General Report on Lands of the Alice Springs Area, Northern Territory, 1956-57

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PART I. INTRODUCTION AND SUMMARY DESCRIPTION OF THE ALICE SPRINGS AREA

By G. A. Stewart* and R. A. Perry*

I. Introduction

The area surveyed covers 144,000 sq. miles in central Australia and has been designated the "Alice Springs area". It includes all the settled country of the Alice Springs pastoral district. The boundaries of the area are lat. 26°S. (Northern Territory–South Australia border) in the south, lat. 21°S. and 20°S. in the western and eastern parts of the northern boundary respectively, long. 130° 30′ E. on the western side, and long. 136° 30′ E. on the eastern side. On the north-east corner it adjoins the Barkly region surveyed by the Land Research and Regional Survey Section in 1947–48 and the Georgina poison area surveyed in 1955.

(a) *Survey Procedure*

The general procedure was similar to that of previous surveys carried out by the Division of Land Research and Regional Survey (Christian and Stewart 1953; Christian *et al.* 1953; Christian *et al.* 1954) but with increased experience some of the techniques have been slightly refined.

Each of the surveys involves the use of a team of scientists, of various disciplines, working together in close collaboration, with the object of scientifically describing and mapping large areas of country to provide a basis for an assessment of potentialities and for recommendations for further research.

The method of survey is based on the concept that each type of country is expressed on aerial photographs by a distinctive pattern and conversely, that by the recognition of these patterns on aerial photographs a map of the types of country can be produced. The method presupposes that a complete aerial photographic cover of the area is available. The Alice Springs area was completely covered by aerial photographs at a scale of 1:50,000 taken in 1950.

The first interpretation of the aerial photographs was done during April to July 1956. At that stage the broad types of country (for example the hills as opposed to the plains) were bounded and any distinctive patterns within these were recognized but not bounded. During the interpretation, traverses were planned to sample each pattern.

The first field season occupied the period August to October 1956. The aerial photographs were taken into the field and traverse routes, speedometer mileages, and descriptive notes were marked directly onto them. In order to do this accurately the position of the team was known to within one-tenth of a mile (approximately one-tenth of an inch on aerial photographs).

The aerial photographs were interpreted in the laboratory for the second time during January to March 1957. During this interpretation the country was mapped as

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accurately as possible in the light of knowledge gained during the first field season. Additional traverses were planned to sample patterns not visited during the first field season and to check doubtful parts of the mapping.

The second field season from June to September 1957 was similar to the first.

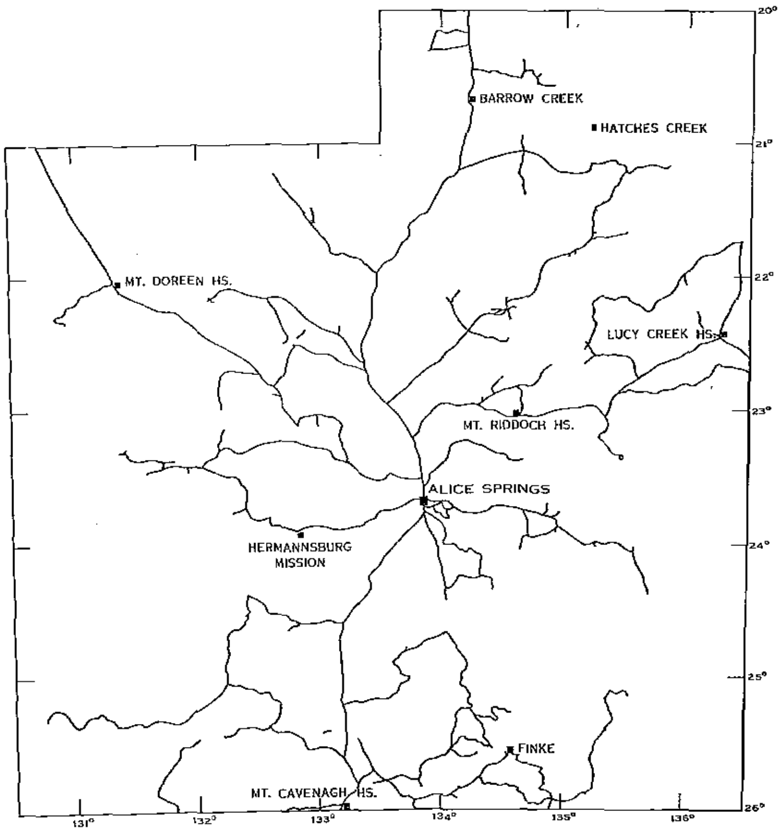

Fig. 1.—Traverse map.

The final interpretation of the aerial photographs in the period January to May 1958 resulted in a map showing 112 types of country. Some of these were grouped to give the 88 land systems described in this report.

During the survey the team spent 11 months interpreting aerial photographs in the laboratory and 5½ months in the field. The total length of traverses was 4500 miles (Fig. 1).

II. Summary Description*

(a) *Population and Communications*

The only town is Alice Springs (population approximately 3500), roughly in the centre of the area. Alice Springs is the terminus of the railway line from Adelaide

* This section is designed to be read in conjunction with the pasture lands map and its small inset maps.

and is therefore the trucking centre for cattle produced in the northern half of the area. Cattle produced in the southern half are trucked at small sidings between Alice Springs and the South Australian border. Alice Springs is also the terminus of the Stuart Highway, which links Darwin and Alice Springs, and is an important stop on the Adelaide–Darwin air route. It is the base from which Connellan Airways, which serves most of the cattle stations in the Northern Territory, operates. The main road system within the area radiates from Alice Springs, as does the stock route system in the northern half of the area. With the exception of the Stuart Highway, which is sealed, all roads are of graded earth.

(*b*) *Climate*

The whole of the area is arid, the mean annual rainfall ranging from 5 in. in the south to 14 in. in the north. The summer predominance of rain increases northwards. Summer maximum temperatures frequently exceed 100°F but nights are generally cool. Frosts do not occur in the far north, but in the southern half may be expected during the period from late May to late August.

Because of the sporadic nature of the rainfall there is no definite growing season. Slatyer in Part III estimates that initial effective rain (sufficient to initiate plant growth) in the summer six months can be expected twice per year in the northern half of the area, decreasing to once every two years at Charlotte Waters. In the winter six months it is most likely to occur in the central part (three times every two years), decreasing to once per year at Charlotte Waters and once per two years at Tennant Creek. Effective carryover rains (sufficient to continue growth in the following month) are less common, particularly in the southern parts.

(*c*) *Physiography*

Three physiographic provinces, each with several subdivisions, can be recognized (Part VII).

(i) The central ranges occupy a belt in the centre of the area. The folded central ranges, which include the southern part of the MacDonnell Ranges, are mainly east–west ridges with narrow valleys, their crests normally being 2000 to 3000 ft above sea-level. Immediately to the north are the crystalline central ranges which rise to 4955 ft at Mount Zeil and are the highest parts of the area. They form the main drainage divide.

(ii) The southern desert basins occupy the southern half of the area and are largely dune covered. The Amadeus depression (altitude 1500 to 2000 ft) is floored with salt pans and limestone plains, and is flanked by gentle slopes with irregular dune patterns. The Simpson Desert (altitude 700 to 1500 ft) is characterized by linear SSE.–NNW. sand dunes. It includes isolated plateaux and ranges near its western margin and sand plains in the north. The southern granite hills and plains (altitude 1750 to 2100 ft) are the northern fringe of the Mann and Musgrave Ranges.

(iii) The northern plains and uplands occupy the northern half of the area. The Burt Plain (altitude 2000 to 2300 ft) is similar to the Amadeus depression, but is mainly sand plain instead of dune fields. It adjoins the extensive sand plains of the north-west plains (altitude 1200 to 2000 ft). The relatively strongly dissected Sandover–

Bundey basin (altitude 1450 to 1800 ft) includes some low hills and plateaux and merges northward into the extensive sand plains of the north-eastern plains. The uplands are plateaux and ranges that are lower than the central ranges, and generally are less than 500 ft above the surrounding plains. They include the north-western hills and ranges (mainly granite and sandstone), the Davenport Range (mostly folded sandstone), and the north-eastern plateaux (mainly sandstone and dolomite). The latter are commonly cliff-faced in the south but slope gently downwards beneath the adjacent plains to the north.

(*d*) *Geology*

The Alice Springs area is part of the relatively stable Australian Pre-Cambrian Shield (Part IV). The exposed basement is composed of Pre-Cambrian granite and metamorphic rocks. The basement is overlain by the Lower Proterozoic Warramunga and Hatches Creek groups which are strongly folded sandstones, greywackes, and shales with granite intrusions and volcanic rocks. Upper Proterozoic and Palaeozoic sandstones, shales, limestones, and dolomites were deposited in several basins developed on the metamorphosed basement. During the Upper Palaeozoic these sediments were moderately to strongly folded in the southern half of the area. A long period of erosion followed before deposition of Mesozoic sediments which underlie an extensive area in the south-east and are also present in several smaller basins. These geological features have been important controlling factors in the subsequent development of landscapes and soils.

The mining of wolfram, copper, and mica makes, at present, only a small contribution to the wealth of the area but has aided in its development.

(*e*) *Geomorphogeny*

At the end of the Mesozoic deposition, uplift initiated a long erosion cycle which culminated in the deeply weathered (lateritic) land surface of probable Tertiary age (Part VII). Except for the crystalline central ranges and some quartzite ridges, which were monadnocks, the weathered surface was a gently sloping plain. The extent and depth of the weathered surface indicate that drainage must have been integrated and the climate must have been moister.

Dissection of this old land surface in the south-eastern part of the area was initiated by crustal warping in the Lake Eyre basin, and mesas to a height of 300 ft, capped by deep weathering products, are indicative of the degree of dissection. However, over the remainder of the area, the Tertiary plain was little altered at intermediate levels, but the higher parts were etched out by erosion and extensive deposition took place in the lowlands. Internal drainage was initiated at this stage, suggesting a drier phase, characterized particularly by dune formation in the southern part of the area. In the north, the movement of sand was generally only sufficient to mask the previous drainage. Subsequent amelioration of the climate is suggested by resumption of drainage incision in some parts. Deposition from this drainage incision has produced the young alluvia of the alluvial fans and flood-plains. The Finke is the only stream that has maintained its drainage beyond the area, the other main channels (Hale, Plenty, Sandover, and Lander Rivers) dispersing their waters within the area.

(*f*) *Soils*

Normally in arid zones soils are shallow, weakly weathered, and generally calcareous. In this area the most extensive soils are strongly weathered and leached, as they are inherited from soils of earlier weathering cycles or are formed on the resorted materials derived from them (Part VIII). They include red earths and red clayey sands with minor areas of yellow earth, all of which are extensive in the northern higher-rainfall parts of Australia. There are also extensive areas of shallow skeletal soils and some alluvial soils, both of which show no profile development. The remaining three soil groups are soils that are typical of arid and semi-arid zones. Calcareous earths are associated with base-rich rocks or alluvia. They are generally grey or brown in colour and may be either sandy or clayey. The texture-contrast soils are solonetzic and are characteristic of arid and semi-arid areas in southern Australia. They have sandy or loam surface horizons over alkaline reddish clay subsoils. The coarse-structured clay soils, similar to the widely distributed cracking "black soils" of northern Australia, are not common. They are generally red or brown in colour and may contain lime and/or gypsum.

In general the soils are of low fertility as they are derived from inherited strongly weathered soil materials or from sedimentary rocks that have already passed through one or more weathering cycles. The most fertile soils are probably those associated with young alluvial materials derived from metamorphic rocks and those formed directly from the granites and metamorphics.

(*g*) *Vegetation and Pastures*

The vegetation ranges in form from grassland or shrubland to low woodland (Part IX). In contrast to more humid parts of Australia, eucalypts are rare, and acacias are the most common trees and shrubs. Spiny plants and succulents, common in overseas arid areas, are not important. Forestry is a small industry, limited to firewood cutting and a small amount of logging. Protection will be its main role in the future. The native plants are adapted to withstand long dry periods in a number of ways, and this is related to their usefulness for grazing animals.

"Top feed" is the local name given to edible, perennial, drought-resisting trees and shrubs, e.g. mulga, witchetty bush, gidgee, etc., which provide at least a subsistence ration through long dry periods. They are associated with various ground storeys on which the pasture types have been defined (Part XI). The pasture types fall into four main classes:

(i) Pastures characterized by drought-evading ephemerals, consisting mainly of grasses after summer rains and forbs after winter rains, provide good grazing for short periods but are rapidly eaten or trodden out and stock must then rely on the associated top feed. At present most of the stock are carried on these pastures.

(ii) Pastures characterized by perennial drought-evading grasses which grow rapidly from dormant buds after rain, then mature and dry off. They provide moderate-quality pasturage when green but their nutritive value is low when dry. Some, e.g. woollybutt, are generally associated with top feed but others, e.g. Mitchell grass, are not.

(iii) Pastures characterized by drought-resisting sclerophyllous grasses (hard spinifex, soft spinifex, and feathertop spinifex) have a low nutritive value and low palatability. They have little or no top feed and are virtually unused.

(iv) Pastures characterized by drought-resisting perennial semi-succulent low shrubs (saltbushes and bluebushes) are both palatable and nutritious. They are most extensive in the southern half of the area. As they commonly occur in small patches amongst inferior pastures, they tend to be selectively grazed.

(*h*) *Land Systems and Pasture Lands*

The area has been subdivided into 88 land systems, each of which is a recurring pattern of land units which have characteristic topography, soil, and vegetation (Plate 1, Figs. 1 and 2). The land systems, which are described in considerable detail in Part II, are a basic inventory of the natural resources. However, the number and complexity of the land systems require a simplification of information in order that broad generalities may be made about the use and potential of the lands. As the area is, and will remain, almost exclusively a pastoral one, this simplification has been attained by grouping the land systems into *eight pasture lands* (Part XI). Their distribution is shown on the pasture lands map, on which they are distinguished by different colours. The constituent subdivisions and individual land systems are also listed and briefly described. The major features of the pasture lands and main differences between land systems are indicated below.

(i) *Spinifex Sand Plains, Dune Fields, and Plains.*—This pasture land (82,700 sq. miles) comprises plains with pastures dominated by hard spinifex with small areas of feathertop spinifex and soft spinifex. The pastures are unattractive to stock, their nutritive value is low, and mostly there are no edible shrubs and trees. They appear to be very well adapted to the sandy soils of low fertility and their replacement by more useful vegetation would be very difficult. These lands are largely undeveloped and are likely to remain so.

Singleton land system is the largest of this pasture land and consists of flat or gently undulating spinifex plain on sandy red soil (Plate 2, Figs. 1 and 2).

Ewaninga land system is undulating sandy country with hard spinifex under a variable mulga cover.

Angas land system consists of hard spinifex sand plain, intermixed with stony heavier soils carrying southern bluebush.

Middleton land system is hard spinifex sand plain intermixed with hills.

Amulda land system has small areas with short grass–forb pastures on flood-plains in extensive hard spinifex sand plain.

Simpson land system includes all the dune fields (Plate 3, Fig. 2). It is most common in the southern half of the area, the dunes being regular and parallel in the Simpson Desert but irregular in most other parts.

Wonorah land system occurs only near the northern margin of the area and has soft spinifex pastures on undulating plain with red earth soils (Plate 3, Fig. 1).

Tennant Creek land system is similar to Wonorah, but contains appreciable proportions of low hilly country.

(ii) *Short Grass–Forb Pastures on Young Alluvia*.—This pasture land (6200 sq. miles) includes flat to gently sloping areas of recent alluvium which occur as flood-plains of major streams or as alluvial fans adjacent to mountains. Parts of it receive run-on from higher catchments and are thus favoured habitats, supporting more productive pastures (Plate 5, Fig. 2). Short grass–forb pastures (Plate 4, Fig. 1; Plate 5, Fig. 1) are characteristic of most of the land, under a cover of generally palatable trees and shrubs. Because of the occurrence of natural waters in stream channels or of shallow ground water, parts of the pasture land were the earliest developed and have suffered from overgrazing.

Sandover land system includes the coarse-textured flood-plains of the rivers in the northern half of the area, with which are associated small areas of better pastures.

Finke land system is similar but has a higher proportion of calcareous soils.

McGrath land system consists of flood-plains with red earth soils carrying short grass–forb pastures.

Ammaroo land system includes the terminal flood-plains in the northern half of the area and contains a small proportion of alluvial basins, mostly with Mitchell grass.

