouragement, and distrust.

(i) *Factors that have Retarded Development*

The long-continued series of failures can be explained mainly in terms of the natural and economic disadvantages of the region. Briefly these are:

(1) Major natural problems of production, contributed to by a formidable climate, unsatisfactory soils, uncontrollable hazards such as floods and regular seasonal droughts, pests, and wide variations in topography and land types which provide their own problems with respect to communications, property management, and land utilization.

(2) Unfavourable economic conditions, including isolation from markets and high transport costs for both imports and exports, inadequate and erratic markets, and the lack of organized transport and marketing facilities.

(3) Unattractive social and living conditions that have deterred many of the progressive type of individual from persisting in their efforts in this region. In this respect the absence of white women on the Daly River Settlement and many of the pastoral properties is itself of considerable significance.

(ii) *Essential Factors for Future Development*

Some main essentials before distrust of the region can be removed and successful development can be expected are:

(1) Demonstration, following adequate investigation, that stable production can be achieved.

(2) Adequate and regular markets for those things that can be produced successfully.

(3) Organization of transport and marketing to minimize costs and reduce the hazards.

(4) Assurance that the foregoing can support a standard of living, and, with government assistance, social conditions adequate to attract, and hold, a virile population.

In this connection an important fact is that *the region does not possess a population adequate for its own development.* This population must be attracted. It must be drawn from other sources in the face of competition from much more congenial and economically far more stable and attractive conditions. For this reason the pattern of development in this region should not be compared with, as is often done, or follow, such world-recognized schemes as the Tennessee Valley Authority.

A benevolent government can do much to assist in overcoming economic and social disabilities. Financial assistance, concessions, and provision of amenities can help to alleviate the hardships under which residents of such an isolated and inhospitable region live. These alone, however, are not sufficient to attract and maintain a permanent population. *The successful and stable production of economically marketable products can alone constitute the real basis for continuous occupation and sound development.*

In spite of all the efforts of the past, it is clear that, before any assured form of economic development can be advocated, still further research and experimental work must be undertaken. Innumerable problems of production remain to be solved. Apart from elementary trials nothing has been done towards this objective.* The continuous series of failures in the past are adequate warning that answers to these problems must first be found before further development is attempted. These can be achieved only by a sustained investigational programme. The unknown factors are numerous and it could not be expected that, in a region with limited potentialities, investigation facilities sufficient to cover all problems of all possible forms of production could be provided. It becomes necessary, therefore, to relate the research programme to a plan of development which the present survey would indicate is the most logical one and the one with the greatest likelihood of success.

(iii) *Interdependence of Industries*

In the past, the exploitative methods characteristic of the pioneer phases of development of all countries have been attempted. Efforts have been made to establish individual forms of production with an immediate market. None has been really successful and, apart from mining, only four industries have been able to persist by providing products of direct marketable value, namely, beef cattle production, buffalo hunting, peanut production, and fruit and vegetable production. Each of these industries has fluctuated between near prosperity and near failure, and none has attained a degree of prosperity and stability that would provide any hope for major expansion under existing circumstances.

In this exploitative phase some forms of production without an immediate market have been neglected. In Section IV it has been suggested that grain sorghums might be grown extensively in the region. The grain of sorghums has no immediate market in this region and has not been sufficiently valuable in the past to pay export costs. Not being used for human consumption in this country, it must first be converted into animal products before production can be justified. It has further been suggested that this grain might represent a satisfactory source of carbohydrates for pig and poultry industries, but these industries also require

* Since this survey was completed, C.S.I.R.O. has established a Research Station at Katherine and experiments with crop and pasture species have been initiated.

an adequate source of animal protein to balance the carbohydrate ration. Freight charges on imported animal protein could prohibit its use in these industries, but this position might be overcome if there were a meat killing and processing works operating within the region. The protein by-products of such a works, in combination with carbohydrates from sorghums produced locally, could provide a sound basis for the establishment of both the pig and poultry industries. It is probable that neither of these animal industries nor the production of grain sorghums could be established and maintained in the absence of local processing of the products of the beef cattle industry.

This interdependence of industries applies more generally. The forms of production most naturally suited to the region are not necessarily those of which the products can be immediately exported. The conversion of these products into some other form before export is possible may be an essential factor in development. This calls not only for research into the problems of production but also for the planning and coordination of all phases of development of primary and secondary production.

(iv) *Concentration of Agricultural Development*

One of the unfortunate features of past efforts, no doubt due to the paucity of information concerning the region and its climate, was that they were dissipated over a wide area and in many localities. Thus it was impossible to concentrate sufficient experimental, advisory, or communal services at any one place. With the recorded failure of such efforts to guide us this mistake should not be repeated.

It is recommended, therefore, that future development should take as one of its major objectives the establishment wherever possible of compact communities of sufficient size to permit the provision of communal services and amenities, and based on forms of production that have been demonstrated previously to be successful.

The achievement of such a plan would make the organization of transport and marketing easier, while educational, medical, and recreational welfare—all essential factors in holding a population—would be more easily cared for. The existence of a population nucleus would itself be an advantage to the region as a whole, as it would be a centre providing many facilities for the large and more isolated pastoral properties, and would eventually become a source of labour for their further development. Research into production problems would be simplified, as it would be concerned with the problems of reasonably homogeneous sections and a limited range of types of production. Once the major problems of the community were solved the research establishment could apply its facilities and accumulated experience to problems of areas further afield, thus gradually bringing them into the production sphere.

The establishment of such a community requires a form of land utilization based on agriculture or an intensive form of animal industry. This in turn necessitates a reasonably large area of land of satisfactory quality and uniform nature. The land and climate of the area must be capable of sustaining production, and the areas chosen must be accessible and adequately supplied by transport and other facilities.

(v) *Irrigation Possibilities*

With the restricted season of adequate rainfall (14-20 weeks) the possibility of modifying the environment by irrigation must be considered. The use of irrigation water reduces the hazard of erratic rainfall and also makes possible the production of crops during the rainless period. On the other hand, it raises costs of production so that only crops giving a high financial return per acre can be economically produced. Thus the choice of crops is restricted.

Physical requirements for irrigation are:

(1) A reliable water supply that can be diverted or pumped.

(2) A reticulation system to carry water to areas of suitable soils.

(3) The existence of soils suitable for irrigation in areas of sufficient size to justify reticulation.

Irrigation by pumping is practised to a small extent in the Katherine and Daly River Settlements, at Adelaide River, Commalie and Hayes Creeks, and Berrimah. In all cases the areas irrigated are small and are used almost entirely for vegetable and fruit production for local markets. The area available for irrigation by this method is limited and, with the exception of the poor lateritic soils at Berrimah, which are watered by tapping the Manton Dam supply for Darwin, is restricted to levees and associated creek or river flats. The total area of such suitable soils that might be irrigated by pumping from natural water supplies is almost certainly less than 20,000 acres; and this area irrigated during the dry season could exhaust the normal dry season stream flow.

Further, irrigation by pumping is likely to be of limited economic use as a lift of at least 40-60 ft. is required in most locations during the dry season. This is economically possible only when high-return crops can be grown. The supply of fruit and vegetables to the local markets would require only a small proportion of this area. If full use is to be made of it, some high-return exportable product must be grown.

In Section II (*e*) it has been indicated that satisfactory combinations of water conservation sites with associated areas of irrigable soils suitable for large-scale irrigation schemes do not occur in the region, and therefore no recommendation along these lines can be made. It is possible that, if the production of hydro-electric power warrants the construction of water conservation structures, spent waters might be used for irrigation on one or more of the following soil groups:

(*a*) residual soils on slopes near the potential water supplies.

(*b*) alluvial flats, generally liable to seasonal flooding.

(*c*) estuarine plains, subject to seasonal flooding.

In the absence of topographic surveys it is not possible to delineate areas of residual soils that might be commanded by water, but where they occur near rivers, levels appear to rise away from the streams and most of these soils are therefore unlikely to be easily commandable. Further, these upland soils in general do not appear suitable for irrigation. The only residual soil well suited is the Limestone Red soil. Some of the sandy soils may be satisfactory for spray irrigation.

The soils of the alluvial flats and estuarine plains are both naturally flooded during the wet season. Irrigation by control and extension of this flooding may be possible in some localities. The estuarine plain has a heavy clay surface and is subject to deeper and more prolonged flooding. It would be much more difficult to utilize than the flood plain alluvia.

In view of the uncertainty of any large-scale schemes and the fact that even if any proved feasible, many years must elapse before the preliminary investigations and construction could be completed, it would be advisable at this stage to concentrate investigation on dry-land agriculture. For the present the extension of irrigation should be confined to the supply of water by pumping to the levees and suitable adjoining soils for the production of intensive crops.

(vi) *Areas in Which Agricultural Development may be Possible*

This survey has made it possible to indicate those sections of the region that have the greatest possibilities of agricultural development. Of the five sections discussed below the first two have the greatest potential and are the only ones in which immediate investigations are recommended.

(1) *Upper Daly River Section*

This section, which appears to have the greatest agricultural potentiality, includes the Tipperary Land System and a narrow belt of the adjacent Cullen Land System. Much of it is readily accessible from Katherine, Pine Creek, or Brocks Creek, but the portion south-west of the Daly River at present can be reached only during the dry season and by fording the Daly River at one of the few existing crossings.

Physically and topographically the deeper soils of this section are satisfactory for arable agriculture but their assessed fertility is only low to moderate. Of the total area of about 7,000 square miles, only a small proportion is covered by these deep soils, the remainder being occupied by rock outcrops and shallow, stony soils. The actual area of arable soils can only be assessed by more intensive soil surveys. Such a survey has been attempted in the vicinity of Katherine by W. Arndt. This has indicated that about 10 per cent. of the area within 25 miles of that township is arable. Using this figure, the very approximate estimation for the whole section is 500,000 acres of arable land.

Irrigation within this section is likely to be restricted to the small areas of river levees, which may be watered by pumping from the permanent streams, and on which an intensive form of agriculture, possibly including tobacco production, should be developed. Agricultural development in the remaining and larger portion of the area must depend upon rainfall alone.

The average annual rainfall of this section is 35 in. or more, increasing to the north-west. If summer rainfall is considered to be only half as efficient as rainfall of the winter rainfall regions, then this area has as its counterpart the extensively farmed wheat areas of the southern States. If this is so, it may be possible to establish here under dry-land farming a comparable system, but growing summer crops in place of winter cereals. Total annual rainfall is, however, only one criterion of the effectiveness of rainfall. The length of growing season and reliability are equally important. The growing season at Katherine is relatively short, and the time of commencement of the season varies (see Section II (*b*)). Drought years, however, are infrequent. The length of season increases towards the north-west. On the whole, the region must be considered, climatically, to be near marginal so far as dry-land agriculture is concerned, and its actual potentialities can only be determined when factual information concerning various types of crops is available from well-conducted field trials.

Utilization of this area under dry-land farming would no doubt involve some form of extensive mechanized system of agriculture, as high production per unit area cannot be expected and labour is likely to be scarce and costly. Further, a permanent system of agriculture would almost certainly require that the extensive harvest of crops should be linked with the animal industries either directly or in a system of rotation, in order that soil structure and fertility might be maintained. Thus short-term pastures or cultivated fodder crops for cattle grazing might be an essential part of such a system. The erosion that is occurring on levee soils of the Katherine River following continuous cropping of peanuts is a warning in this direction.

It is recommended that experiments to obtain factual information concerning the production of a variety of crops and fodders under dry-land conditions, on four major soils, and over a period of several years, should be commenced. The four soils in order or preference are Red Limestone soil, Elliott Creek soil, Deep Red Sandy soil, and Sandstone Lateritic Podsol. Only in this way can the economic possibilities and the problems of dry-land farming in the area be accurately assessed.

(2) *Lower Daly River Section*

Within the Lower Daly River Section of the Western Fault Block subdivision, there are several areas with some agricultural potentiality, which are grouped for consideration on the basis of their geographical occurrence. They include the Elliott Creek Land System, that portion of the Litchfield Land System in the vicinity of Mt. Litchfield, and a small neighbouring portion of the Brocks Creek Undulating Land System.

This section is generally less accessible than the Upper Daly River Section, particularly during the wet season. It can be reached by tracks joining the road from Adelaide River or by sea via the Daly River estuary.

In some respects this section has greater agricultural potentialities than the previous one. A much larger proportion of the area is potentially arable and of the total of approximately 500 square miles, probably 100,000 acres could be cultivated. This would include some soils of low fertility. The rainfall is higher and the growing season longer than in the Upper Daly River Section and it is likely that underground water supplies may be more readily available.

The form of land use in this section would follow that proposed for the previous section but the higher rainfall and the possibility of small-scale irrigation by pumping underground water may permit a more intensive development. The association of agriculture with the animal industry may be aided by the close proximity of large areas of flooded Sub-Coastal Plain which provide good dry season grazing.

Because of the greater isolation of this section from present centres of population or communication, and the fact that similar soils occur in the Upper Daly River section, initial agricultural investigations can be more readily conducted in the latter, and recommendations are made accordingly.

(3) *"Bull-Dust" Plains*

In the Marrakai and Finniss Land Systems there are extensive areas of alluvial plains which are liable to flooding each wet season for periods up to three or four months. They are generally unsatisfactory for usual forms of agriculture but may have potentialities for the production of rice under conditions of controlled natural flooding and mechanized farming. Past records suggest that rice has been satisfactorily produced on soils similar to these although the actual soil types have not been indicated. Commercial rice production would almost certainly require the application of fertilizer. Cost of production therefore would have to be seriously considered. The period, extent, and reliability of flooding cannot be judged from a dry season survey but it is likely that at least some areas may prove satisfactory and there is the possibility of partial control and extension of the period of flooding.

An estimate of the actual area that might be used would require a detailed topographic and engineering survey. The total area of the two land systems is 1,040 square miles. About one half represents plains country of which only a portion could be utilized in this way.

Associated with these plains are small areas of levee soils along the major rivers. Near Adelaide River township such areas are cultivated for the production of peanuts, fruits, and vegetables. Should it be proved practicable to utilize the plains of this section, these levees may form valuable focal points from which development may proceed. It is recommended that the use of these plains for rice production should be examined, and that initial investigations should be conducted in the more accessible portions near Adelaide River.

(4) *Tertiary Lateritic Soils*

The Tertiary Lateritic soils in the northern part of the region are of good depth and are topographically and physically suitable for cultivation. They have the further advantage of an annual average rainfall of 50-60 in. and portions are readily accessible from Darwin. However, these advantages are offset by low fertility and fairly heavy tree cover. Irrigation does not appear to be practicable, except on a very small scale, e.g. for vegetable production. Use may be found for these soils for special crops warranting application of fertilizer and the higher cost of clearing, but at present their development does not appear feasible.