McDills land system, which occurs only in the southern half of the area, is similar to Ammaroo but has mostly *Bassia* spp. pastures with old-man saltbush in the alluvial basins.

Kanandra land system is coarse-textured alluvial fans at the foot of Harts Range, and has kerosene grass pastures under sparse low trees.

Todd land system consists of coarse to medium-textured alluvium carrying short grass–forb pastures under sparse low trees.

Woodduck land system includes areas of spinifex and perennial tussock grasses.

Adnera land system consists of alluvial fans with short grass–forb pastures under mulga, with small areas of channels and alluvial basins.

Deering land system has mostly texture-contrast soils with *Bassia* spp. pastures.

Hamilton land system has clayey soils supporting short grass–forb, Mitchell grass, or northern bluebush pastures intermixed with mulga country.

Utopia land system consists of heavy clay soils periodically flooded and carrying northern bluebush pastures.

(iii) *Short Grass–Forb Pastures on Flat or Undulating Country*.—In this pasture land (21,900 sq. miles) the short grass–forb pastures occur on uplands and in almost all cases have associated top feed with them. It carries most of the cattle at present and has potential for further development by intensification of watering. Seven subdivisions have been made on the basis of top feed and associated pastures.

Mulga country (10,100 sq. miles) (Plate 6, Figs. 1 and 2) consists of plains with red earth soils with mulga growing in groves (Plate 7, Fig. 1) in Boen land system (metamorphics) and Bushy Park land system (stable alluvia). In the south of the area sandier soils support a similar vegetation in Karee land system (sandy alluvium) and Tietkins land system (granite with sand plain).

Mulga country mixed with spinifex sand plain (2000 sq. miles) occurs in Lindavale land system (limestone plains), Leahy land system (sandy alluvium), and

Alinga land system (Palaeozoic sandstone, shale, and thin limestone and sand plains).

Gidgee country (2200 sq. miles) (Plate 7, Fig. 2) occurs mainly to the north-east of Alice Springs and is mainly associated with limestone. Lucy land system has shallow soils on limestone. Ooratippra land system is similar but contains broad drainage floors with red earth soils. Pulya land system consists of narrow vales between limestone ranges and Ringwood land system is on alluvium.

Witchetty bush country (1000 sq. miles) (Plate 8, Fig. 1) includes Outounya land system on granite and schist and Muller land system on conglomerate. They are plains with shallow red soils and are drier environments than gidgee or mulga country.

Sparse low tree country (4400 sq. miles) (Plate 8, Fig. 2) includes most of the undulating country formed on granites or metamorphic rocks. The combination of sparse low trees (mulga, whitewood, ironwood, and corkwood) and the short grass–forb pasture is considered to be the most nutritious pasture in the area possibly because the shallow residual soils are more fertile than others.

The 11 constituent land systems—Alcoota, Ryan, Ennugan, Jinka, Anderinda, Barrow, Delny, Indiana, Unca, Dinkum, and Warburton—are all formed on granite, gneiss, or schist, and they have been differentiated mainly on the basis of rock type, degree of dissection, soils, and the associated vegetation communities.

Open country with *Bassia* spp. pastures (1000 sq. miles) mostly occurs on texture-contrast soils in the southern half of the area. It is mostly developed for grazing and parts have been overgrazed. Chandlers land system is formed on sandstones and shales.

Variable sparse low vegetation over short grass–forb pastures with some spinifex (1200 sq. miles) occurs on linear limestone tracts (Woolla land system) or on plains adjacent to salt lakes (Titra land system). Both land systems are stocked at a low rate.

(iv) *Saltbush and Bluebush Country*.—This pasture land (3300 sq. miles) occurs mostly in the southern half of the area on undulating to hilly terrain with calcareous earth or texture-contrast soils. Most of them have been developed pastorally and some have suffered severe overgrazing. Southern bluebush is characteristic of Lilla (stony plains and terraces), Ebenezer (stony calcareous plains), and Renners (undulating shale and limestone country) land systems. Treeless bladder saltbush (Plate 10, Fig. 1; Plate 11, Figs. 1 and 2) characterizes Kulgera (schist plains), Wilyunpa (stony tableland), Peebles (stony plains and low hills), and Endinda (stony plains with minor sand dunes), while Kalamerta land system has mulga over saltbush on sand plains.

(v) *Mitchell Grass Country*.—This pasture land (300 sq. miles) occupies only a small part of this area, but is very extensive in the adjacent Barkly region. It occurs on treeless gently sloping plains with heavy clay soils, and has a high carrying capacity in normal seasons but has no top feed to sustain cattle through long droughts (Plate 9, Figs. 1 and 2). It occurs on alluvia near the central mountain ranges (Undippa land system) or on calcareous terraces in basins within those ranges (Ambalindum land system).

(vi) *Alternating Hills and Lowlands*.—This pasture land (13,500 sq. miles) includes mountainous or hilly country which is closely interspersed with valleys, plains, and undulating country (Plate 12, Figs. 1 and 2; Plate 15, Fig. 2). It is only the latter that are available to stock and they have been utilized only where their size warrants the supply of water. The land systems have mostly been differentiated according to the form of the hills and to the rock type, which includes granites, schist, and gneiss (Bond Springs, Chisholm, Napperby, Cavenagh, Aileron, and Pularoo), folded sandstones and quartzites (Hann and Gillen), volcanic rocks (Kurundi), limestones (Allua and Ilgulla), duricrusted shales (Rumbalara), sandstones (Ilbumric, Kernot), shale (Coghlan), sandstone and limestone (Hogarth), dissected gravel terraces (Weldon and Stokes), and chalcedony (Table Hill land system).

(vii) *Mountains and Hills*.—These steep stony lands (14,500 sq. miles) are inaccessible to stock (Plate 13, Fig. 1; Plate 14, Fig. 1; Plate 15, Fig. 1) but are important catchment areas and provide the flood waters which run onto the flood-plains. They have been differentiated mainly on topographic form and geology. Rock types include gneiss and granite (Harts), quartzite and sandstone (Sonder, Davenport, Tomahawk, and Krichhauff), limestone (Huckitta), conglomerate (Pertnjara), shales and limestone (Cherry Creek), gravel terraces (Reynolds and Berrys Pass), and chalcedony (Santa Teresa land system).

(viii) *Salt Pans*.—This pasture land (1800 sq. miles) consists of salt pans (Plate 13, Fig. 2) and some associated spinifex dune fields (Amadeus land system). It is poor pastoral country and is virtually undeveloped.

(*i*) *The Pastoral Industry*

Cattle grazing (Plate 16, Fig. 1) is the most important industry in the area, the cattle population being 273,000 in 1953–56. A small number of sheep are run for wool, but their numbers are decreasing. It has been estimated that of the 42,000 sq. miles of usable pastures, only 17,000 sq. miles is within 3 miles of water and therefore effectively grazed (Part XII). Thus, provision of adequate watering points would permit more than twice as many stock to be carried. With the present intensity of stock waters areas of pasture degradation occur and provision of more watering points would increase this danger. At present landholders do not practise pasture management of any kind, primarily because there is no basic information to indicate desirable practices. In order that sound management practices to preserve the natural pastures can be formulated it is essential that range management research should be undertaken, particularly in the fields of range condition and trend.

Pasture improvement in the southern Australian sense is unlikely to be applicable to the area because of the erratic rainfall and the low return per unit area. The most likely sites for successful pasture improvement are the favoured habitats which receive run-on from adjacent country. Many of these sites have more fertile alluvial soils, and in some, competition from native plants has been reduced by heavy grazing. Some success has been obtained with buffel grass in favoured sites, but lack of success in experiments with it on spinifex and mulga country indicates that its potential is limited.

Many low tree species are palatable to stock but only the lower branches can be reached. Clearing of these inaccessible trees and also non-forage trees may make more water and nutrients available to ground storeys and so increase forage production. Experimental work in this field is desirable.

Natural water-spreading occurs in the area and its efficiency may be increased by artificial means. This may allow the introduction of pasture plants that could normally be grown only in higher-rainfall areas.

(j) *Agriculture*

The rainfall is too low and erratic for dry-land agriculture. The main limitation to irrigated agriculture is the availability of water, as the soil and topography of large areas are suitable for irrigation (Part XII). Surface storage of water is unattractive because of the low and unreliable run-off, the high evaporation, and the relatively small catchments above suitable sites for storage dams. However, in a number of areas ground water of suitable quality for irrigation is known to occur and some of these contain soluble nitrate equivalent to 4 cwt of sulphate of ammonia per acre-foot of water. Existing data on available supplies are very limited, but annual recharge to six catchments north of Alice Springs has been estimated as 70,000 ac. ft. and storage in four of these has been estimated as 4×10^6 ac. ft. These estimates are high enough to justify more intensive investigation of water resources, soils and topography, and crops that might be grown. The most desirable irrigated crops would be fodders for use by the grazing industry, high-value crops for export to southern markets (e.g. cotton), and crops particularly adapted to the arid environment (dates).

(k) *The Tourist Industry*

The warm, dry winter days and the spectacular mountain scenery are the main attractions for the rapidly growing tourist industry. With the development of more and better facilities tourism could rival the cattle industry in earning power. A policy of protection is necessary to preserve the attractiveness of the scenic spots.

III. Acknowledgments

Acknowledgments are due to many individuals and organizations.

The Bureau of Mineral Resources, Geology and Geophysics made available T. Quinlan for the second field season and the second photo-interpretation period. C.S.I.R.O. Division of Soils seconded W. H. Litchfield for the full survey period. R. A. Patterson, of the Bureau of Agricultural Economics, spent about six weeks in the field during 1956 but has not made a contribution to the report. Various officers of the Animal Industry Branch of the Northern Territory Administration contributed in discussions with members of the survey team. The National Mapping Division, Department of National Development, compiled the base map of the area. Meteorological information was supplied by the Commonwealth Bureau of Meteorology. Figures from reports of the Northern Territory Administration have been quoted.

Miss M. Mills has been responsible for a great deal of editorial work on the report. The preparation of all the maps, diagrams, illustrations, and the manuscript was done by the staff of the Division. The guidance and criticism of G. A. Stewart, Chief of the Division, is gratefully acknowledged.

The members of the survey team are indebted to various station owners and managers, the staff of the Animal Industry Branch and Mines Branch of the Northern Territory Administration, and the staff of the C.S.I.R.O. field station at Alice Springs for assistance and hospitality during the field seasons.

IV. References

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

CHRISTIAN, C. S., NOAKES, L. C., PERRY, R. A., SLATYER, R. O., STEWART, G. A., and TRAVES, D. M. (1954).—Survey of the Barkly region, Northern Territory and Queensland, 1947–48. C.S.I.R.O. Aust. Land Res. Ser. No. 3.

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

PART II. LAND SYSTEMS OF THE ALICE SPRINGS AREA

By R. A. PERRY,* J. A. MABBUTT,* W. H. LITCHFIELD,† and T. QUINLAN‡

The lands of the area have been mapped and described in 88 land systems which are composite mapping units (Plate 1, Figs. 1 and 2) developed and defined by Christian and Stewart§ as "an area or group of areas throughout which there is a recurring pattern of topography, soils, and vegetation". Subsequently the land system concept has been used on all surveys conducted by the Division of Land Research and Regional Survey, C.S.I.R.O.

The land systems and their component units are described in tabular form and illustrated with block diagrams. They are arranged in geomorphological groups and are described under the same number and in the same order in Part VII. The same arrangement has been used on the land system map. The relief shown on the block diagrams is not absolute, nor are the relative areas of the units accurate.

Individual land systems can be located by reference to the index. More detailed information about the land systems can be obtained by referring to Parts III, IV, VII, VIII, and IX. For climatic information one or more recording stations are listed for each land system. Data from these stations are tabulated in Part III. The main groups of soils are referred to by name but the subgroups are indicated only by a number. Both names and numbers are identical with those used in Part VIII. Each plant community referred to is described under the same name in Part IX. For conciseness in the tables *Acacia* and *Eucalyptus* are abbreviated to *A.* and *E.* respectively.

The land systems are also delineated on the pasture lands map where they are grouped according to their major pastoral characteristics into eight pasture lands which are described in Part XI.

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

(1) Harts Land System (4500 sq. miles)

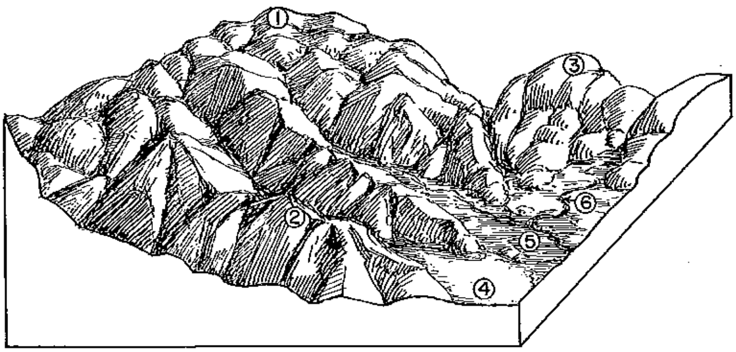
Rugged mountain ranges trending east–west through the centre of the area.

Geology.—Gneiss and schist, some massive granite and basic intrusives. Pre-Cambrian age, Arunta block, MacDonnell–Harts Ranges and Mt. Doreen–Reynolds Range.

Geomorphology.—Erosional weathered land surface: mountains with relief about 1000 ft; dense, vigorously-dissecting drainage.

Water Resources.—Small supplies of good to moderate-quality water from some fracture zones and small alluvial pockets.

Climate.—Nearest comparable climatic station is Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Uplands: rounded, locally bevelled crests, and rectilinear rocky slopes attaining 60%; narrow, winding valleys	Outcrop with pockets of shallow, gritty and stony soils	*A. kempeana* (witchetty bush)–*Cassia* spp. or sparse shrubs and low trees over sparse forbs and grasses or *Triodia clelandii* (spinifex). Minor bare rock
2	Large	Mountain ridges: narrow crests with structural benches and escarpments; rocky slopes, attaining 60%; closely spaced valleys as in unit 1		
3	Medium	Granite domes and tors: bare rock summits and rectilinear, boulder-strewn slopes, 40–60%; narrow, joint-controlled valleys with steep amphitheatral heads, locally opening into small upland basins		Sparse shrubs and low trees, or minor *A. aneura* (mulga) over *Triodia pungens* (soft spinifex), *T. spicata* (spinifex), or minor sparse forbs and grasses
4	Small	Erosional slopes at the foot of units 1, 2, and 3: some rock outcrops	Shallow soils—gritty red clayey sands (3*a*), red earths (4*a*), and calcareous earths (6*a*)	Sparse low trees, or minor *A. aneura* (mulga) over short grasses and forbs
5	Small	Drainage floors and tributary fans: narrow and discontinuous	Coarse-textured alluvial soils (1*a*, 1*h*)	Sparse low trees over short grasses and forbs
6	Very small	Shallow channels	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(2) Bond Springs Land System (1300 sq. miles)

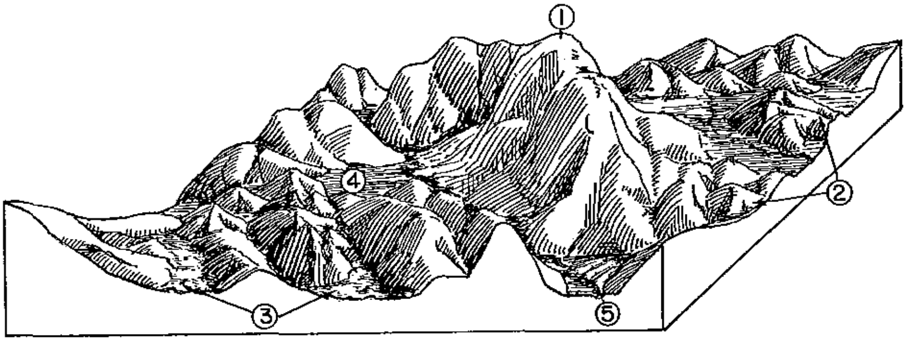
Bold rocky hills, lower rugged country, and narrow plains, in the centre of the area.

Geology.—Gneiss and schist. Pre-Cambrian age, Arunta block, MacDonnell–Harts Ranges.

Geomorphology.—Erosional weathered land surface: mainly very hilly country with narrow plains and relief up to 500 ft; some rugged terrain dissected up to 100 ft; dense subrectangular drainage.

Water Resources.—Ground-water aquifers difficult to find. Some areas have catchments suitable for surface storages.