(5) *Sub-Coastal Plains*

The Sub-Coastal Plains are flat areas of heavy-textured or peaty soils which on first sight give the impression that they may be of agricultural value. On further consideration numerous disadvantages become apparent. The plains are flooded deeply for several months each wet season by high rainfall and accumulated runoff from higher areas. During the dry season the peaty soils remain swampy. The remaining heavy clay plains dry and crack severely. Apart from small marginal areas, wet season drainage or protection from flooding does not appear practicable because of the nearness to sea-level. In any case the whole area is liable to receive up to 5 ft. of rainfall in a five-month wet season, a quantity sufficient to waterlog these heavy-textured soils. Normal forms of agriculture therefore appear to be impossible. The only use which might be considered is rice culture. However, the natural vegetation thrives under the flooded conditions and would constitute an extremely difficult weed problem. Cultivation during the dry season would require exceedingly high tractive power, and when the soils are wet would present almost insuperable mechanical difficulties. Hence no recommendations for agricultural investigations are made with respect to this section.

The remaining sections of the region are either inaccessible or do not have sufficient areas of deep soils to warrant any special agricultural investigations.

(vii) *Further Development of Existing Agricultural Areas and Their Use as Focal Points for Investigation*

At the present time, agriculture is restricted to small settlements at Katherine, Daly River, and Adelaide River, with a few market gardens in favoured localities along the north-south highway. For the most part, these settlements, totalling 20 to 30 farms, are located on the irrigable levee soils referred to in (v) above but not all farms are irrigated.

Except for vegetable and fruit production, present agriculture is based on a one-crop system, namely peanuts following peanuts. It has already been demonstrated that peanuts, vegetable crops, certain fruits, and fodder crops can be successfully grown. Tobacco also grows reasonably well but has not been produced commercially at Katherine, although one farmer on the Daly River has supplied a local market with plug tobacco for several years.

Although the total area of such irrigable land would not be great, there is the possibility of development of a more intensive form of agriculture to supply local markets and provide for some exports.

Investigations of these lands should aim at establishing a system of mixed farming, utilizing irrigation for high-return crops grown in rotation with wet season or partially irrigated crops or pastures. Amongst the high-return crops necessary to pay for the high lift of irrigation water, tobacco deserves particular attention. As with the dry-land areas it would be of considerable advantage to link these with animal production. The levees are subject to erosion, particularly where they have been continually cultivated. Many animal authorities consider that there are no insurmountable bars to the successful development of the pig, poultry, and dairying industries to supply local demands and that there are prospects of development of these also on a large scale. Small-scale cattle fattening might also be successful as a side line. The period of establishment of these industries to supply the local market could enable sufficient information to be gained to determine the prospects of contributing to an export trade.

The general possibilities which should be considered for these levee areas include:

(1) Supply of local markets with vegetables, local fruits, dairy produce, poultry produce, and pork and bacon.

(2) The possibility of small-scale export to the south of winter-grown vegetables, especially tomatoes and possibly citrus fruits.

(3) Small-scale canning of excess production (especially tomato juice) for consumption during the wet season and on outback properties with the possibilities of a small export trade to the north.

(4) Production for export of such crops as tobacco and peanuts, and special semi-tropical crops.

It is not to be anticipated that the total production from these levee soils would be of any great magnitude. However, they do offer definite possibilities for the supply of many products to a local market, the demands of which are either not met or are met only by the payment of high freight charges from the South. A successful development of these areas could do much to improve the general welfare of the population of Darwin, and together with the development of dry-land agriculture if the latter is proved successful, would form the basis for a worth-while compact community.

As these levees are associated with areas considered worthy of further attention, they will also serve as satisfactory focal points from which investigation might be conducted.

Several small farms have been established on lateritic soils in the Berrimah area, near the water pipeline that supplies Darwin from the Manton Dam. The soils in this area are not attractive agriculturally and under intensive farming will require the application of considerable quantities of fertilizers. The availability of water makes their use for intensive small crops possible, but they should not be considered for major development.

VI. Proposed Investigation Programme

(a) *Summary of Factors Likely to Influence any Developmental Plan for the Region*

To indicate the problems most urgently needing field investigations, it is necessary to present the factors likely to influence a plan for the development of land industries. These include:

(i) The location of meat processing works in the region could provide:

(1) A regular market for fat cattle from the region, thereby removing one of the major factors at present restricting the development of this industry;

(2) An outlet for scrub and cull cattle, thus removing one of the major factors restricting herd improvement;

(3) A market for a pig industry, thus creating an outlet for summer cereals that might be produced in the region;

(4) By-products, at a reasonable cost, for local use, such as animal protein necessary for the pig and poultry industries, and fertilizers for intensive agriculture.

(ii) The data presented warrant attention being paid to the possibilities of establishing an agricultural community initially concentrated, as far as possible, in one section so that communal and social services may be provided. The nature of the products must depend upon further investigations, but it is visualized that production might be based on:

(1) Exportable crops such as tobacco, peanuts, and possibly rice, cotton, oil, and fibre plants;

(2) Fodder and grain crops for use in the animal industries which could include farm fattening of beef cattle, dairying to supply local markets, pig raising, and poultry and egg production;

(3) Vegetable and fruit crops, primarily to supply local markets but with the possibility of an export trade for certain products to the south and, at a later date, the use of surplus production of certain crops in a small canning industry.

(b) *Specific Subjects Requiring Investigation*

The fields of investigation that require more urgent attention are:

Crops

(i) The general possibilities of economic crop production under natural rainfall conditions should be investigated in the Tipperary, Elliott Creek, and Litchfield Land Systems. Because of its greater accessibility and proximity to existing transport facilities it is recommended that initial investigation should concern the Tipperary Land System.

These investigations should cover a wide range of crops including fodder crops, summer cereals, tobacco, peanuts, cotton, and oil and fibre plants. They should be designed to obtain factual information concerning production and to determine which crops, if any, can provide a stable and economic return on the major soils of these land systems.

(ii) A thorough exploration of tobacco growing under all likely conditions should be made. As tobacco is one of the few high-return exportable crops that may be grown in this region, a serious and sustained attempt should be made to establish the industry.

(iii) The existing peanut industry should be investigated with the object of achieving greater and more regular production, and of developing a system of mixed farming in place of the present one-crop system.

(iv) The growing of rice on the "bull-dust" plains under natural flooding should be examined and the possibilities of controlled flooding by the construction of low banks determined. As the plains near Adelaide River township are the most accessible, it is recommended that investigations should be begun in this locality.

(v) Production problems concerning fruits and vegetables should receive attention. These crops are already grown at a number of locations and a considerable amount of information and experience has been accumulated by growers and by Army farms concerning various crops and varieties. This information is not available in printed form for the benefit of growers, nor is there an advisory service in existence.

Pastures

(vi) The problems of pasture improvement and pasture management should be investigated and extensive testing of pasture grasses and legumes should be commenced with the major object of improving stock feeding conditions during the dry season.

Stock

(vii) Following the results of trials with summer cereals and other crops, the possibility of producing a type of pig satisfactory for the local and export trade should be examined. Initially it would be necessary to import animal protein for these experiments.

(viii) The problem of breeding efficient and satisfactory types of beef and dairy cattle adapted to conditions in northern Australia should be examined. (It is not suggested that this should necessarily be done within the area which was the subject of this survey.)

(ix) A small herd of dairy cattle should be established and the problems associated with milk production, based on locally grown crop products, investigated.

More Detailed Surveys

(x) If any of the initial crop investigations should give favourable results, a more detailed soil and vegetation survey of selected areas should be conducted before the settlement and utilization of these lands are planned.

Advisory Services

(xi) It is considered that an Agricultural Extension Service should be established and that this should work in close cooperation with the C.S.I.R.O. research staff.