Climate.—Nearest comparable climatic station is Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Gneiss ridges and hills: up to 500 ft high; rocky slopes, 35–60%, with minor gullies; narrow, joint-controlled valleys	Outcrop with pockets of shallow, stony or gritty soil	*A. kempeana* (witchetty bush)–*Cassia* spp., sparse shrubs and low trees or minor *A. aneura* (mulga) over sparse forbs and grasses
2	Medium	Schist ridges: up to 100 ft high, forming closely dissected tracts up to 500 yd wide; short rocky hill slopes, 10–35%, with basal colluvial aprons		As unit 1, plus *A. kempeana* (witchetty bush) over short grasses and forbs
3	Small	Erosional slopes at the foot of unit 1: 1–5%, and up to 250 yd long; rock outcrops in upper sectors, shallow gullying down slope	A range of mainly shallow soils including gritty red clayey sands (3*a*), texture-contrast soils (7*a*), red earths (4*a*), and calcareous earths (6*a*)	*A. aneura* (mulga), minor *A. georginae* (gidgee), or sparse low trees over short grasses and forbs. Sparse shrubs and low trees over *Triodia basedowii* (spinifex) on sandier parts
4	Small	Discontinuous drainage flats and basins: up to 200 yd wide, with minor tributary fans	A range of soils—alluvial soils (1*a*, 1c, 1*h*), red earths (4*d*, 4*e*), and texture-contrast soils (7*g*)	Absent, sparse low trees, or minor *A. aneura* (mulga) over short grasses and forbs, *Eragrostis eriopoda* (woollybutt), or *Aristida browniana* (kerosene grass)
5	Very small	Channels: up to 100 ft wide, and 5 ft deep	Mainly coarse grit bed-loads	*E. camaldulensis* (red gum)—*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(3) Napperby Land System (1000 sq. miles)

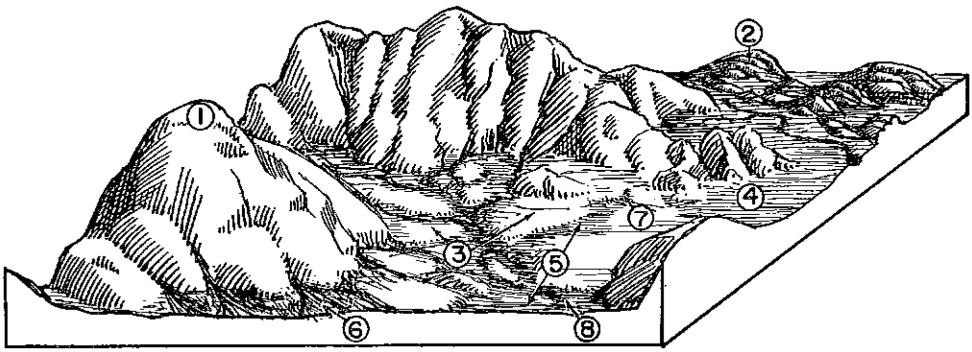
Granite hills and plains with lower rugged country in a strip from Aileron to west of Mt. Doreen homestead.

Geology.—Massive granite and gneiss, some schist. Pre-Cambrian age, Arunta block, Mt. Doreen–Reynolds Range; Lower Proterozoic, Warramunga geosyncline.

Geomorphology.—Erosional weathered land surface: hills up to 500 ft high and plains with branching shallow valleys; less extensive rugged ridges with relief up to 50 ft, and a dense rectangular pattern of narrow steep-sided valleys.

Water Resources.—Isolated alluvial or fracture aquifers may yield supplies of ground water. There are areas suitable for surface catchments.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Granite hills: tors and domes up to 500 ft high; bare rock summits, and rectilinear boulder-covered hill slopes, 40–60%, with minor gullies; short colluvial aprons, 5–10%	Outcrop with pockets of shallow, gritty or stony soils	Sparse shrubs and low trees over sparse forbs and grasses, *Triodia spicata*, or *Plectrachne pungens* (spinifex)
2	Medium	Closely-set gneiss ridges and quartz reefs: up to 50 ft high; short rocky slopes, 10–35%; narrow intervening valleys		
3	Medium	Interfluves: up to 20 ft high and ½ mile wide; flattish or convex crests, and concave marginal slopes attaining 2%	Mainly red earths (4*a*), locally red clayey sands (3*a*), and texture-contrast soils (7*a*), stony soils near hills	Sparse low trees over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
4	Medium	Erosional plains: up to 1 mile in extent, slopes generally less than 1%		
5	Small	Drainage floors: 200–400 yd wide, longitudinal gradients about 1 in 200	Mainly texture-contrast soils (7*e*), locally alluvial soils (1*a*) and red earths	*Eremophila* spp.—*Hakea leucoptera* over short grasses and forbs; minor *Kochia aphylla* (cotton-bush)
6	Small	Alluvial fans: ill-defined distributary drainage; gradients above 1 in 200	Alluvial brown sands (1*a*) and red clayey sands (3*d*)	Sparse low trees over short grasses and forbs or *Aristida browniana* (kerosene grass)
7	Small	Rounded drainage heads: up to 200 yd wide and 5 ft deep on the flanks of unit 3	Red earths	Dense *A. aneura* (mulga) over short grasses and forbs
8	Very small	Channels: up to 50 yd wide and 5 ft deep and braiding locally	Bed-loads mainly coarse grit	*E. camaldulensis* (red gum) – *A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(4) Cavenagh Land System (400 sq. miles)

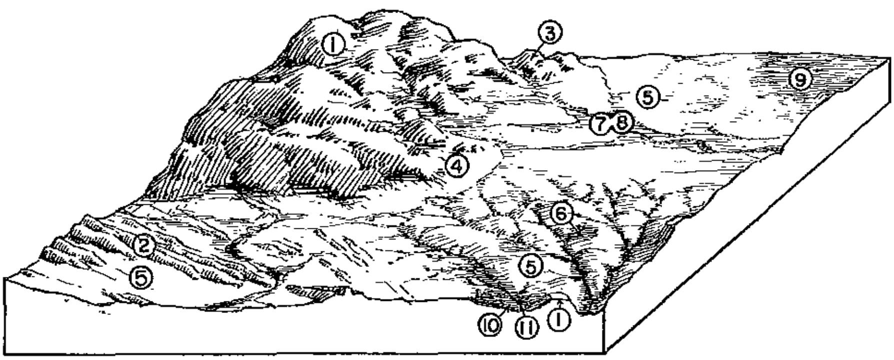
Granite hills and plains in the far south of the area.

Geology.—Massive granite intruded by dolerite dykes. Pre-Cambrian age, Arunta block, Mann–Musgrave Ranges. Small areas of conglomerate, Permian age, Great Artesian Basin.

Geomorphology.—Erosional weathered land surface: western part, hills up to 350 ft and sand-covered plains with less than 5 ft relief; further east, lower hills, and plains broken by dyke ridges and dissected up to 30 ft by a close, branching pattern of winding valleys.

Water Resources.—Prospect poor, some small supplies of good-quality water available from fracture zones.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Granite hills: bosses and tors up to 350 ft high; bare rock summits with minor laterite caps, and rectilinear, boulder-strewn slopes, 45–70%	Outcrop: pockets of shallow, gritty or stony soil	Absent or sparse shrubs and low trees or *A. kempeana* (witchetty bush)–*Cassia* spp. over sparse forbs and grasses
2	Small	Dyke ridges: up to 50 ft high and 1–3 miles long		
3	Very small	Rounded hills of boulder conglomerates: rounded crests, up to 150 ft high, and convex stony slopes, up to 50%		
4	Small	Erosional hill-foot slopes: 1–3%, and up to 400 yd long	A range of soils, mainly shallow, gritty red clayey sands (3*a*), calcareous earths (6*a*), and texture-contrast soils (7*a*) with occasional gilgais (8*a*)	*A. kempeana* (witchetty bush) or minor *A. calcicola* (myall) over short grasses and forbs
5	Medium	Interfluves: up to ½ mile wide and 30 ft high; stony, flat or convex crests, with steeper margins, 0·5–2%		
6	Small	Rounded valley heads: up to 200 yd wide, 5 ft deep, and ½ mile long: flat floors, gradients about 1 in 350; concave marginal slopes attaining 0·5%	Red earths (4*b*, 4*d*, 4*e*)	
7	Small	Shallow valley floors: flat, unchannelled surfaces up to 300 yd wide, scalded locally		*A. aneura* (mulga) over short grasses and forbs
8	Small		Texture-contrast soils (7*e*, 7*i*)	*Kochia astrotricha* (bluebush) or *K. aphylla*
9	Small	Alluvial plains and sand plains: up to ½ mile in extent, regional slopes less than 1%; ill-defined surface drainage	No records, but probably mainly red clayey sands (3*d*) with, locally, brown gritty micaceous sands (1*a*)	*A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
10	Very small	Entrenched valley floors	Coarse-textured alluvial soils (1*a*, 1*h*) and minor calcareous earths (6*a*)	Sparse low trees over short grasses and forbs
11	Very small	Channels	Bed-loads of coarse grit	*E. camaldulensis*–*A. estrophiolata* over *Chloris acicularis*

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(5) AILERON LAND SYSTEM (100 SQ. MILES)

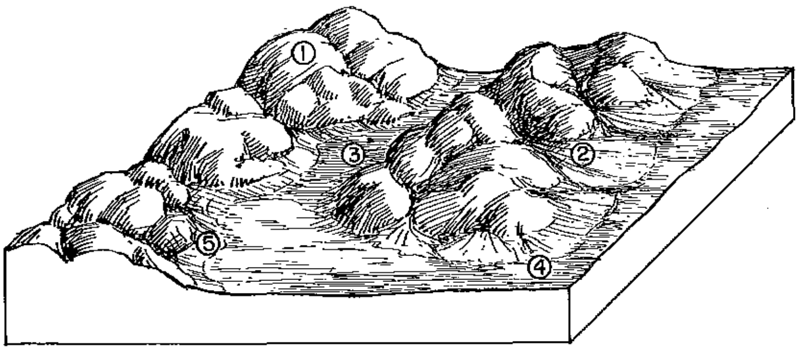
Granite hills and sandy plains near Aileron and Mt. Doreen homesteads.

Geology.—Massive granite. Pre-Cambrian age, Arunta block, Mt. Doreen–Reynolds Range. Areas of Quaternary wash.

Geomorphology.—Erosional weathered land surface: hills in plains which are partially masked by alluvium and sand.

Water Resources.—Little prospect for obtaining supplies of ground water. There are catchments suitable for surface storages.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Hills: tors and domes up to 350 ft high, with steep boulder-strewn slopes, 45–70%; small slope gullies; short colluvial aprons, 5–10%	Outcrop with pockets of shallow stony soil	Sparse shrubs and low trees over *Triodia pungens* (spinifex), minor *T. spicata* (spinifex), or sparse forbs and grasses
2	Medium	Alluvial fans: up to 1 mile long, gradients 1 in 100 to 1 in 200; channelled upper sectors, with distributary zones down slope	Alluvial brown sands (1*a*) and red clayey sands (3*d*)	Sparse low trees over short grasses and forbs or *Aristida browniana* (kerosene grass)
3	Medium	Erosional intermont plains: up to ½ mile wide, with little channel drainage	Red earths (4*d*, 4*e*) with minor alluvial variants	*A. aneura* (mulga) over *Eragrostis eriopoda* (woollybutt) or *Plectrachne schinzii* (spinifex)
4	Medium	Sand plain: no surface drainage	Red clayey sands (3*d*)	Sparse shrubs and low trees over *Plectrachne schinzii* (spinifex)
5	Small	Short erosional slopes at the foot of unit 1: 0·5–5%; some rock outcrops	Mainly gritty red clayey sands (3*a*) and stony soils; locally texture-contrast soils (7*a*)	Sparse low trees over short grasses and forbs

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(6) Boen Land System (2700 sq. miles)

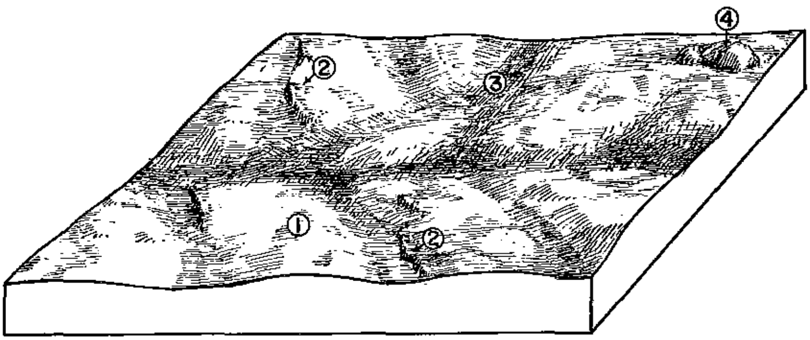
Gently undulating mulga plains (Plate 6, Fig. 1; Plate 7, Fig. 1) with red soils, mainly in the northern half of the area.

Geology.—Quaternary soils and Tertiary minor basins and piedmonts.

Geomorphology.—Erosional weathered land surface: stable or lightly-dissected peneplain on selectively weathered rocks; open branching pattern of shallow valleys.

Water Resources.—Ground-water prospects variable. Good-quality water is available from thin aquifers in the minor basins and piedmonts. Aquifers difficult to find in the metamorphic rocks. There are catchments suitable for surface storages.

Climate.—Comparable climatic stations are Alice Springs, Tea Tree Well, and Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to 2 miles wide and 20 ft high; flattish or convex crests, and steeper concave margins	Mainly red earths (4*a*, 4*g*, locally 4*b*), local red clayey sands (3*a*), texture-contrast soils (7*a*), and outcrop	*A. aneura* (mulga), minor *A. kempeana* (witchetty bush), or *A. georginae* (gidgee) over short grasses and forbs, or minor *Eragrostis eriopoda* (woollybutt)
2	Small	Low rises or slopes on the dissected margins of unit 1: lateritic cappings and outcrops of weathered or fresh rock		
3	Small	Drainage depressions: up to 400 yd wide, longitudinal gradients 1 in 250 to 1 in 500; flat floors, with concave margins up to 0·4%	Red earths (4*e*)	Dense *A. aneura* (mulga), or minor *A. kempeana* (witchetty bush) over *Chloris acicularis* (curly windmill grass)
4	Very small	Low hills on unit 1	Outcrop with pockets of shallow, stony or gritty soil	Sparse shrubs and low trees or *A. kempeana*–*Cassia* spp. over short grasses and forbs or sparse forbs and grasses

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(7) Warburton Land System (600 sq. miles)

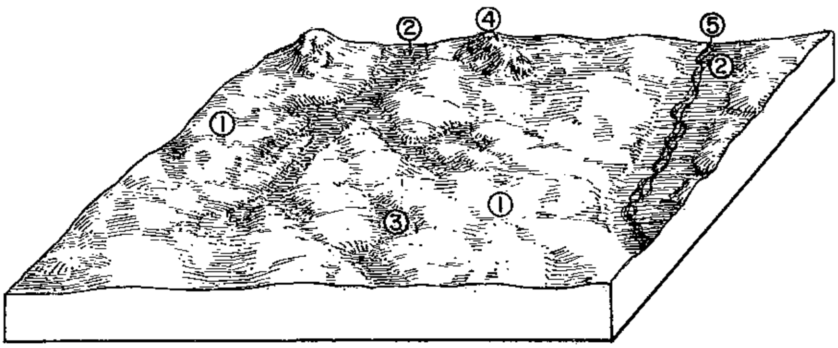
Sparsely-timbered granite plains in the north and north-west of the area, mainly near Coniston homestead.

Geology.—Quaternary soils and Tertiary "deep weathering profile". Overlying Pre-Cambrian granite, schist, and gneiss.

Geomorphology.—Erosional weathered land surface: peneplain of selectively weathered rocks; open sub-rectangular pattern of shallow valleys.