(*c*) *Duration of Investigations*

Past experimental work in the region has been confined to intermittent trials at the Darwin Botanic Gardens, investigations over a short period of years at the Batchelor and Daly River Demonstration Farms, occasional trials and farmer's plantings elsewhere and, more recently, fruit and vegetable trials on Army farms.

The establishment of investigations in this region presents problems greater than in similarly developed regions in the southern part of the continent. Records indicate that for a number of reasons experimental work in the past has failed to solve the problems of the region. For example, the Demonstration Farms were adversely affected by circumstances associated with the First World War and its aftermath.

If an investigation programme is initiated it should be in accordance with a plan that it will be continued for a long period. In this region many failures must be expected, but it is only by learning the cause of failures that success can be achieved. The regularity and relative reliability of the wet season in this region are assets that it should be possible to use to the region's economic advantage. A well-planned programme of investigation may indicate how this can be done in a short period of years. On the other hand, unknown factors are so numerous that this period may only serve to define the real problems, solutions to which must then be found before the basis of sound development can be demonstrated.

(*d*) *Katherine Research Station*

The Army experiment farm at Katherine was transferred to C.S.I.R. in May 1946, and has been established as a C.S.I.R.O. Research Station.

The Station is well placed geographically. It is situated within the Tipperary Land System. The Station itself is confined to the levee soils of the Katherine River but additional areas of major soil types have been acquired in the district and experiments have been begun.

The main north-south highway, which passes the Station, provides easy access to the higher rainfall country of the north, including the "bull-dust" plains near Adelaide River, and the low rainfall country of the south. Katherine is a landing point for planes flying to the Kimberleys and the Barkly Tableland as well as to Darwin, Brisbane, Adelaide, and Perth.

Climatic conditions at Katherine are somewhat less unpleasant than those at Darwin, the only other major centre of population in this portion of the Northern Territory. The population of Katherine is small but it is expected to grow to a sufficient size to provide reasonable communal amenities.

The annual average rainfall at Katherine is 35-40 in., which will probably prove the lower limit for arable agriculture in this region. The Katherine River provides adequate water for irrigation for a small intensive settlement on the river levee.

The existing C.S.I.R.O. Research Station therefore constitutes a satisfactory base for agricultural and pastoral investigations in the northern part of the Northern Territory and is also well placed for the coordination of other investigations in this portion of northern Australia.

VII. Acknowledgments

It is desired to acknowledge the help received from many Government Departments and individuals during the course of the survey and in the preparation of this report. The Department of the Army assisted in many ways during the organization of the party and in the provision of vehicles, equipment, and supplies from Darwin depots. Aerial photographs were made available by this Department and two members of the Army Survey Corps were attached to the party for the purpose of making astro-fixes. The R.A.A.F. provided a plane and crew for aerial reconnaissance.

In the formation of the survey party, the Commonwealth Bureau of Mineral Resources made available the service of Mr. L. C. Noakes as geologist, while the Queensland Department of Agriculture and Stock seconded Mr. S. T. Blake as systematic botanist.

During the preparation of the report reference has been made to official reports of the Northern Territory Administration and to files and survey data made available by the Department of the Interior. The maps were prepared for publication by the National Mapping Section of that Department. Meteorological data were made available by the Central Meteorological Bureau.

SUMMARY OF THE MAIN CHARACTERISTICS OF THE LAND SYSTEMS OF THE KATHERINE-DARWIN REGION

Geomorphological Unit, Land System, and Area	Geology	General Topography	Major Soils	Major Vegetation Communities	Characteristics of Agricultural Importance	Agricultural Potentialities
Northern Lateritic Plains						
(1) Charles Point 335 sq. miles	Lateritic formations on shales, sandstones, and limestones (Port Keats and Mullaman Groups)	Gently undulating plains, widely spaced streamlines	Tertiary Lateritic Red Earths and Tertiary Lateritic Podsols	Tall Open Forest or Mixed Open Forest	Soils are arable but highly leached. Moderate tree cover. In higher rainfall area	Low fertility and cost of clearing likely to limit agriculture to small areas for special crops where water is available for irrigation
(2) Koolpinyah 3810 sq. miles	Lateritic formations on shales, (Mullaman Group), metamorphics (Brocks Creek Group), and granites	Gently undulating plains, with widely spaced streamlines	Tertiary Lateritic Podsols, some Tertiary Lateritic Red Earths	Tall Open Forest	Soils are arable but are sandy, highly leached. In higher rainfall area	Soils are poorer than those of Charles Point Land System, generally less suitable for agriculture
(3) Bynoe 280 sq. miles	Dissected lateritic formations on shales (Mullaman Group), metamorphics (Brocks Creek Group), and granite	Complex of lateritic residuals and moderate to steep-sided dissection valleys with narrow bottoms	Tertiary Lateritic soils, gravelly truncated soils, some "Acid" Alluvial soils	Mostly Palm Scrub and Open Forests	Broken topography and variable leached soils, not generally suitable for agriculture	Small, isolated areas of alluvial soils might be developed for horticultural crops

SUMMARY OF THE MAIN CHARACTERISTICS OF THE LAND SYSTEMS OF THE KATHERINE-DARWIN REGION (*continued*)

Geomorphological Unit, Land System, and Area	Geology	General Topography	Major Soils	Major Vegetation Communities	Characteristics of Agricultural Importance	Agricultural Potentialities
Elevated Lateritic Residuals						
(4) Mullaman 415 sq. miles	Lateritic formations on shales (Mullaman Group), underlying geology variable	Flat-top tablelands bordered by steep dissection slopes	Tertiary Lateritic Red Earths, sometimes truncated on tablelands. Skeletal soils on dissection slopes	Tall Open Forest on tableland Mixed Open Forest on slopes	Broken topography, leached or stony soils not suitable for agriculture	No agricultural prospects
Elevated Backbone Country						
(5) Brocks Creek Ridge 1560 sq. miles	Strongly folded slates, quartzites, etc. of Brocks Creek Group	Sharp north-south ridges and hills	Rock outcrops and skeletal soils	Deciduous Open Forest and Mixed Open Forest	Steep topography, with shallow soils, not suitable for agriculture	Agricultural development will be restricted to small areas of alluvial soils
(6) Brocks Creek Foot-hill 2340 sq. miles	Strongly folded slates, quartzites, etc. of Brocks Creek Group	Hills and small flats	Gravelly soils, some "Acid" Alluvial soils	Mixed Open Forest with Parkland on flats	Hilly topography, mostly gravelly soils not suitable for agriculture	Agricultural development will be confined to small areas of alluvial soils
(7) Brocks Creek Undulating 300 sq. miles	Strongly folded slates, quartzites, etc. of Brocks Creek Group	Undulating with scattered hills and flats	Yellow Podsolic soils, some "Acid" Alluvial soils and gravelly soils	Orchard, Mixed Open Forest with Parkland on flats	Arable, but soils are highly leached. Occurs in small scattered areas	Agricultural development will be confined to small areas of alluvial soils

SUMMARY OF THE MAIN CHARACTERISTICS OF THE LAND SYSTEMS OF THE KATHERINE-DARWIN REGION (*continued*)