Water Resources.—Prospects generally poor but isolated fracture aquifers may yield supplies of ground water. There are areas suitable for surface catchment.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Very large	Interfluves: up to ½ mile wide and 15 ft high; flat or slightly rounded stony crests with minor rock outcrops; short concave marginal slopes attaining 1%	Mainly red earths (4*a*), locally red clayey sands (3*a*), and stony soils including texture-contrast soils (7*a*)	Sparse low trees, *A. aneura* (mulga), or *A. kempeana* (witchetty bush) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
2	Medium	Drainage floors: up to 300 yd wide; flat, unchannelled central tracts and gently sloping margins	Presumably red earths as 4*e*	*A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
3	Small	Short valley heads shallowly entrenched on the flanks of unit 1: unchannelled floors up to 500 yd wide liable to shallow gullying; longitudinal gradients above 1 in 500	Texture-contrast soils (7*e*)	*Eremophila* spp.–*Hakea leucoptera* over short grasses and forbs or *Bassia* spp.; or minor *Kochia aphylla* (cotton-bush)
4	Very small	Small hills and quartz reef ridges: up to 30 ft high	Outcrop with pockets of shallow, gritty or stony soil	Sparse shrubs and low trees over *Triodia pungens* (spinifex), *T. spicata* (spinifex), or sparse forbs and grasses. Far north: *E. brevifolia* (snappy gum) over *Triodia pungens* (spinifex) or *Plectrachne pungens* (spinifex)
5	Very small	Channels: wide, shallow, and braiding	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(8) Tietkins Land System (100 sq. miles)

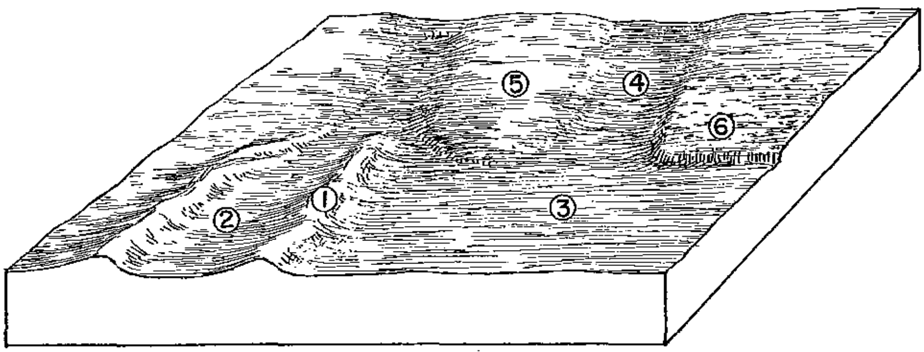
Sandy mulga plains on granite, in the far south of the area.

Geology.—Tertiary "deep weathering profile". Overlying massive Pre-Cambrian granite.

Geomorphology.—Erosional weathered land surface: peneplain of selectively weathered rock; southern parts are slightly dissected by disconnected valleys; northern parts are masked by sand plain, dunes, and calcrete, and have little surface drainage.

Water Resources.—Moderate supplies of good-quality water may be available from granite aquifers and alluvium.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Small	Sand dunes: up to 20 ft high, trending NNE.; broad flat crests, and steeper eastern flanks; stabilized by vegetation	Red sands (3*f*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex) or *Cassia eremophila* over short grasses and forbs
2	Small	Dune swales: up to 300 yd wide, locally receiving run-on from unit 4; minor ferricrete or calcrete exposures	Red clayey sands (3*d*)	*A. aneura* (mulga) over *Eragrostis eriopoda* (woollybutt) or short grasses and forbs
3	Medium	Sand plain: down slopes from flood-outs of unit 4		
4	Small	Drainage floors: up to ½ mile wide, with flat, unchannelled, central tracts and gently sloping concave margins	Red clayey sands (3*d*) and red earths (4*d*)	
5	Medium	Interfluves: up to ½ mile wide and 15 ft high; bevelled or slightly rounded stony crests	Red earths (4*f*, 4*g*)	
6	Small	Calcrete platforms: up to 30 ft high; uneven surfaces with some sand cover; steep escarpments with stony upper slopes and basal sand aprons	Red clayey sands (3*b*), red earths (4*b*), and stony, shallow soils, probably calcareous, near escarpments	*A. kempeana* (witchetty bush) over *Triodia longiceps* (spinifex)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(9) Outounya Land System (600 sq. miles)

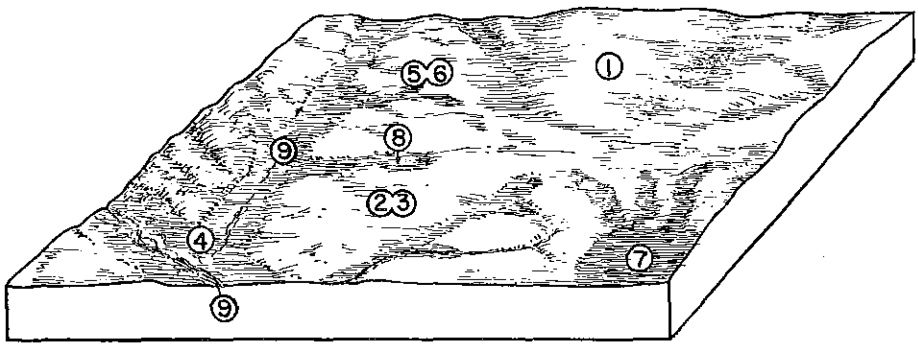
Granite plains in the far south of the area.

Geology.—Massive granite and schist. Pre-Cambrian age, Arunta block, Mann–Musgrave Ranges. Areas of Quaternary wash and alluvium.

Geomorphology.—Erosional weathered land surface: peneplain of selectively weathered rocks; in the north-west, undissected with some alluvial cover and little surface drainage; further east, lightly dissected by an open subrectangular pattern of valleys.

Water Resources.—Isolated aquifers may yield moderate to very small supplies of variable-quality water. Surface catchment may be necessary.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Erosional plains: flat surfaces with minor calcrete exposures and selectively weathered, branching depressions	Unknown — probably rather coarse-textured soils (*3d, 4b, 4d*)	*A. kempeana* (witchetty bush), minor *A. aneura* (mulga), or *A. calcicola* (myall), over short grasses and forbs; minor areas treeless with *Atriplex vesicaria* (saltbush)
2	Large	Interfluves: up to 20 ft high and ½ mile wide; bevelled or rounded stony crests with minor outcrops; steeper margins, 0·5–2%	A range of mainly shallow soils —red clayey sands (*3a*), calcareous earths (*6a*), and as unit 3	
3	Very small		Texture-contrast soils (*7a*), occasional gilgais (*8a*)	Mainly treeless, minor areas *A. aneura*, *A. calcicola*, or *A. kempeana* over *Kochia astrotricha;* minor *K. aphylla* or samphire
4	Small	Main valley floors: slightly entrenched, flat floors up to 500 yd wide, with discontinuous channel drainage	Coarser-textured texture-contrast soils (*7e, 7i*)	*Kochia astrotricha* (bluebush), *Bassia* spp., minor *K. aphylla* (cotton-bush), or *Arthrocnemum* (samphire)
5	Small	Rounded valley heads: on the flanks of units 2 and 3: up to 300 yd wide, 5 ft deep, and 500 yd long, longitudinal gradients 1 in 350; flat, scalded central tracts, and concave margins attaining 0·5%		
6	Very small		Coarser-textured red earths (*4b, 4d*)	*A. aneura* (mulga) over short grasses and forbs or minor *Eragrostis eriopoda* (woollybutt)
7	Small	Alluvial plains and tributary drainage floors: flat surfaces with minor calcrete exposures	Unknown—probably rather coarse-textured soils	
8	Small	Tributary valley floors: flat, unchannelled surfaces up to 200 yd wide	Alluvial reddish clayey sands (*1h*)	*A. aneura* (mulga) over *Chloris acicularis* (curly windmill grass)
9	Very small	Channels: up to 75 yd wide and incised up to 15 ft, locally with low calcrete terraces	——	*A. aneura* or *E. camaldulensis–A. estrophiolata* over *Chloris acicularis*

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(10) Hann Land System (1500 sq. miles)

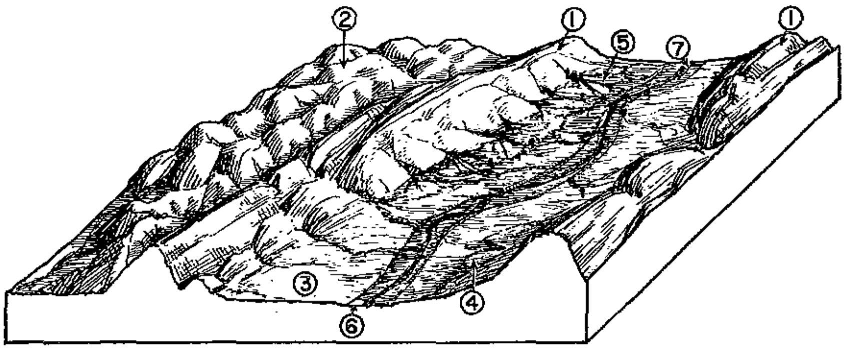
Rugged sandstone ranges and adjacent plains, in the north of the area.

Geology.—Sandstone, quartzite, siltstone, and conglomerate. Lower Proterozoic age, Warramunga geosyncline (Hatches Creek group); Upper Proterozoic age, Ngalia trough, Georgina basin (Mopunga group in part); upper Palaeozoic age, Ngalia trough.

Geomorphology.—Erosional weathered land surface: mountain ridges and uplands and tributary slopes; drainage with prominent transverse elements and closely-spaced, branching head channels.

Water Resources.—Good supplies of moderate-quality water are available from sandstones and limestones. Aquifers are difficult to find in the metamorphic rocks.

Climate.—Comparable climatic stations are Tea Tree Well and Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Ridges: up to 300 ft high; escarpments with sheer rock faces and gullied rock-strewn lower slopes, 15–40%; dissected dip slopes with secondary ridges; transverse drainage gaps	Outcrop, very little soil	Sparse shrubs and low trees, minor *A. aneura* (mulga), *A. georginae* (gidgee), *A. kempeana* (witchetty bush) or (in far north) *E. brevifolia* (snappy gum) over *Triodia pungens* (spinifex), *T. spicata*, minor *T. longiceps*, (in south) *T. clelandii*, (in north) *Plectrachne pungens* (spinifex), or minor sparse forbs and grasses
2	Medium	Uplands and hills: rounded, locally bevelled summits somewhat lower than unit 1, with minor weathering crusts; steep hill slopes; closely-spaced branching valleys		
3	Very small	Erosional slopes at the foot of units 1 and 2: approximately 1–2%, and up to 300 yd long; stony surfaces with rock outcrop, with shallow gullying in lower parts	Shallow, stony or sandy soils	*E. microtheca* (coolibah), *A. aneura* (mulga), (in far north) *E. brevifolia* (snappy gum), or sparse shrubs and low trees over *Triodia pungens* (spinifex) or *T. spicata*
4	Very small	Short colluvial aprons: stony slopes, attaining 10%, terraced locally		Sparse low trees over short grasses and forbs
5	Small	Alluvial fans, coalescing down slope as alluvial vales up to 1½ miles wide: gradients 1 in 25 to 1 in 250; terraced up to 5 ft locally	Mainly red clayey sands (3*d*), locally red earths (4*d*, 4*e*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex) or minor *T. pungens* (spinifex)
6	Small	Flood-plains: up to 400 yd wide	Mainly alluvial soils (1*h*, 1*i*); locally red clayey sands (3*d*), red earths (4*d*, 4*e*), stony or gravelly soils, and very locally, yellow earths (5*a*)	On alluvial soils sparse low trees over *Aristida browniana;* on red earths *A. aneura* (mulga) over short grasses and forbs; on yellow earths *E. microtheca* (coolibah) over *Chrysopogon fallax* or *Themeda avenacea*
7	Very small	Channels: up to 50 yd wide; meandering or braiding lower sectors, with alternate deep and shallow reaches	——	*E. camaldulensis–A. estrophiolata* or *E. microtheca*, over *Chloris acicularis*, *Themeda avenacea*, *T. australis*, or *Bothriochloa ewartiana–Eulalia fulva*

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(11) Wonorah Land System (4600 sq. miles)

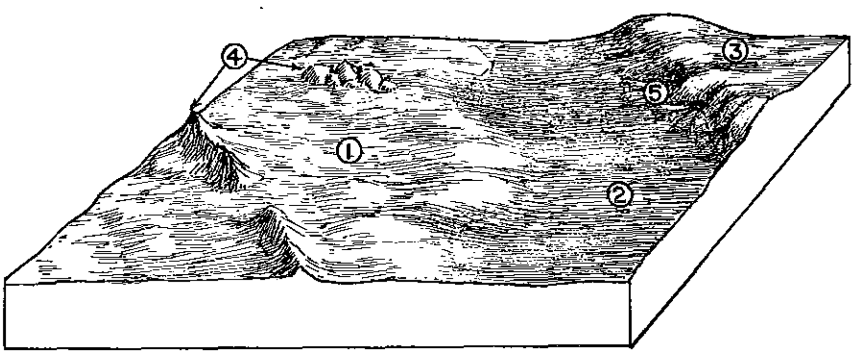
Spinifex-covered plains (Plate 3, Fig. 1) in the far north of the area.

Geology.—Tertiary "deep weathering profile". Developed on flat-lying shales and limestones of lower Palaeozoic age in the Georgina basin; and strongly deformed sandstones, greywackes, and siltstones of Lower Proterozoic age, Warramunga geosyncline (Warramunga group).

Geomorphology.—Erosional weathered land surface: stable or lightly dissected peneplain with little organized surface drainage.

Water Resources.—Ground water is unobtainable in some areas, and is difficult to find in others because aquifers are restricted or concealed. Few catchments are suitable for surface storage.

Climate.—Nearest comparable climatic station is Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Higher parts of plain: lightly-stripped, stony surfaces with outcrops of weathered rock and surface limestone; disorganized surface drainage	No records for this region but probably red clayey sands (3*d*, 3*e*) and red earths (4*f*) as for the dominant soils of this land system in the Barkly region; and presumably some shallow stony soils	Sparse shrubs and low trees, minor *A. aneura* (mulga), or *E. brevifolia* (snappy gum) over *Triodia pungens* (spinifex)
2	Large	Lower parts of plain: flat plains with no surface drainage		
3	Small	Strike rises up to 30 ft high and ¼ mile wide; bevelled stony crests; marginal slopes, up to 400 yd long and attaining 5%, with short, incised drainage channels	Presumably outcrop and shallow, stony soils	
4	Very small	Hills: of various forms, up to 100 ft high		
5	Very small	Alluvial fans: up to ½ mile long	Presumably red clayey sands (3*d*)	Sparse shrubs and low trees or *E. brevifolia* (snappy gum) over *Triodia pungens* (spinifex) or *T. longiceps* (spinifex)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(12) ALINGA LAND SYSTEM (800 SQ. MILES)

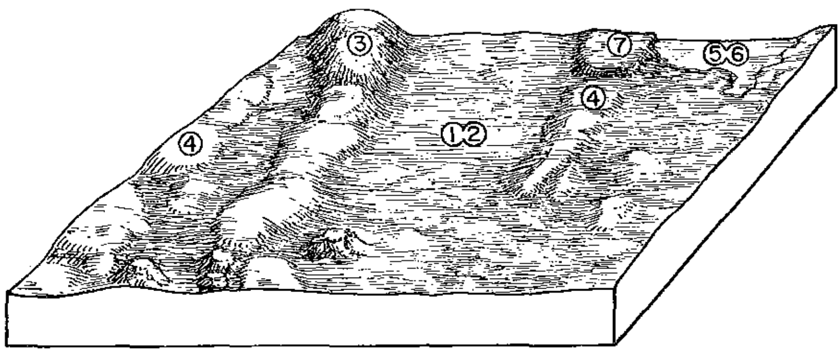
Mulga or spinifex on undulating plains in the north-east of the area, mainly between Ammaroo and Murray Downs homesteads.

Geology.—Sandstone and shale, some thin limestone. Lower Palaeozoic age, Georgina basin (Sandover beds).

Geomorphology.—Erosional weathered land surface: undulating plains traversed by low, rounded, strike ridges; vales with disorganized surface drainage.

Water Resources.—Supplies of good to moderate-quality water available at moderate depths from sandstone and limestone aquifers.

Climate.—Nearest comparable climatic station is Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Plains: up to 1 mile wide; little channel drainage	Red earths (4*e*)	*A. aneura* (mulga), minor *A. georginae* (gidgee) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
2	Small	Sand plain in unit 1	Red clayey sands (3*d*	Sparse shrubs and low trees over *Triodia pungens* (spinifex), *T. basedowii* (spinifex), or *Plectrachne pungens* (spinifex)
3	Small	Rounded strike ridges and small mesas: stony crests up to 70 ft high, with lateritic gravels; dissected slopes, 3–10%	Outcrop, with shallow stony soil	Sparse shrubs and low trees over *Triodia pungens* (spinifex)
				A. kempeana (witchetty bush)–*Cassia* spp. over sparse forbs and grasses
4	Small	Broad rises: flattish or gently rounded stony crests up to 10 ft high, with weathered rock outcrops and lateritic gravels	Shallow, stony soils, including texture-contrast soils (7*d*); red clayey sands (3*e*) and red earths (4*f*)	*Bassia* spp., *Atriplex vesicaria* (saltbush), or *Triodia longiceps* (spinifex), *A. georginae* (gidgee) over bare ground
5	Very small	Pans and swamps: up to 1 mile in extent; branching tributary flats, and gently sloping margins	Coarse-structured clay soils (8*b*, very locally 8*a*)	Absent or *E. microtheca* (coolibah) over *Chenopodium auricomum* (bluebush) or *Astrebla lappacea* (curly Mitchell grass)
6	Very small		Yellow earths (5*a*) and locally a texture-contrast soil (7*h*)	*E. microtheca* (coolibah) or minor *A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
7	Very small	Calcrete platforms on unit 4: up to 15 ft high, with stony higher parts and sand-covered lower parts	Calcrete exposures and shallow calcareous earths (6*a*)	*A. kempeana* (witchetty bush) over short grasses and forbs

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(13) OORATIPPRA LAND SYSTEM (200 SQ. MILES)

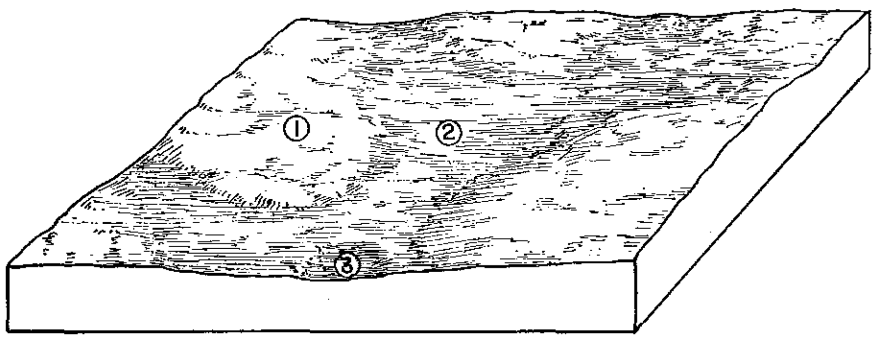
Limestone plains with mulga or gidgee, near the lower Sandover River in the north-east of the area.

Geology.—Gently dipping interbedded dolomite, limestone, and shale. Lower Palaeozoic age, Georgina basin.

Geomorphology.—Erosional weathered land surface; plains with an open branching pattern of drainage floors with restricted tributary development.

Water Resources.—Moderate supplies of moderate-quality water are available from some porous and fractured limestones, dolomites, and sandstones. Drilling may be difficult because of boulders or hard rock.

Climate.—Nearest comparable climatic station is Urandangie.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to 2 miles wide and 5 ft high; flat, stony crests with rock outcrops and some calcrete; gently sloping margins with shallow, branching valley heads	Mainly red earths (?4*b*); locally, shallow, stony soils and calcareous earths (6*b*)	*A. georginae* (gidgee) or *A. kempeana* (witchetty bush) over short grasses and forbs
2	Medium	Drainage floors: straight-sided valleys up to ¾ mile wide with flat, unchannelled floors	Red earths (4*e*, 4*g*)	Mainly *A. aneura* (mulga) over short grasses and forbs; minor sparse shrubs and low trees over *Triodia pungens* (spinifex) or *T. basedowii* (spinifex)
3	Very small	Alluvial basins in unit 2	No records	*E. microtheca* (coolibah) over *Chrysopogon fallax* (golden-beard grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(14) Chisholm Land System (200 sq. miles)

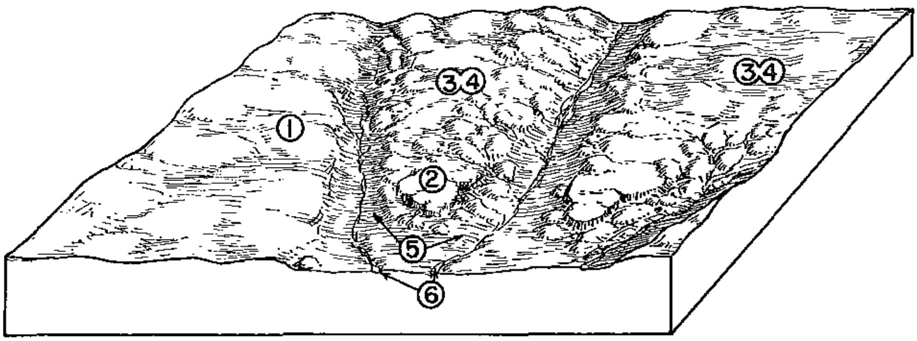
Broken country with little relief near the centre of the area, mainly between Bond Springs and Woodgreen homesteads.

Geology.—Tertiary "deep weathering profile". Developed on Pre-Cambrian schist and gneiss.

Geomorphology.—Partially dissected erosional weathered land surface: undulating peneplain remnants and stripped interfluves; a close rectangular pattern of entrenched valleys.

Water Resources.—Isolated aquifers may yield supplies of ground water. There are areas suitable for surface catchments.

Climate.—Comparable climatic stations are Alice Springs and Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Undulating surfaces: up to 1 mile in extent, relief up to 10 ft; stable surfaces with lateritic and calcareous weathering crusts	Red earths (4*g*)	*A. aneura* (mulga) over short grasses and forbs
2	Small	Limestone cappings: forming flat-topped rises up to 15 ft above units 3 and 4	Shallow soils—including stony soils and calcareous earths (6*a*)	Sparse shrubs and low trees over *Triodia longiceps* (spinifex)
3	Medium	Stripped interfluves: bevelled stony crests up to 400 yd wide and 25–75 ft high, with outcrops of fresh and weathered rock; steep, rocky margins		
4	Small		Outcrop of ferruginous rock with shallow, stony soils	*A. kempeana–Cassia* spp. or minor *A. aneura* (mulga) over sparse forbs and grasses
5	Small	Valley floors: flat floors up to 300 yd wide, with restricted channelling, some scalding, local gilgais, and minor alluvial basins	Mainly texture-contrast soils (7*g*) with, locally, gilgais and small areas of coarse-structured clay soils (8*a*)	Sparse low trees over short grasses and forbs
6	Very small	Channels: up to 50 yd wide; shallow, and locally braiding	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) or *E. microtheca* (coolibah), over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(15) Delny Land System (500 sq. miles)

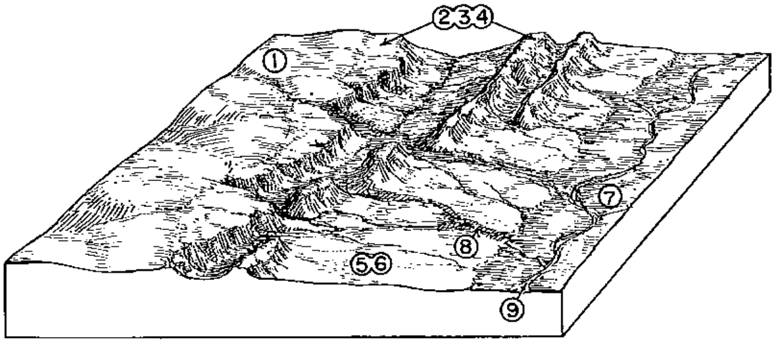
Broken country with moderate relief (Plate 8, Fig. 2) in the east central part of the area, between Mt. Riddoch and Delny homesteads.

Geology.—Schist and gneiss, Pre-Cambrian age, Arunta block, MacDonnell–Harts Ranges. Moderate areas with development of Tertiary "deep weathering profile". Small areas with Tertiary chalcedony and calcareous silt.

Geomorphology.—Partially dissected erosional weathered land surface: peneplain, dissected margins, and lower erosional plains with a rectangular drainage pattern.

Water Resources.—Ground-water prospects generally poor but isolated aquifers may yield supplies of variable-quality water. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Undulating plains: up to 1 mile in extent, with up to 20 ft relief; weathered surfaces with some calcrete cover	A number of soils with markedly different characteristics including red earths (4*g*), calcareous earths (6*b*), and outcrop with shallow stony soils, including texture-contrast soils	*A. aneura* (mulga), *A. georginae* (gidgee) or *A. kempeana* (witchetty bush) over short grasses and forbs, *Eragrostis eriopoda* (woollybutt), or *Bassia* spp.; minor *Kochia astrotricha* (bluebush)
2	Small	Spurs, mesas, and accordant ridges: up to 100 ft high; stripped laterite cappings, and steep slopes in calcified or fresh rock		
3	Small		On areas of fresh crystalline rock, pockets of shallow, stony or gritty soil	Absent or *A. aneura* (mulga) over sparse forbs and grasses
4	Small		On chalcedonic rock and calcrete, pockets of shallow, stony calcareous earths	
5	Small	Interfluves: up to 10 ft high; broad, flattish stony crests and concave margins	Outcrop and a range of shallow soils including calcareous earths (6*a*), red clayey sands (3*a*), and red earths (4*a*)	As units 1 and 2 or sparse low trees over short grasses and forbs or *Bassia* spp.
6	Small		Texture-contrast soils (7*a*) with gilgais (8*a*)	*Bassia* spp. or *Atriplex vesicaria* (saltbush)
7	Small	Main valley floors: 200 to 800 yd wide; longitudinal gradients approximately 1 in 500	Mainly red earths of varying texture (4*d*, 4*e*); local alluvial variants	*A. aneura* (mulga) or sparse low trees over short grasses and forbs or *Eragrostis eriopoda* (woollybutt): minor dense *A. georginae* (gidgee) over bare ground
8	Small	Tributary valley floors: up to 200 yd wide; flat floors with numerous small gullies but few large channels	Mainly texture-contrast soils (7*g*); locally replaced by, or in a complex with, red coarse-structured clay soils (8*a*)	Absent or minor dense *A. georginae* (gidgee) over short grasses and forbs, *Eragrostis xerophila* (neverfail), or bare ground
9	Very small	Channels: up to 200 ft wide and 5 ft deep	——	Dense *A. aneura* (mulga) over short grasses and forbs or *E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(16) Kulgera Land System (<50 sq. miles)

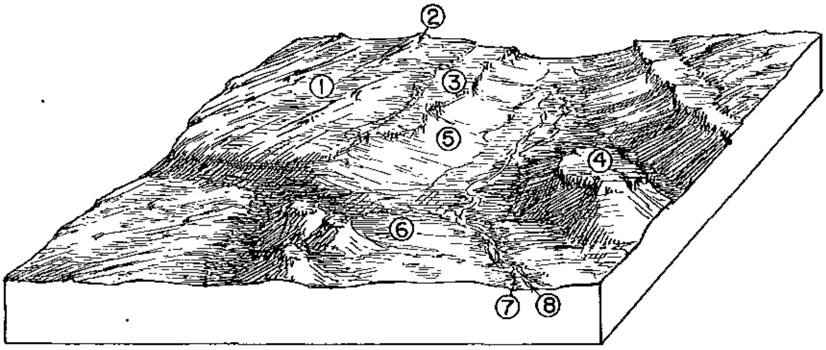
Broken country with little relief in the far south of the area.

Geology.—Tertiary "deep weathering profile". Developed in Pre-Cambrian schist and Mesozoic sandstone (valley fill). Very small areas of Tertiary chalcedony.

Geomorphology.—Partially dissected erosional weathered land surface: undulating plains with moderately dissected weathered lower tracts.

Water Resources.—Metamorphic rocks yield small supplies of water of variable quality. There are areas suitable for surface catchment.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Interfluves: up to ½ mile wide and up to 50 ft above unit 3; flat crests and steeper margins, locally attaining 10%; stony surfaces with some calcrete cover	A range of soils—gritty red clayey sands (3*a*), calcareous earths (6*a*), texture-contrast soils (7*a*) with occasional gilgais (8*a*), and very locally red earths (4*d*, 4*e*)	Absent or *Cassia eremophila* over short grasses and forbs
2	Very small	Narrow dyke ridges: up to 25 ft high, with steep, boulder-mantled slopes	Outcrop, very little soil	Absent or sparse shrubs over sparse forbs and grasses
3	Small	Laterite-capped mesas and benches: up to 35 ft high; cappings of lateritic ironstone with low breakaway margins; lower slopes up to 10%, developed in weathered granite	Outcrop, and shallow, stony soils including texture-contrast types	*Atriplex vesicaria* (bladder saltbush)
4	Small	Limestone-capped plateaux: up to 100 ft high; rocky summits, breakaway margins, and stony, gullied hill slopes, 10–25%	Outcrop, and shallow, stony calcareous earths	Absent or minor *A. aneura* (mulga) over *Atriplex vesicaria* (bladder saltbush) or *Kochia astrotricha* (bluebush)
5	Small	Slopes below units 3 and 4: 0·5–3%, and up to 500 yd long; stony surfaces subject to scalding and shallow gullying	Texture-contrast soils (7*e*, 7*f*)	
6	Small	Plains: with less than 5 ft relief		Absent or *A. kempeana* (witchetty bush) over short grasses and forbs; *A. aneura* (mulga) over *Kochia astrotricha* (bluebush); *Atriplex vesicaria* (bladder saltbush)
7	Very small	Valley floors: flat, scalded surfaces up to 300 yd wide and lowered to 5 ft in unit 6		Absent; minor *A. calcicola* (myall) over short grasses and forbs; *Kochia astrotricha* (bluebush), *K. aphylla* (cottonbush), or *Atriplex vesicaria* (bladder saltbush)
8	Very small	Channels: up to 10 yd wide; discontinuous, shallow, and braiding locally	——	*A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(17) Pularoo Land System (100 sq. miles)

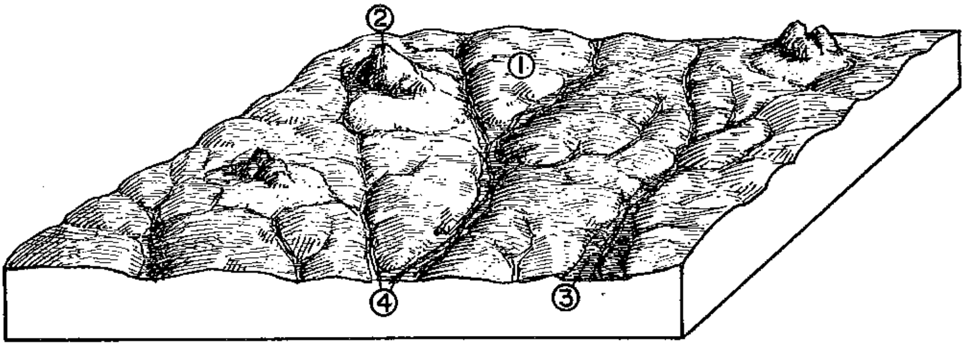
An area of sparsely timbered broken lowlands on granites, in the north-west of the area.

Geology.—Massive granite and gneiss. Pre-Cambrian age, Arunta block, Mt. Doreen–Reynolds Range.

Geomorphology.—Partially dissected erosional weathered land surface: stony plains dissected by closely-spaced branching valleys.

Water Resources.—Ground-water prospects are generally poor but isolated aquifers may yield large supplies of ground water.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to 500 yd wide and 30 ft high; bevelled stony crests and steeper, gullied marginal slopes up to 5%	Gritty red clayey sands (3*a*) and red earths (4*a*); minor salting in gullies	Sparse low trees or minor *A. kempeana* (witchetty bush) over short grasses and forbs
2	Very small	Small hills: tors up to 50 ft high, with steep, boulder-covered slopes	Outcrop, with pockets of shallow, stony or gritty soil	Sparse shrubs and low trees over sparse forbs and grasses
3	Very small	Valley floors: flat scalded surfaces up to 300 yd wide	No records, probably coarse-textured alluvial soils	*A. aneura* (mulga) over short grasses and forbs
4	Very small	Channels: up to 50 yd wide, shallow, and braiding locally	———	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(18) Alcoota Land System (1100 sq. miles)

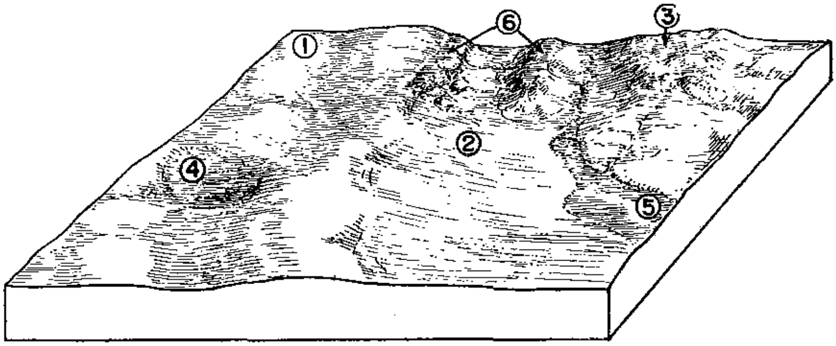
Slightly broken, sparsely timbered plains, in the north central part of the area.