Geomorphological Unit, Land System, and Area	Geology	General Topography	Major Soils	Major Vegetation Communities	Characteristics of Agricultural Importance	Agricultural Potentialities
(8) Batchelor 300 sq. miles	Strongly folded slates, quartzites, etc. of Brocks Creek Group	Mostly hills, some undulating and flat country	Mostly stony soils, yellow Podsolic Soils, Lateritic Soils, and "Acid" Alluvial soils	Tall or Mixed Open Forest, patches of Grassland on flats	Mostly hilly topography, some small areas of variable arable soils	Agricultural development will be confined to small areas of alluvial soils and better residual soils
(9) Cullen 1360 sq. miles	Granite	Mixed hills and undulating plains	Rocky skeletal soils, Granite Yellow Podsolic soil, Granite Lateritic Podsol	Deciduous Open Forest or Mixed Open Forest or Scrubby Open Forests	All except skeletal soils are arable, but are highly leached, have coarse sandy surface	Some portions of the arable areas are worth examination for peanuts and other crops and for tobacco where water is available for irrigation
(10) Buldiva 2750 sq. miles	Strongly jointed sandstones, conglomerates, and quartzites (Buldiva Quartzite)	Mostly rocky hills with gorges and scarps, some gentle slopes and alluvial fans	Skeletal soils or bare rock, small areas of Sandstone Lateritic Podsol and Deep Sandy, Light Grey soils	Mostly sparse eucalypts with *Triodia* and *Plectrachne*	Steep hilly areas are not arable. Other soils are arable, but are highly leached sands. Occur in small, scattered areas	No agricultural development is possible except on small, scattered areas of arable soils near springs

SUMMARY OF THE MAIN CHARACTERISTICS OF THE LAND SYSTEMS OF THE KATHERINE-DARWIN REGION (*continued*)

Geomorphological Unit, Land System, and Area	Geology	General Topography	Major Soils	Major Vegetation Communities	Characteristics of Agricultural Importance	Agricultural Potentialities
(11) Volcanics 42 sq. miles	Basic Volcanics, probably Lower Cambrian	Low hills, some undulating and flat	Stony soils and Heavy Grey Pedocals	Open forest and *Dichanthium* Savannah	Some very small areas of the Heavy Grey Pedocal are arable	Minor dry-land agricultural development may be possible
Daly River Basin						
(12) Tipperary 6890 sq. miles	Sandstones, limestones, and some shales (Daly River Group)	Mixed low hills and undulating plains	Limestone Red soil, Sandstone Lateritic Podsol, "Elliott Creek" soil, Deep Red Sandy soil and skeletal soils, small areas of Levee soils	Mostly Low Open Forest or Mixed Open Forest or Scrubby Open Forest	Some large areas of arable soils, but some soils are highly leached. Limestone Red soil and "Elliott Creek" soil appear most suitable for agriculture	Farming of the Levee soils should be intensified and the thorough examination of dry-land agriculture on Limestone Red and "Elliott Creek" soils is warranted
Western Fault Block Plains						
(13) Litchfield 830 sq. miles	Granite	Most gently undulating with some scattered rocky hills	Mostly Granite Lateritic Podsol and Granite Yellow Podsolic soil, some rocky skeletal soils and "Acid" Alluvial soils	Mostly Palm Scrub, some Mixed Open Forest	Most soils are arable, but are highly leached, have a coarse, sandy surface. Mostly difficult of access. Relatively high rainfall	More accessible parts should be investigated for the production of crops such as peanuts and tobacco

SUMMARY OF THE MAIN CHARACTERISTICS OF THE LAND SYSTEMS OF THE KATHERINE-DARWIN REGION (*continued*)

Geomorphological Unit, Land System, and Area	Geology	General Topography	Major Soils	Major Vegetation Communities	Characteristics of Agricultural Importance	Agricultural Potentialities
(14) Elliott Creek 400 sq. miles	Interbedded shales, limestones, and sandstones (Elliott Creek Formation)	Gently undulating plains	"Elliott Creek" soil, small areas of Limestone Red soil	Palm Scrub or Low Open Forest	High proportion of arable lands which appear suitable for agriculture. Not accessible by all-weather road. Relatively high rainfall	Possibilities of dry-land agriculture should be investigated
(15) Moyle 190 sq. miles	Sandstones, limestones, and shales (Port Keats Group)	Gently undulating plains	Sandstone Lateritic Podsols, "Moyle" soil, and Deep Sandy Light Grey soils	Tall Open Forest with palm understory	High proportion of arable soils, but some soils are highly leached, very sandy. Occurs in inaccessible part of the region. Moderate tree cover	Isolation excludes the possibility of agricultural development at this stage
Flood Plain Alluvia of Northern Rivers						
(16) Marrakai 680 sq. miles	Quaternary Flood Plain Alluvia with "islands" of Metamorphics of Brocks Creek Group	Nearly flat plains liable to shallow seasonal flooding, scattered low hills	"Acid" Alluvial soils, small areas of gravelly Yellow Podsolic soils	Grassland with patches of Parkland. Mixed Open Forest on gravelly hills	Soils of flats arable, but liable to shallow flooding	The possibility of utilizing natural flooding for rice production should be examined

SUMMARY OF THE MAIN CHARACTERISTICS OF THE LAND SYSTEMS OF THE KATHERINE-DARWIN REGION (*continued*)

Geomorphological Unit, Land System, and Area	Geology	General Topography	Major Soils	Major Vegetation Communities	Characteristics of Agricultural Importance	Agricultural Potentialities
(17) Finniss 360 sq. miles	Quaternary Flood Plain Alluvia with considerable areas of metamorphics of Brocks Creek Group	Flats liable to flooding intermixed with hills and undulating country	"Acid" Alluvial soils, gravelly Yellow Podsolic soils, and skeletal soils	Grassland on flats, Mixed Open Forest on remainder	Soils of flats arable, but liable to shallow flooding	The possibility of utilizing natural flooding for rice production should be examined
Estuarine Alluvia						
(18) Sub-coastal Plain 2650 sq. miles	Quaternary Estuarine Alluvia	Flat plains liable to deep seasonal flooding	Estuarine Plain Clays and Peats	Grass-reed Swamp Communities, patches of tall *Melaleuca* forests	Heavy clays and wet peats would be difficult to cultivate. Liable to longer, deeper flooding	There may be prospects for rice production at the margins if the soils can be cultivated and if flooding can be controlled
(19) Littoral 840 sq. miles	Quaternary Estuarine Alluvia, re-sorted beach deposits, laterite-capped cliffs	Salt and mud flats liable to saline flooding, beaches, and sand-dunes, laterite-capped cliffs	Salt Flat soils, dune sands	Salt meadows, samphire flats, mangroves, dune scrubs	Soils are saline or very sandy, not suitable for agriculture	No agricultural prospects

Fig. 1.—Creek dissection in the Brocks Creek Ridge Land System with *mixed open forest* and a very sparse creek *fringing community* which includes *Pandanus*.

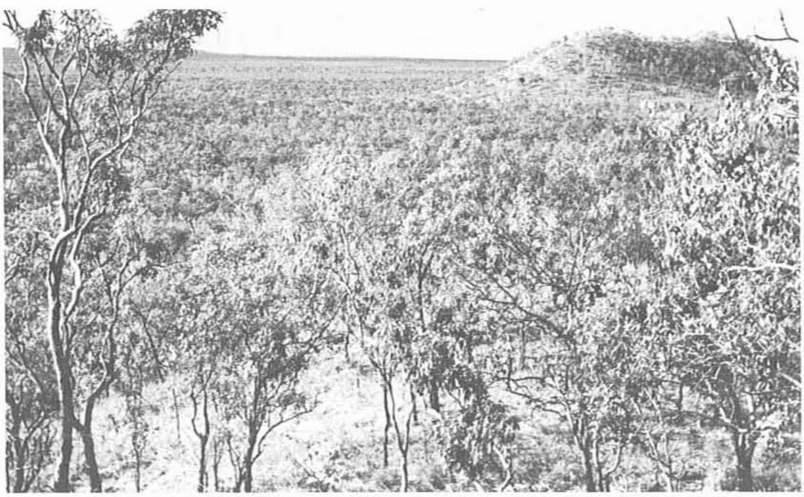


Fig. 2.—Ridge, foothill, and undulating country of the Brocks Creek Land System. *Mixed open forest* in foreground with *deciduous open forest* on the crests and *orchard community* on the low undulating country.