Geology.—Tertiary "deep weathering profile" on Pre-Cambrian schist, gneiss, and granite. Small areas of relatively fresh rock.

Geomorphology.—Partially dissected erosional weathered land surface: extensively stripped and dissected peneplain on selectively weathered rocks; open branching pattern of broad alluvial valleys.

Water Resources.—Difficult to obtain large supplies of ground water. There are areas suitable for surface catchment.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Gently undulating plains: relief up to 20 ft	Mainly red earths (4*g*), locally texture-contrast soils	*A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
2	Medium	Slopes below units 3 and 6: erosional and depositional in origin	Texture-contrast soils (7*a*, 7*d*, 7*e*, 7*g*)	*Bassia* spp., short grasses and forbs, or *Kochia astrotricha* (bluebush), in some parts with *Eremophila* spp.–*Hakea leucoptera*
				Minor *A. aneura* (mulga) or *A. georginae* (gidgee) over *Bassia* spp.
3	Very small	Stripped surfaces: uneven terrain, with many outcrops of fresh and weathered rock, and some surface limestone	Shallow stony soils and calcareous earths (6*a*, 6*b*)	*A. kempeana* (witchetty bush) over short grasses and forbs
4	Very small	Alluvial flats on unit 1: stony surfaces, with some gilgais	Mainly red, coarse-structured clay soils with gilgai depressions (8*a*); texture-contrast soils (7*g*) may occur marginally to or in a complex with 8*a*	*Bassia* spp., short grasses and forbs, *Kochia astrotricha* (bluebush), *K. aphylla* (cotton-bush), *Astrebla pectinata* (Mitchell grass), or *Eragrostis xerophila* (neverfail)
5	Very small	Valley plains: typically unchannelled	Mainly red earths (4*d*, 4*e*), locally alluvial variants	Sparse low trees over short grasses and forbs or *Chloris acicularis* (curly windmill grass)
				E. camaldulensis (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)
6	Very small	Mesas and broad rises: up to 50 ft high, with flat cappings of lateritic ironstone gravel	Outcrop with shallow stony soil	*A. aneura* (mulga) or sparse shrubs and low trees over sparse forbs and grasses; minor *Kochia astrotricha* (bluebush)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(19) Ryan Land System (300 sq. miles)

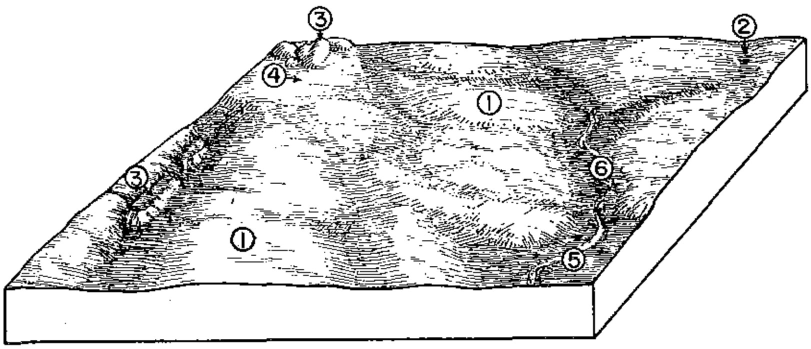
Stony granite plains with sparse vegetation in the northern half of the area.

Geology.—Granite and granite gneiss. Pre-Cambrian age, Arunta block, Mt. Doreen–Reynolds Range and MacDonnell–Harts Ranges. Partially with Tertiary "deep weathering profile".

Geomorphology.—Partially dissected erosional weathered land surface: locally stripped and dissected peneplain on selectively weathered rocks; subrectangular drainage pattern.

Water Resources.—Prospects for useful supplies of ground water are poor, surface catchment recommended.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to ¾ mile wide and 20 ft high; convex or bevelled stony crests; steeper, concave margins, up to 1%, with rounded valley heads up to 300 yd wide and 5 ft deep	Mainly texture-contrast soils (*7a*, *7e*), locally red earths (*4a*)	Absent or *Eremophila* spp., *Hakea leucoptera* over short grasses and forbs, *Bassia* spp., *Eragrostis xerophila* (never-fail), *Atriplex vesicaria* (bladder saltbush), or *Kochia aphylla* (cotton-bush)
2	Medium	Tributary valley floors: up to 200 yd wide, locally opening into plains up to 500 yd wide; drainage tracts marked by linear scalding and shallow gullying, with restricted channelling in lower sectors		
3	Small	Hills and bevelled rises: tors and domes up to 50 ft high, with thin laterite or silcrete crusts locally	Outcrop, with shallow stony or gritty soils	Sparse shrubs and low trees over *Triodia pungens* (spinifex) or *T. spicata* (spinifex); or *A. aneura* (mulga) or *A. kempeana* (witchetty bush)–*Cassia* spp. over sparse forbs and grasses
4	Very small	Short slopes below unit 3: 0·5–3%; shallow gullying on lower parts	Gritty red clayey sands (*3a*) and alluvial brown sands (*1a*)	Sparse low trees or *A. aneura* (mulga), minor *A. kempeana* (witchetty bush) or *A. georginae* (gidgee) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
5	Small	Main valley floors: widening to 1 mile in the lower sectors	Red earths (*4e*)	*A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
6	Very small	Channels: up to 75 yd wide and 2 ft deep, in unit 5	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(20) Ennugan Land System (200 sq. miles)

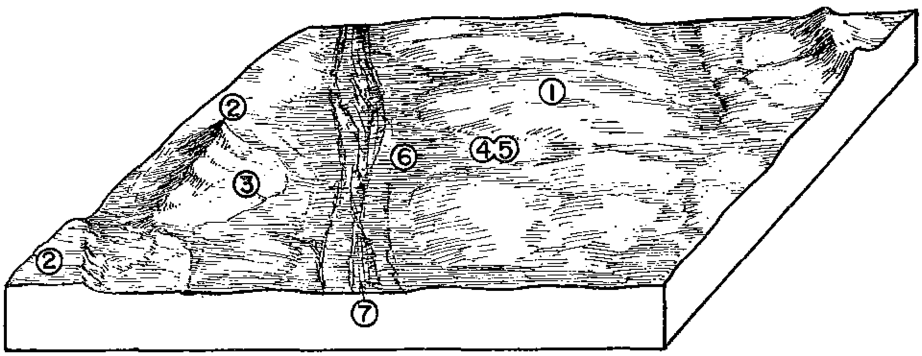
Sparsely timbered, undulating plains in the north central part of the area.

Geology.—Schist and gneiss. Pre-Cambrian age, Arunta block, Mt. Doreen–Reynolds Range.

Geomorphology.—Partially dissected erosional weathered land surface: slightly dissected peneplain with relief up to 20 ft; open subrectangular drainage pattern.

Water Resources.—Isolated aquifers may yield supplies of ground water of variable salinity. There are catchments suitable for surface storages.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: $\frac{1}{4}$–1 mile wide and 5–20 ft high; convex or bevelled stony crests	No records, but probably mainly red earths (*4a*), with locally, red clayey sands (*3a*) and stony soils including texture-contrast soils (*7a*)—as in Warburton land system	Sparse low trees over short grasses and forbs; minor sparse shrubs and low trees over *Triodia basedowii* (spinifex)
2	Small	Low hills, ridges, and rocky rises: up to 500 yd wide; partially bevelled crests, with laterite caps; marginal slopes up to 20%	Outcrop; pockets of shallow, stony or gritty soil	Sparse shrubs and low trees over *Triodia spicata* (spinifex)
3	Small	Slopes below unit 2: up to 500 yd long, 0·5–2%; stony surfaces, with rock outcrops in upper parts and shallow gullying down slope	No records, probably texture-contrast soils (*7a, 7e*)	As unit 1
4	Small	Flat valley floors: up to 400 yd wide; without channel drainage	No records, probably red earths	*A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
5	Very small		No records, probably texture-contrast soils (*7e*)	*Eragrostis xerophila* (neverfail)
6	Small	Valley plains: up to $\frac{1}{2}$ mile wide, with lightly scalded surfaces in flood zones	No records, probably alluvial soils	Sparse low trees over short grasses and forbs
7	Very small	Shallow drainage channels: 50–200 yd wide, braiding locally	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(21) Sonder Land System (2300 sq. miles)

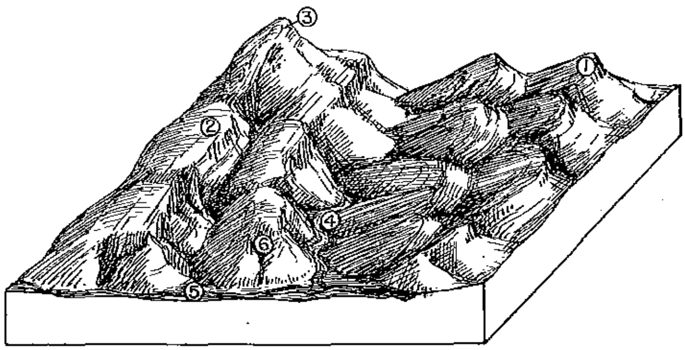
Bold sandstone ranges trending east–west through the centre of the area.

Geology.—Steeply dipping sandstone, quartzite, quartz greywacke, and shale, with minor dolomite and conglomerate. Upper Proterozoic age, Amadeus trough (Heavitree quartzite), Georgina basin (Mopunga group in part); lower Palaeozoic age, Amadeus trough (Larapintine "series"), Georgina basin (Mopunga group in part); upper Palaeozoic age, Amadeus trough (Mareenie sandstone and Pertnjara "series").

Geomorphology.—Partially dissected erosional weathered land surface: partially bevelled strike ranges; relief up to 2500 ft; narrow strike valleys and transverse gorges.

Water Resources.—Sandstone and limestone aquifers will yield good supplies of good water but because of its inaccessible nature few bores are needed. There are some permanent water-holes.

Climate.—Nearest comparable climatic stations are Henbury and Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Cuestas: on moderately to steeply dipping strata; slightly bevelled, weathered crests; rock faces and structural benches; gullied, concave escarpments and rectilinear dip slopes dissected by parallel V-shaped valleys; rocky, boulder-covered slopes, 30–65%	Outcrop; very little shallow stony soil	Sparse shrubs and low trees, *A. kempeana* (witchetty bush)–*Cassia* spp., or minor *A. aneura* (mulga) over *Triodia clelandii* (spinifex) or sparse forbs and grasses
2	Medium	Ridges: single or multiple, on very steeply dipping or vertical strata, narrower, more completely bevelled crests, with cyclic benches; steeper slopes than unit 1		
3	Small	Prominent peaks: sheer structural faces; gentler lower slopes, dissected into long spurs passing into units 1 and 2		
4	Small	Strike valleys between units 1 and 2: narrow V-profiles, with interlocking spurs		
5	Very small	Major channels: up to 10 ft deep with adjacent narrow sandy flats	Bed-loads range from sand to boulders	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)
6	Very small	Minor channels: narrow and deeply incised, with rocky beds	———	

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(22) Pertnjara Land System (300 sq. miles)

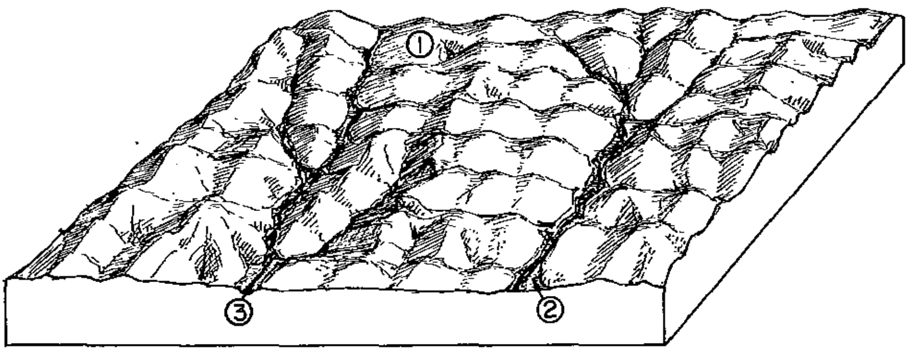
Spinifex-covered hills in the western MacDonnell Ranges.

Geology.—Calcareous and quartzose conglomerates with steep to moderate dips. Upper Palaeozoic age, Amadeus trough (Pertnjara "series").

Geomorphology.—Partially dissected erosional weathered land surface: steeply rounded hills and ridges; relief up to 300 ft; transverse trunk valleys with closely spaced tributaries.

Water Resources.—Ground-water prospects poor but few watering points required because of inaccessible nature.

Climate.—Nearest comparable climatic station is Hermannsburg.



Unit	Area	Land Form	Soil	Plant Community
1	Very large	Hills and ridges: up to ¾ mile long and 300 ft high; flattish or rounded crests with calcreted residual gravels; stony, convex hill slopes, 15–35%, with local calcrete crusts; short, narrow strike valleys with V-profiles, interlocking spurs, and amphitheatral heads, gradients 1 in 20 to 1 in 50	Shallow stony soils with calcrete	Sparse shrubs and low trees over *Triodia clelandii* (spinifex)
2	Small	Main valley floors: up to 150 yd wide and ¾ mile apart; uneven surfaces, with flood banks of gravels and sands	Some calcareous sands and gravelly soils	
3	Very small	Channels: up to 50 yd wide, and incised up to 15 ft into sand, gravels, and locally into calcrete substrata	Bed-loads range from sand to large cobbles	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

(23) Davenport Land System (2700 sq. miles)

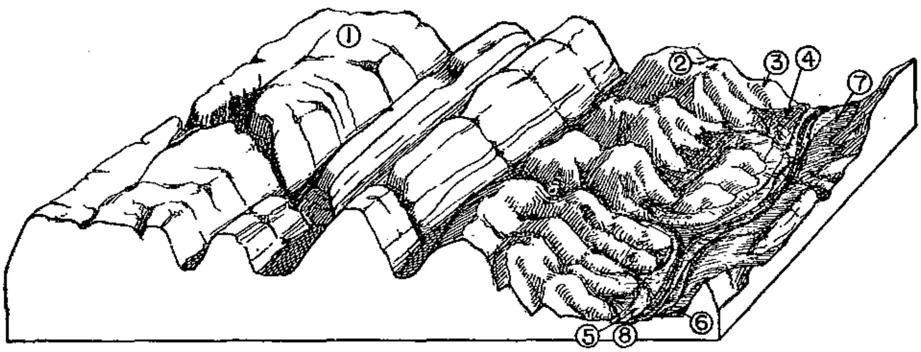
Sandstone ranges (Plate 14, Fig. 1) in the northern half of the area, mainly the Davenport Range.

Geology.—Strongly folded and faulted quartzite, sandstone, siltstone, and pebble conglomerate and bedded acid and basic volcanics. Lower Proterozoic age, Warramunga geosyncline (Hatches Creek group).

Geomorphology.—Partially dissected erosional weathered land surface: bevelled ridges and uplands and narrow strike vales; rectangular drainage pattern.

Water Resources.—Sandstones should yield supplies of good to moderate-quality water, but not yet tested as natural water-holes are available.

Climate.—Comparable climatic stations are Tea Tree Well, Barrow Creek, and Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Strike ridges: up to 750 ft high; bevelled stony crests, and gullied hill slopes, 15–45%	Outcrop with shallow, stony soils	Sparse shrubs and low trees, or (in far north) *E. brevifolia* (snappy gum) over *Triodia pungens* (spinifex) or *T. spicata* (spinifex), or (in far north) *Plectrachne pungens* (spinifex)
2	Medium	Dissected rounded uplands: up to 300 ft high	Shallow, stony soils (some clayey soil overlain by a dense, stony mantle)	
3	Small	Bevelled spurs: up to 400 yd long and 100 ft high; flattish gravel-capped crests, and convex stony slopes up to 20%	Shallow, stony soils	
4	Very small	Alluvial fans: gradients 1 in 125 to 1 in 250	Coarse and coarse to medium-textured soils: alluvial soils (*1h, 1i*) and red clayey sands (*3d*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex), minor *T. pungens* (spinifex), or *Plectrachne schinzii* (spinifex)
5	Small	Flood-plains, up to 400 yd wide		Sparse low trees over *Triodia basedowii* (spinifex), minor *T. pungens* (spinifex), or *Plectrachne schinzii*
6	Very small	Colluvial aprons: short stony slopes, 1–10%, dissected up to 25 ft		As unit 4
7	Very small	Erosional lower slopes: 2–5% and up to 100 yd long; stony surfaces with shallow gullying	Mainly shallow, stony soils	As units 1, 2, and 3
8	Very small	Channels: up to 50 yd wide, with alternate deep and shallow braiding reaches	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis*

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(24) Gillen Land System (3700 sq. miles)

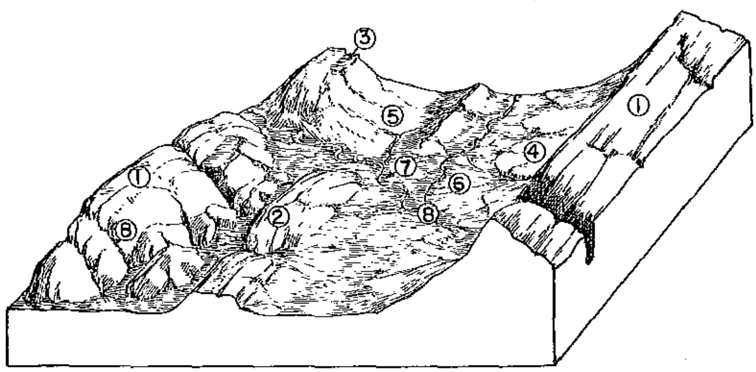
Sandstone ranges and vales (Plate 12, Fig. 1) trending east–west through the centre of the area.

Geology.—Steeply dipping, very thickly interbedded hard rocks (quartzite, sandstone, and conglomerate), moderately hard rocks (dolomite, limestone, and shale), and soft rock (shale and siltstone). Upper Proterozoic to upper Palaeozoic age, Amadeus trough (Heavitree quartzite, Bitter Springs limestone, Pertatataka, Pertaoorrta, and Larapintine "series", Mareenie sandstone, and Pertnjara "series").

Geomorphology.—Partially dissected erosional weathered land surface: strike ridges, with vales formed on softer rocks and partly filled with alluvium and gravels; relief up to 1000 ft; transverse gorges with trellised tributaries.

Water Resources.—Good supplies of water of variable quality available from sandstones and limestones. Large areas of shales yield small supplies of saline water. Suitable catchments for surface storage available.

Climate.—Comparable climatic stations are Henbury, Hermannsburg, and Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Ridges and cuestas: up to 1000 ft high; partially bevelled crests; rock faces, steep, concave escarpments, and rectilinear dip slopes, 40–70%	Outcrop and very little shallow, stony soil	Sparse shrubs and low trees over *Triodia clelandii* or *T. irritans;* small areas *A. aneura* (mulga) over sparse forbs and grasses
2	Medium	Foothill ridges and spurs: with partially bevelled crests, in zones up to ½ mile wide at the foot of unit 1 or through unit 7		*A. kempeana* over short grasses and forbs; *A. kempeana–Cassia* spp. or *A. aneura* over sparse forbs and grasses
3	Very small	Benches and accordant mesas: up to 200 ft high; flattish silcrete and laterite caps with marginal breakaways, and steep, gullied hill slopes		Sparse shrubs and low trees over sparse forbs and grasses; minor (in far south) *A. calcicola* (myall) over *Bassia* spp.
4	Small	Gravel terraces and fans: extending up to 2 miles from unit 1, slopes 0·4–2%: dissected up to 75 ft, with indented terrace faces up to 15%	Mainly stony soils, including fine-textured red earths (*4h*), and, locally, stony calcareous earths	Treeless or *A. aneura* (mulga) over *Triodia clelandii* (spinifex) or short grasses and forbs
5	Very small	Erosional slopes at the foot of units 1, 2, and 3: 0·5–5%, and up to 400 yd long; stony surfaces, liable to shallow gullying and locally dissected up to 15 ft	Stony soils including texture-contrast soils (*7b*); and locally shallow, calcareous earths (*6a*) near limestone outcrop	Treeless or *Eremophila* spp.–*Hakea leucoptera* with *Bassia* spp. or *Kochia aphylla;* minor *A. georginae* over short grasses and forbs
6	Small	Colluvial and alluvial fans and aprons: up to 400 yd long, slopes 1–10%; locally terraced up to 20 ft in lower parts	Red clayey sands (*3d*)	Treeless or *A. aneura* over short grasses and forbs or *Eragrostis eriopoda;* sparse shrubs and low trees over *Triodia basedowii*
7	Small	Flood-plains and alluvial plains: extensively scalded hummocky surfaces up to 1 mile wide	Various soils, mainly coarse-textured, including *1a*, *1h*, *3d*, *7e*, and red earths	Sparse low trees over short grasses and forbs
8	Very small	Channels: up to 200 yd wide and 10 ft deep, gradients above 1 in 500; winding and locally braiding, with narrow levees of sand and gravels up to 5 ft high	Bed-loads range from grit to small boulders, locally on bedrock	*E. microtheca* (coolibah) or *E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis*

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(25) Middleton Land System (800 sq. miles)

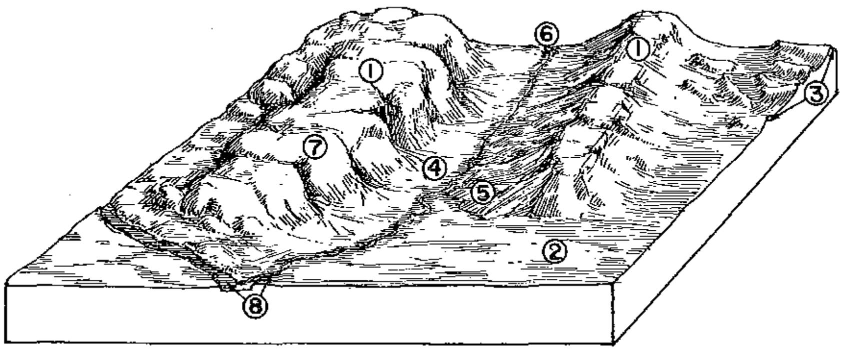
Sandstone uplands in spinifex sand plains in the southern half of the area.

Geology.—Steeply dipping, hard sandstone very thickly interbedded with soft sandstone, shale, siltstone, and limestone. Palaeozoic age, Amadeus trough (Pertaoorrta and Larapintine "series", Mareenie sandstone, and Pertnjara "series").

Geomorphology.—Partially dissected erosional weathered land surface: impersistent strike ridges and plateaux in sandy lowlands; relief up to 300 ft; vigorous upland drainage becoming disorganized on plains.

Water Resources.—Good supplies of variable-quality water are available from sandstones.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Uplands of varied form: up to 300 ft high; ridges and plateaux, with bevelled, weathered summits, and rocky slopes up to 60%; closely-spaced, narrow, V-shaped strike valleys	Outcrop and shallow, stony soils	Sparse shrubs and low trees over *Triodia clelandii* (spinifex) or (in far south) *T. irritans* (spinifex); minor *A. aneura* (mulga) over sparse forbs and grasses
2	Medium	Sand plain: without surface drainage, occupying lowest areas	Red clayey sands (3*d*)	Sparse shrubs and low trees, in some parts *Casuarina decaisneana* (desert oak), over *Triodia basedowii* (spinifex)
3	Small	Dunes: up to 30 ft high, with intervening flat swales up to 400 yd wide; varied forms, with stable flanks and semi-mobile crests	Red sands (3*f*)	
4	Small	Alluvial fans: coalescing down slope into alluvial vales up to 1 mile wide; up to ½ mile long, gradients 1 in 50 to 1 in 150	No records; but probably mainly coarse-textured soils — red clayey sands (3*d*) and alluvial reddish clayey sands (1*h*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex) or short grasses and forbs
5	Small	Erosional slopes at the foot of unit 1: up to 1 mile long, slopes 1–5%; locally dissected up to 30 ft into spurs with flattish stony crests and with marginal slopes up to 20%	No records; but probably mainly stony soils or sandy soils as in unit 4	Sparse shrubs and low trees over *Triodia clelandii* (spinifex)
6	Very small	Flood-plains: up to 500 yd wide	No records; but probably mainly rather coarse-textured soils —alluvial soils (1*h*) and severely scalded texture-contrast soils (7*e*)	Sparse low trees over short grasses and forbs
7	Very small	Incised minor channels: up to 20 yd wide, commonly braiding, with low sand banks	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass) or *Themeda australis* (kangaroo grass)
8	Very small	Major channels: up to 200 yd wide and 5 ft deep, commonly braiding, with low sand banks		

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(26) Kurundi Land System (300 sq. miles)

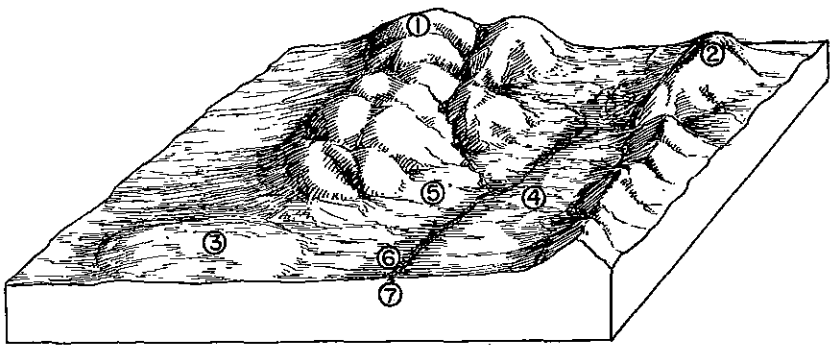
Uplands and undulating lowlands forming a small part of the Davenport Range.

Geology.—Intrusions of quartz-feldspar porphyry, and basic intrusives. Lower Proterozoic age, Warramunga geosyncline.

Geomorphology.—Partially dissected erosional weathered land surface: uplands, strike ridges, and undulating lowlands with alluvial plains; relief up to 500 ft; trellised drainage pattern.

Water Resources.—Variable supplies of variable-quality water can be obtained from weathered and fracture aquifers. There are catchments suitable for surface storages.

Climate.—Nearest comparable climatic station is Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Uplands: up to 500 ft high; rounded crests up to $\frac{1}{2}$ mile wide; dissected by narrow, V-shaped valleys	Outcrop with shallow, stony soils	Sparse shrubs and low trees or (in far north) *E. brevifolia* (snappy gum) over *Triodia pungens* (spinifex) or *Plectrachne pungens* (spinifex)
2	Medium	Ridges: up to 250 ft high; narrow, laterite-capped crests and rocky slopes, 15–30%, closely gullied in lower parts		
3	Small	Low, rounded rises: up to 400 yd in extent and 50 ft high, with flattish stony crests, and concave marginal slopes up to 10%		
4	Medium	Alluvial fans: coalescing down slope as alluvial valley plains up to $\frac{1}{2}$ mile wide; gradients 1 in 100 to 1 in 150	Red earths of variable depth and texture (including 4*a*)	*A. georginae* (gidgee) or sparse low trees over short grasses and forbs
5	Small	Erosional slopes at the foot of units 1 and 2: 1–3%, and up to 100 yd long		
6	Small	Flood-plains: up to 400 yd wide	No records but probably alluvial soils of variable texture	
7	Very small	Channels: up to 50 yd wide; meandering courses, with alternate deeper and shallower braiding reaches	——	*E. camaldulensis* (red gum)– *A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(27) Ilbumric Land System (1200 sq. miles)

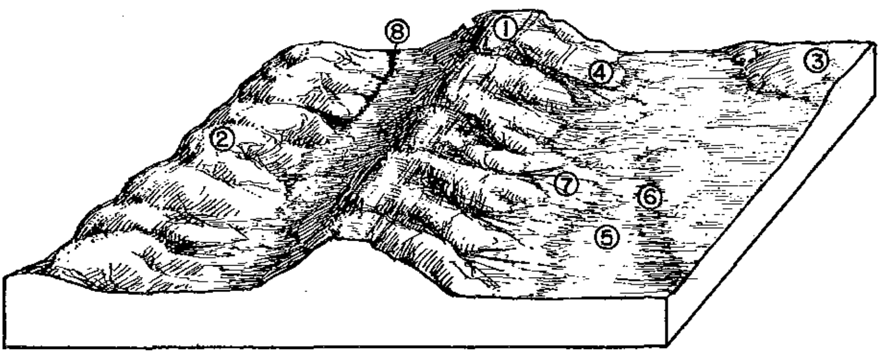
Low sandstone uplands and lowlands, mainly flanking the Davenport Range.

Geology.—Sandstone, quartzite, quartz-greywacke, and siltstone. Lower Proterozoic age, Warramunga geosyncline (Hatches Creek group), Lower Palaeozoic age, Georgina basin (Mopunga group in part, Sandover beds as valley fill). Minor areas of Pertaoorrta "series" and Pre-Cambrian schist.

Geomorphology.—Partially dissected erosional weathered land surface: strike ridges and uplands of selectively weathered rocks; adjoining lowlands with ill-defined drainage; relief up to 200 ft.

Water Resources.—Supplies of stock water available at moderate depths from aquifers in the lower Proterozoic sediments.

Climate.—Comparable climatic stations are Barrow Creek and Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Ridges: up to 200 ft high, 2–4 miles long, and ½ mile wide; partially bevelled summits and benches with siliceous duricrusts; rocky hill slopes, 10–30%, with parallel V-shaped valleys	Outcrop with shallow, stony soils	Sparse shrubs and low trees, (in far north) *E. brevifolia* (snappy gum), minor *A. aneura* (mulga) over *Triodia pungens* (spinifex), (in far north) *Plectrachne pungens* (spinifex), or minor sparse forbs and grasses
2	Medium	Uplands: up to 1½ miles in extent; bevelled gently sloping summits, with stony weathered surfaces; hill slopes, 10–20%, with closely-spaced branching V-shaped valleys		
3	Small	Low rises: stony bevelled crests, marginal slopes 5–10%		
4	Very small	Erosional slopes at the foot of units 1 and 2: 1–5%, and up to 200 yd long; stony surfaces, narrowly dissected up to 20 ft locally		
5	Medium	Alluvial plains: up to 1 mile wide	Mainly red earths (4*e*, 4*g*), some red clayey sands (3*d*)	*A. aneura* (mulga), minor *A. georginae* (gidgee) over short grasses and forbs
6	Small	Drainage floors: ill-defined, shallow floors up to 150 yd wide	As for unit 5; and also alluvial soils (1*h*, 1*i*); and very locally, yellow earths (5*a*)	Sparse low trees over short grasses and forbs
7	Small	Alluvial fans: stony, unchannelled surfaces up to 400 yd long, gradients 1 in 50 to 1 in 200, with some scalding	Red clayey sands (3*d*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex) or minor *T. pungens* (spinifex)
8	Very small	Channels: up to 30 yd wide	——	*E. microtheca* over *Aristida pruinosa* (3-awned spear grass), *Themeda australis* (kangaroo grass), *T. avenacea* (native oat grass), *Chrysopogon fallax* (golden-beard grass), or *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(28) Tennant Creek Land System (300 sq. miles)

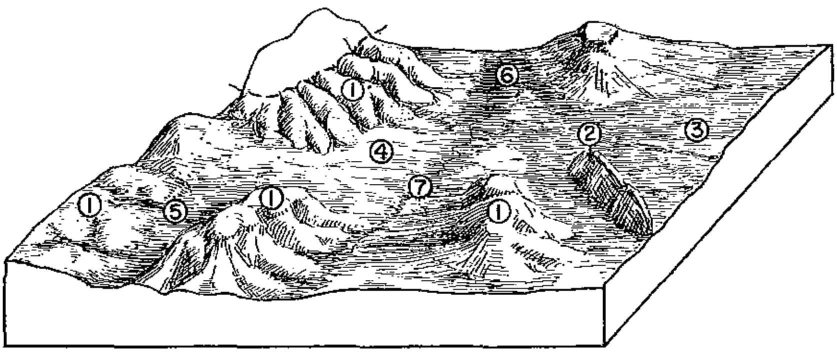
Spinifex-covered sandy country with stony rises and flat-crested hills, mainly in the far north of the area.