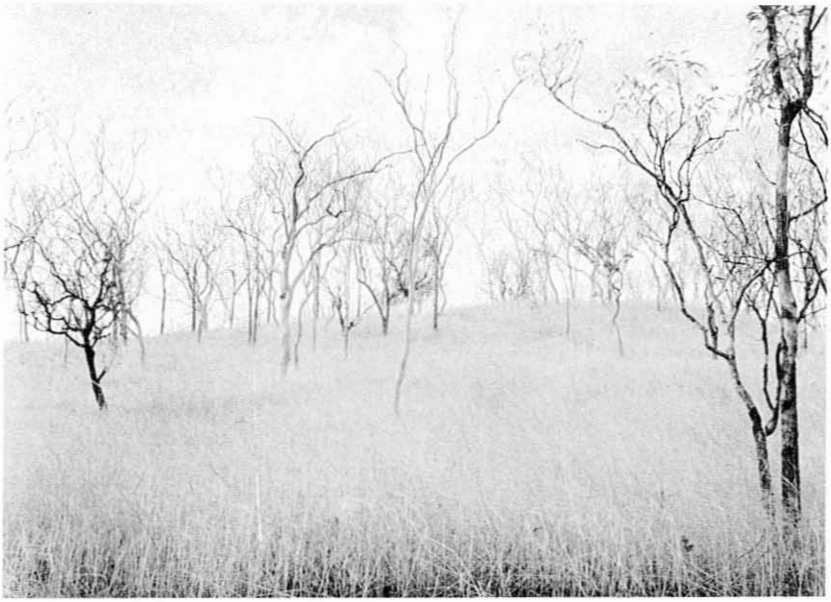


Fig. 1.—*Deciduous open forest* with *Eucalyptus alba, E. tectifica,* and tall annual *Sorghum* spp. on stony ridge country.

Fig. 2.—*Orchard community* with *E. confertiflora* and *E. foelscheana* on Yellow Podsolic soils of the Brocks Creek Undulating Land System.

Fig. 1.—A drainage flat with *parkland community* and patches of *grassland* between hills covered by *mixed open forest* in the Brocks Creek Foothill Land System. Scattered *Pandanus* is seen along the main drainage line.

Fig. 2.—A typical "bull-dust" plain with *Themeda-Eriachne grassland* after burning, on the Flood Plain Alluvia of the major northern rivers (Marrakai Land System).

Fig. 1.—*Parkland community* of scattered *Eucalyptus grandifolia* and stunted *Eugenia* sp. with an unburnt patch of grass (annual *Sorghum*) near the edge of a "bull-dust" plain (Marrakai Land System).

Fig. 2.—*Low mixed deciduous open forest* on a low gravelly rise in the "bull-dust" plain.

Fig. 1.—A lagoon in the "bull-dust" plain. *Barringtonia* sp. occurs as a fringe to these lagoons and various water-loving plants are found in them.

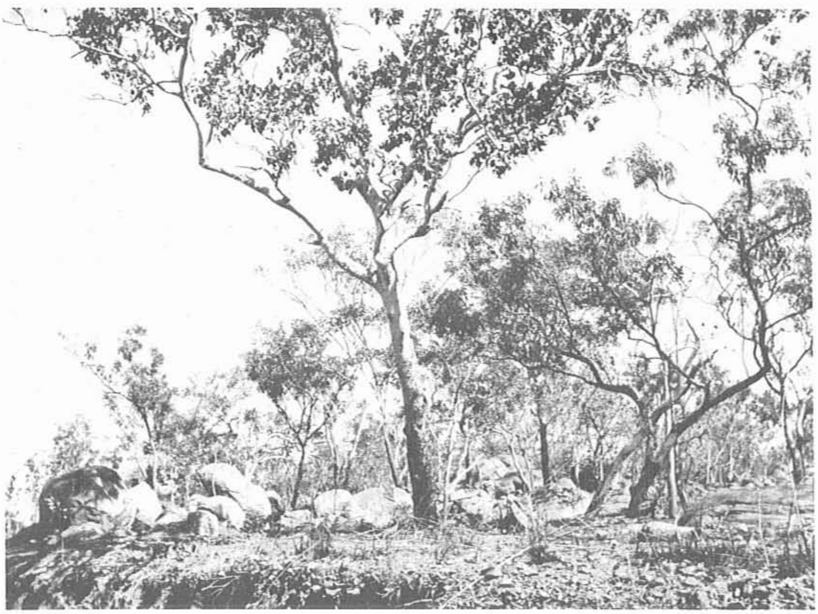


Fig. 2.—Granite outcrop in the Cullen Land System near Pine Creek. *Mixed open forest* with mainly tall annual grasses.

Fig. 1.—*Livistona palm scrub* on Granite Yellow Podsolic near Murrenja Hill on the Western Fault Block Plain.

Fig. 2.—Mixed *palm scrub* and *open forest* on Granite Lateritic Podsol near Mt. Litchfield on the Western Fault Block Plain.

Fig. 1.—Typical *low open forest* on Limestone Red soil near Katherine. *Eucalyptus confertiflora*, *E. tectifica*, and *E. foelscheana* dominant, with *Themeda australis* dominant in the grass flora.

Fig. 2.—*Scrubby open forest* with annual *Sorghum* sp. on Sandstone Lateritic Podsol on Douglas Station in the Tipperary Land System.

Fig. 1.—Platey limestone outcrop near Katherine in the Tipperary Land System. These outcrops are intermixed with areas of deeper soils.

Fig. 2.—Dry bed of Limestone Creek. Most creeks cease to flow for long periods during the dry season.

Fig. 1.—Cannon Hill, rocky outlier of the Buldiva Land System near the East Alligator River, with Para grass (*Brachiaria mutica*) on the Sub-Coastal Plain in the foreground.

Fig. 2.—The Katherine Gorge which follows joint lines in the rocks of the Buldiva Land System for about 11 miles.

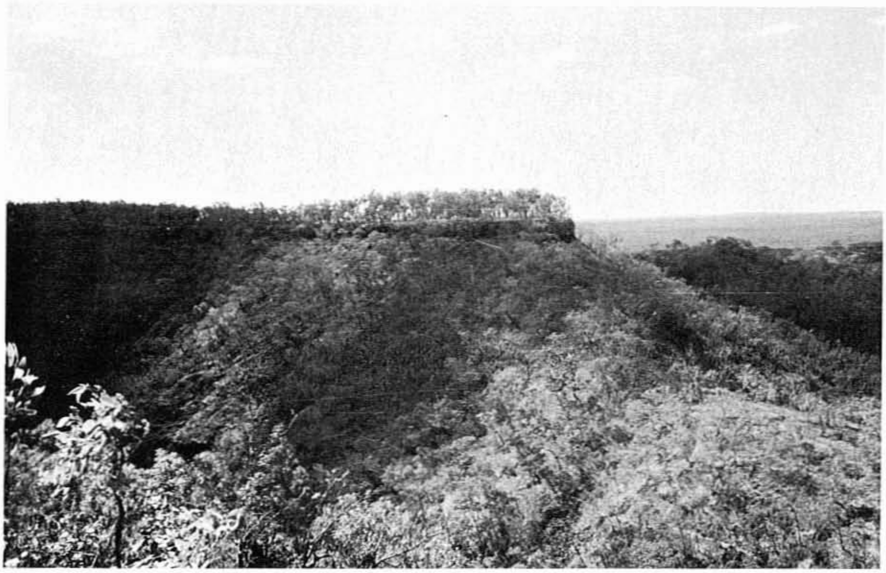


Fig. 1.—View of a tableland of the Mullaman Land System showing the silicified cap rock and the *tall open forest* vegetation on the tableland.

Fig. 2.—The silicified cap rock near the edge of a tableland of the Mullaman Land System.

Fig. 1.—View of the Sub-Coastal Plain Land System between the Mary and West Alligator Rivers. *Ischaemum* sp. and *Imperata cylindrica* var. *major* at the edge of the plain in foreground, and a line of paperbarks (*Melaleuca* sp.) in the distance.

Fig. 2.—The severely cracked surface of the heavy clay soil of the Sub-Coastal Plain Land System during the dry season. The cracks are up to 3 ft. deep. These soils are deeply flooded for long periods during the wet season.

Fig. 1.—A dense stand of *Oryza fatua*, a native perennial species of rice, and dense paper barks (*Melaleuca* sp.) on a swamp portion of the Sub-Coastal Plain Land System.

Fig. 2.—The lower Adelaide River illustrating the mature meandering nature of the rivers which flow through the Sub-Coastal Plain Land System.

Fig. 1.—A patch of introduced Para grass (*Brachiaria mutica*) which has persisted on the Sub-Coastal Plain near the East Alligator River for many years. This is indicative of the type of introduced grass suitable for these conditions.

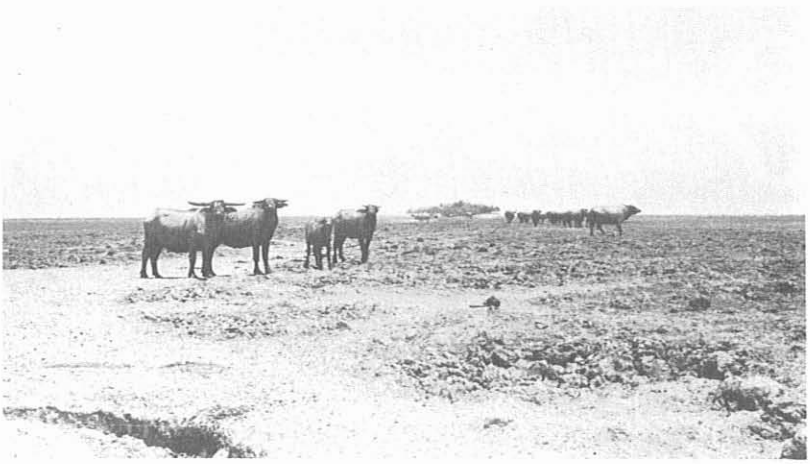


Fig. 2.—A group of buffalo cows and calves on an old beach line. Buffaloes are the main grazing animals on the northern plains. Shooting them for their hides is a major industry in this area.

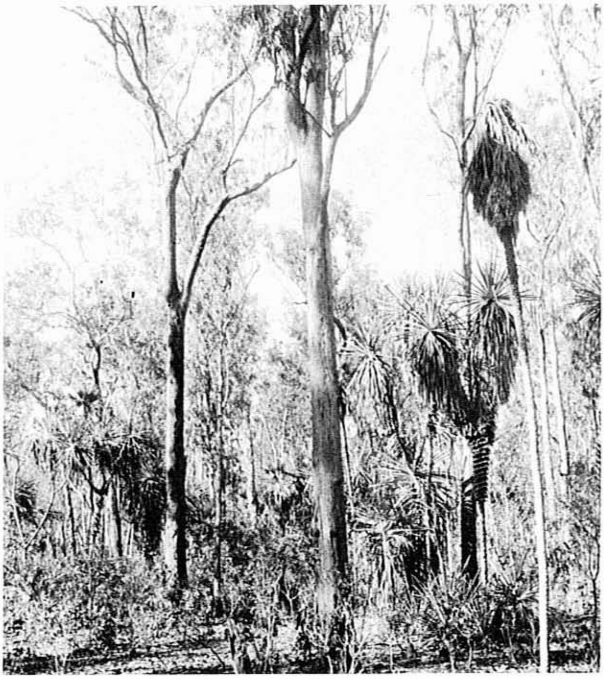


Fig. 1.—*Tall open forest,* with *E. tetradonta* and *Pandanus* in centre, on Tertiary Lateritic Red Earth soil of the Koolpinyah Land System.

Fig. 2.—*Leguminous—Myrtaceous scrub* on Tertiary Lateritic soil near the fringe of the Sub-Coastal Plain.

Fig. 1.—A lagoon in a Tertiary Lateritic Flat of the Koolpinyah Land System. *Mixed open forest* in the background with open *grassland* surrounding the lagoon. The grazing animals are buffaloes.

Fig. 2.—A lateritic profile exposed in a coastal cliff at Charles Point showing the shallow A horizon, massive laterite and mottled and pallid zones.

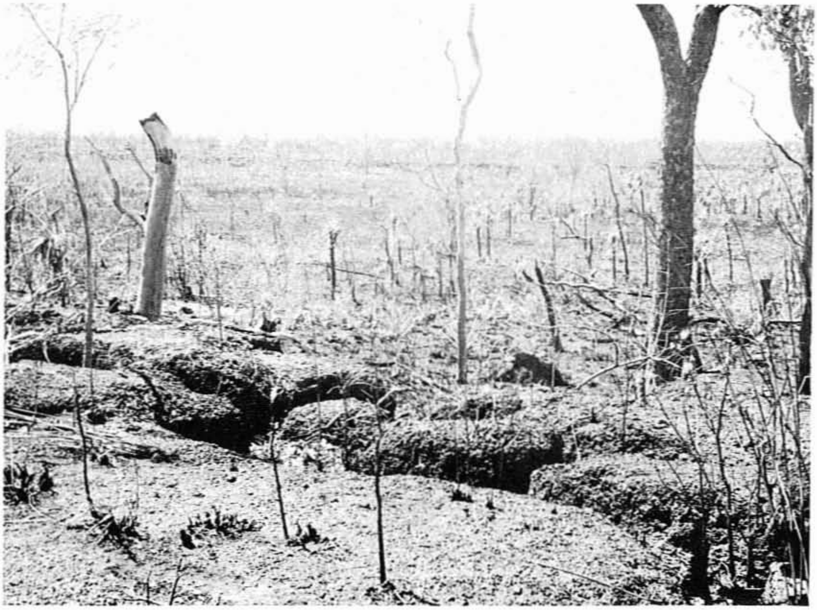


Fig. 1.—Edge of lateritic residual showing massive laterite in the foreground with dissection area in centre of picture. The line of massive laterite can also be seen on the far side of the valley.

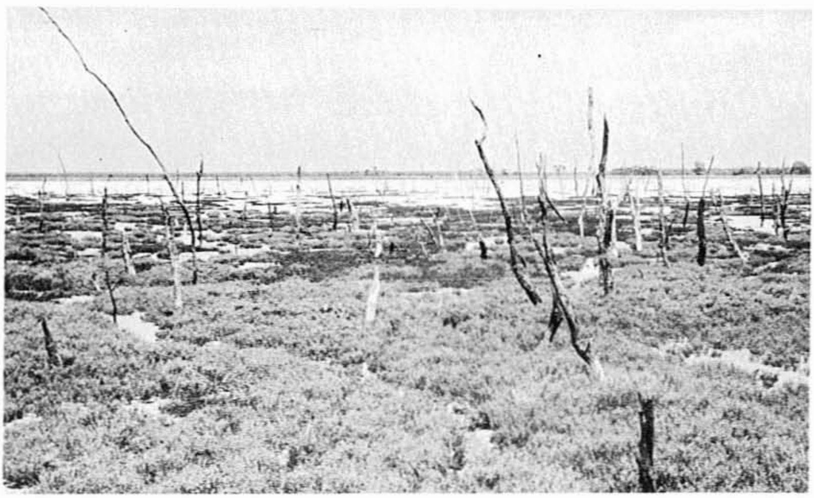


Fig. 2.—Salt pans with *Salicornia* sp. and dead mangroves behind the mangrove fringe in the Littoral Land System.

Fig. 1.—Low sand dunes in the Littoral Land System behind the beach. In the troughs between the dunes natives find fresh water at shallow depths.

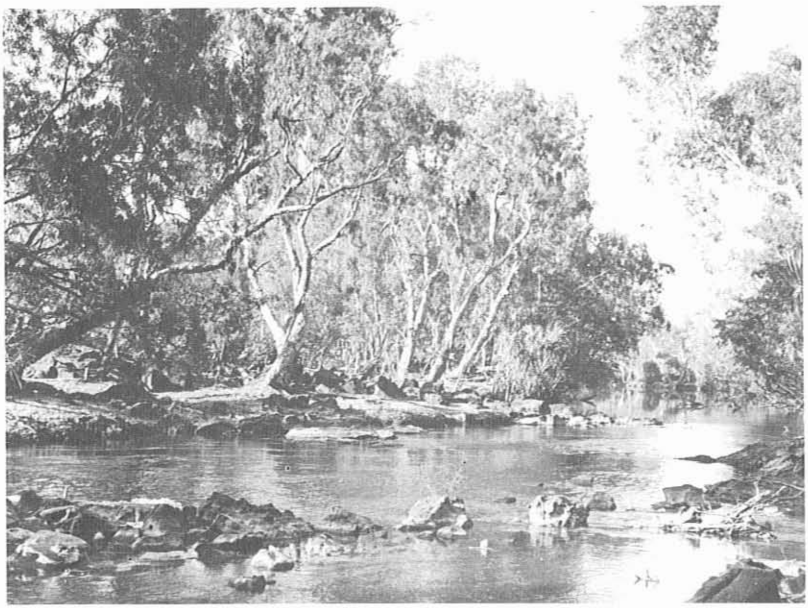


Fig. 2.—The Katherine River. The *fringing forest* includes *Melaleuca* spp., *Barringtonia* sp., *Pandanus aquaticus*, and *Casuarina* spp. Rock bars, rapids, and low falls are characteristic of the Daly River and its tributaries.

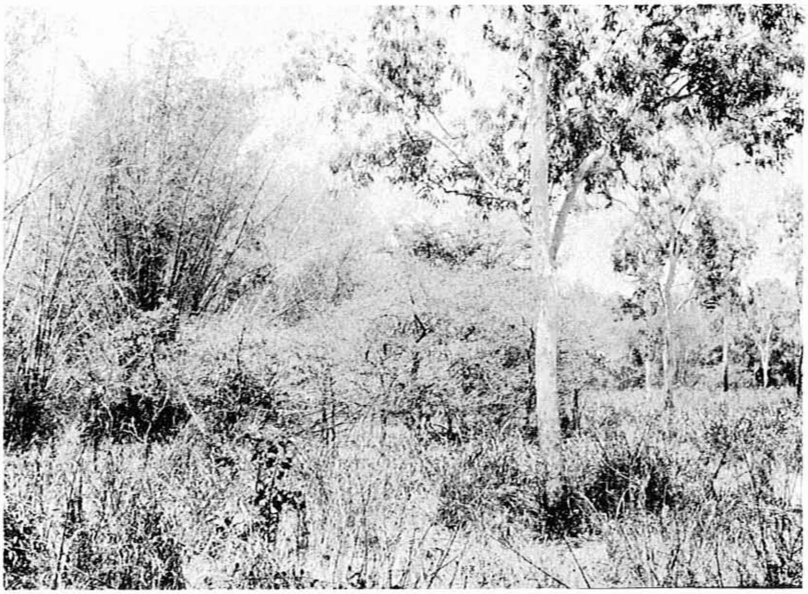


Fig. 1.—Eucalypt *parkland* with tall grass ground flora on the levee of the South Alligator River with bamboos forming a dense *fringing community.*

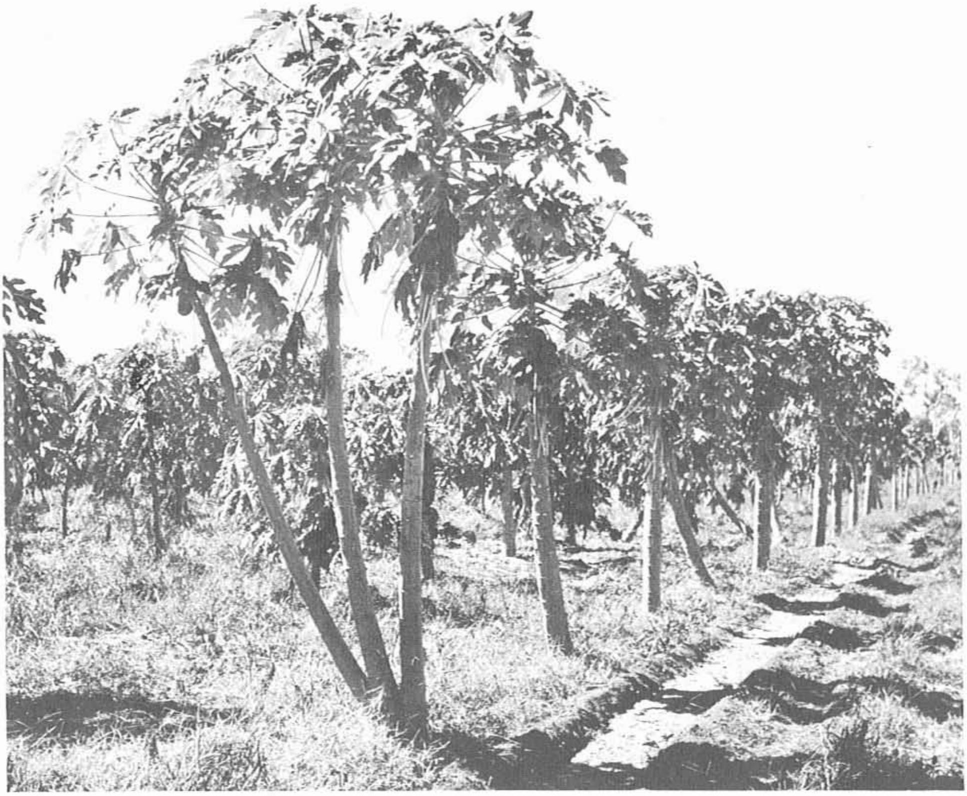
Fig. 2.—*Deciduous parkland* with scattered *Bauhinia cunninghamii*, *Eucalyptus microtheca* (coolabah), *Acacia bidwillii*, and *Dichanthium grassland* on Heavy-Textured Grey Pedocal in the Tipperary Land System.

Fig. 1.—*Tristania-Grevillea-Banksia* community on deep sandy wash soil along a creek on Humpty Doo Station.

Fig. 2.—Banka jungle, a patch of *monsoon forest* on Humpty Doo station. Such communities are usually of very small extent.

Fig. 1.—Soil sampling on a peanut farm on the Daly River levee. The crop system is peanuts following peanuts with an occasional year without cropping.

Fig. 2.—Vegetables for Darwin are grown under irrigation, mainly on levee soils.



A variety trial of pawpaws at the Katherine Research Station.