Geology.—Tertiary "deep weathering profile". Developed on strongly deformed sandstone, greywacke, siltstone, and shale, lower Proterozoic age, Warramunga geosyncline (Warramunga group) and low-grade metamorphic rocks (schist and phillite), Pre-Cambrian age, Arunta block, Mt. Doreen–Reynolds Range.

Geomorphology.—Partially dissected erosional weathered land surface: closely dissected uplands; plains with extensive sand cover and little surface drainage; relief up to 75 ft.

Water Resources.—Ground-water prospects are generally poor. Isolated fracture aquifers may yield supplies of ground water of variable quality. There are catchments suitable for surface storages.

Climate.—Comparable climatic stations are Barrow Creek and Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Interfluves, spurs, and mesas: up to 50 ft high and 1 mile in extent; bevelled stony crests with laterite and silcrete duricrusts; steep, closely dissected hill slopes	Outcrop with shallow, stony soils	Sparse shrubs and low trees over *Triodia pungens* (spinifex)
2	Small	Narrow ridges: quartz reefs or quartzite strike ridges up to 75 ft high, locally with silcrete duricrust		
3	Medium	Sandy plains: up to ½ mile in extent, with little surface drainage	No records, but probably mainly rather coarse-textured soils as red clayey sands (3*d*) or red earths (4*d*)	*E. brevifolia* (snappy gum) over *Triodia pungens*
				Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
				Minor *A. aneura* (mulga) over short grasses and forbs
4	Medium	Slopes at the foot of unit 1: stony surfaces with close, shallow gullying; formed in or tributary to weathering zones	Texture-contrast soils (7*b*, 7*f*) showing severe scalding	Sparse shrubs and low trees over *Triodia pungens* (spinifex) or *T. longiceps* (spinifex)
5	Very small	Valley floors: flat floors up to 200 yd wide, with little discontinuous channel drainage		As unit 4
				Atriplex vesicaria (saltbush)
				A. georginae (gidgee) over short grasses and forbs)
6	Very small	Alluvial valley plains of major drainage	No records; probably mainly coarse-textured soils including some alluvial soils	Sparse low trees over short grasses and forbs
7	Very small	Channels: up to 30 yd wide, with alternating shallow and deep sectors	———	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(29) Kernot Land System (300 sq. miles)

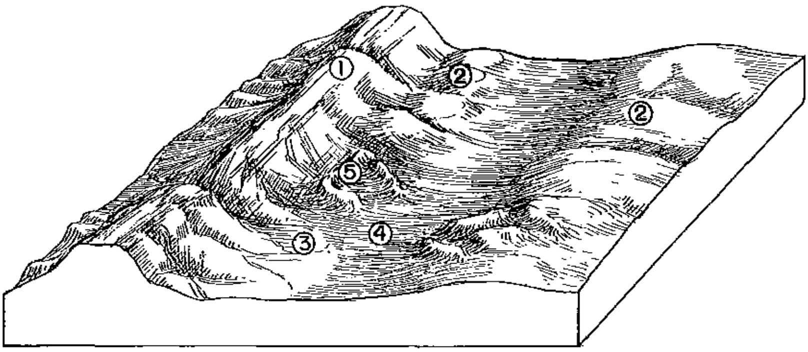
Low hilly or steeply undulating sandstone country in the south-west of the area.

Geology.—Sandstone and conglomerate. Palaeozoic age, Amadeus trough (Pertaoorrta, Larapintine, Pertnjara "series"). One small area of Pre-Cambrian schist.

Geomorphology.—Partially dissected erosional weathered land surface: strike ridges and rises of selectively weathered rocks; lowlands with little surface drainage; relief up to 200 ft.

Water Resources.—Sandstones are expected to yield supplies of moderate-quality ground water.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Ridges: up to 200 ft high and ½ mile wide; partially bevelled weathered crests, and rocky hill slopes, 15–40%	Outcrop with very little shallow, stony soil	Sparse shrubs and low trees or minor *A. aneura* (mulga) over sparse forbs and grasses or minor *Triodia irritans* (in far south)
2	Medium	Interfluves and hill spurs: up to 50 ft high; bevelled or gently convex crests with minor laterite or silcrete duricrusts and gravels; dissected hill slopes, up to 20%, with small breakaways locally	No records; but probably mainly shallow, stony soils, cf. texture-contrast soils as 7*b*	
3	Small	Alluvial fans: up to 400 yd long, gradients 1 in 25 to 1 in 100	No records; but probably mainly rather coarse-textured soils as red clayey sands (3*d*) or coarser-textured red earths (4*d*)	*A. aneura* (mulga) or minor sparse shrubs and low trees over short grasses and forbs, *Eragrostis eriopoda* (woollybutt), or minor *Triodia basedowii* (spinifex)
4	Medium	Alluvial plains occupying strike vales up to ½ mile wide		
5	Small	Irregular sand dunes and broad sand banks: up to 20 ft high, with flat swales up to 200 yd wide; surfaces stabilized by vegetation	Red sands (3*f*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex). In swales *A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(30) Hogarth Land System (400 sq. miles)

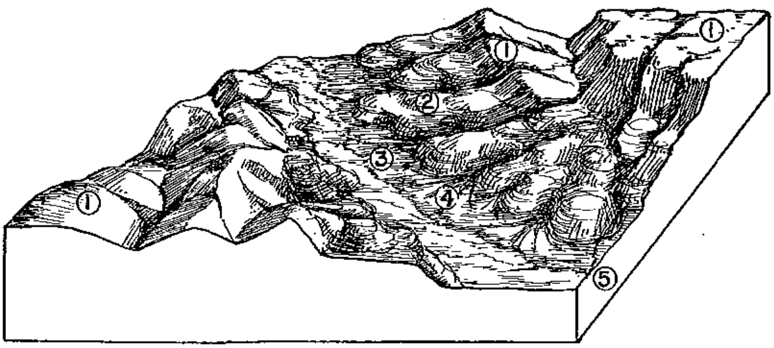
Low sandstone hills with mulga, and broken limestone country with gidgee, in the north-east of the area.

Geology.—Mainly sandstone, interbedded with dolomite, limestone, shale, with low dips. Lower Palaeozoic age, Georgina basin.

Geomorphology.—Partially dissected erosional weathered land surface: uplands and ridges of weathered sandstones and shales with flanking benches of dolomites and limestones; relief up to 100 ft; open, joint-controlled drainage.

Water Resources.—Water of moderate quality may be obtained from beds of porous and fractured sandstones, dolomites, and limestones.

Climate.—Nearest comparable climatic station is Urandangie.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Uplands, ridges, and rounded hills: partially bevelled, weathered crests up to 75 ft above unit 2; hill slopes 15–40% with minor structural benches and closely-spaced gullies in weathered rock	Outcrop with little shallow, stony soil	*A. aneura* (mulga) or sparse shrubs and low trees over sparse forbs and grasses *A. georginae* (gidgee) or sparse shrubs and low trees over short grasses and forbs
2	Medium	Benches and spurs: extending up to ¼ mile from the foot of unit 1, slopes 1–5%; stony surfaces with some calcrete cover, dissected up to 30 ft in outer parts, with dissection slopes up to 10%	Shallow, stony soils and fine-grained clayey sands (3*b*)	*A. georginae* (gidgee) over short grasses and forbs
.3	Small	Valley plains: up to ¼ mile wide; flat ill-drained central tracts with scalded surfaces, and marginal slopes up to 1%	Fine-grained, red clayey sands (3*d*)	Sparse low trees or A. *aneura* (mulga) over short grasses and forbs or minor *Eragrostis eriopoda* (woollybutt)
4	Small	Alluvial fans: up to 500 yd long, gradients 1 in 25 to 1 in 125		Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
5	Very small	Channels: up to 20 yd wide and incised up to 15 ft, commonly into calcreted gravels and alluvium	———	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(31) KRICHAUFF LAND SYSTEM (3100 SQ. MILES)

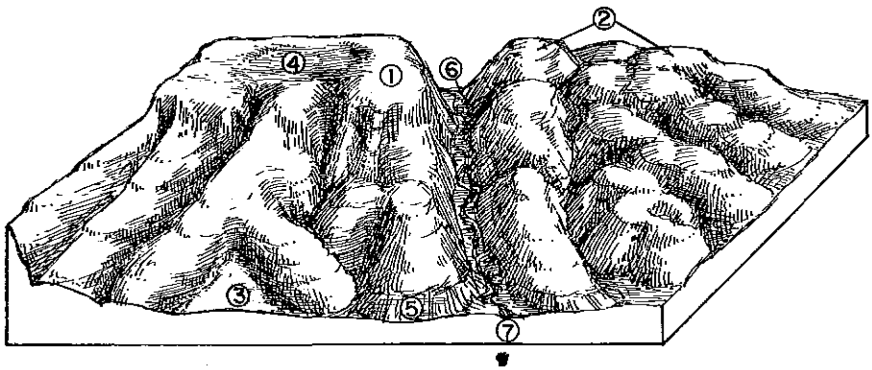
Bold sandstone plateaux in the centre and north of the area.

Geology.—Flat-lying sandstone, siltstone, and conglomerate. Upper Proterozoic age, Amadeus trough (Heavitree quartzite); lower Palaeozoic age, Georgina basin (Mopunga group in part); upper Palaeozoic age, Amadeus trough (Mareenie sandstone, Pertnjara "series"), Georgina basin (Dulcie sandstone).

Geomorphology.—Partially dissected erosional weathered land surface: strongly dissected high plateaux, superimposed drainage with narrow gorges and joint-controlled tributaries; relief up to 500 ft.

Water Resources.—Moderate to large supplies of good-quality water available from bores sunk to supplement natural water-holes.

Climate.—Comparable climatic stations Henbury, Hermannsburg, Tea Tree Well, and Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Undissected inner plateau surfaces: gentle regional slopes; irregular in detail, with minor structural terraces, deep joint clefts, and much rock outcrop	Outcrop with very little shallow, stony soil	Sparse shrubs and low trees or minor *A. aneura* (mulga) over *Triodia pungens* (spinifex), *T. spicata* (spinifex), sparse forbs and grasses, minor *Triodia clelandii* (spinifex), or *Triodia hubbardii* (spinifex)
2	Large	Dissected plateau margins: flat-crested plateau remnants, spurs, and buttes; indented escarpments, with rock faces, structural benches, and gullied hill slopes, above 25%		
3	Very small	Erosional slopes: 1–5%, at the foot of unit 2	Shallow, stony soils	
4	Small	Upland basins: of structural origin, up to 1 mile in extent, and commonly with centripetal drainage	Stony or gravelly soils and red sands or red clayey sands (3*c*, 3*d*)	
5	Very small	Colluvial aprons: dissected stony slopes, 1–10%, up to 200 yd long		Rockier parts similar to units 1, 2, 3, and 4, sandier parts with sparse shrubs and low trees over *Triodia basedowii* (spinifex)
6	Very small	Narrow valley floors of major, through-going drainage: sand and gravel surfaces with rock bars		
7	Very small	Channels: up to 50 yd wide; narrowly incised upper sectors with irregular gradients, and shallower, braiding lower reaches	Bed-loads of ill-sorted materials, ranging from coarse sand to boulders, with rock outcrop, particularly in upper sectors	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(32) Tomahawk Land System (<50 sq. miles)

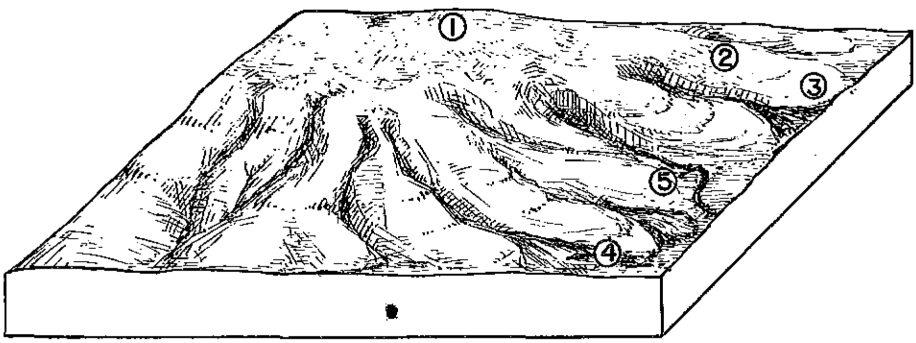
Low sandstone plateaux in the north of the area, near Utopia homestead.

Geology.—Flat-lying sandstone. Lower Palaeozoic age, Georgina basin.

Geomorphology.—Partially dissected erosional weathered land surface: dissected plateaux up to 150 ft high, with regionally sloping summits.

Water Resources.—Large supplies of good to moderate-quality ground water available from sandstones.

Climate.—Comparable climatic station is Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Plateau surfaces: up to 1 mile in extent, with slopes less than 3%; very stony surfaces with much outcrop, partly of weathered rock	Outcrop and shallow, stony soils; minor shallow red clayey sands (3*c*)	*A. kempeana* (witchetty bush)–*Cassia* spp. over sparse forbs and grasses
2	Large	Plateau margins: smooth slopes, 3–12% with very minor structural terraces; indented up to ½ mile by blunt-headed valleys up to 400 yd wide		
3	Very small	Erosional slopes at the foot of unit 2: stony, little-dissected slopes, 1–3% and up to 100 yd long		*A. georginae* (gidgee) over short grasses and forbs
4	Very small	Alluvial fans: up to 300 yd long, gradients 1 in 25 to 1 in 100	Red clayey sands (3*d*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
5	Very small	Channels in unit 2: up to 10 yd wide and 5 ft deep, braiding locally	———	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over short grasses and forbs or *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(33) Cherry Creek Land System (700 sq. miles)

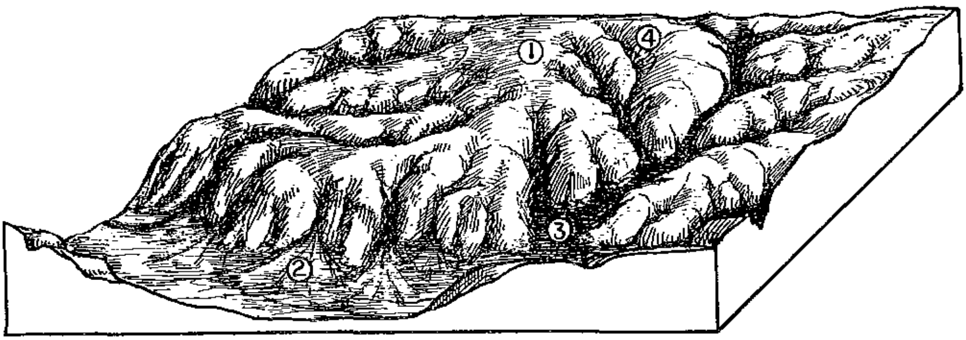
Low plateaux in the north-east of the area, near the Sandover River.

Geology.—Gently dipping shale, limestone, and sandstone. Lower Palaeozoic age, Georgina basin (in part Sandover beds), upper Palaeozoic age, Georgina basin (Dulcie sandstone).

Geomorphology.—Partially dissected erosional weathered land surface: subdued plateaux marginally dissected by a close branching pattern of short valleys and with fringing alluvial plains; relief up to 75 ft.

Water Resources.—Moderate supplies of moderate-quality water available in some areas. There are areas suitable for surface catchments.

Climate.—Nearest comparable climatic station is Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Very large	Plateaux or bevelled low rises: flat, or gently sloping crests with outcrops of weathered rock and much derived stone; marginal slopes, up to 15%, indented up to 1 mile by entrenched blunt-headed valleys up to ½ mile wide	Outcrop and shallow, stony soils; minor shallow red clayey sands (3*c*) and shallow red earths (4*c*)	Sparse shrubs and low trees over *Triodia pungens* (spinifex)
				A. aneura (mulga) over sparse forbs and grasses
				A. georginae (gidgee) over short grasses and forbs or bare ground
2	Medium	Alluvial fans and plains: up to 1 mile in extent, typically without drainage channels	Fine-grained red clayey sands (3*d*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
3	Small	Valley floors: up to 200 yd wide typically without drainage channels		
4	Very small	Channels of minor drainage incised in unit 1: up to 20 yd wide	——	*A. aneura* (mulga) or *E. microtheca* (coolibah) over short grasses and forbs, *Aristida browniana* (kerosene grass) or *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(34) Lucy Land System (1000 sq. miles)

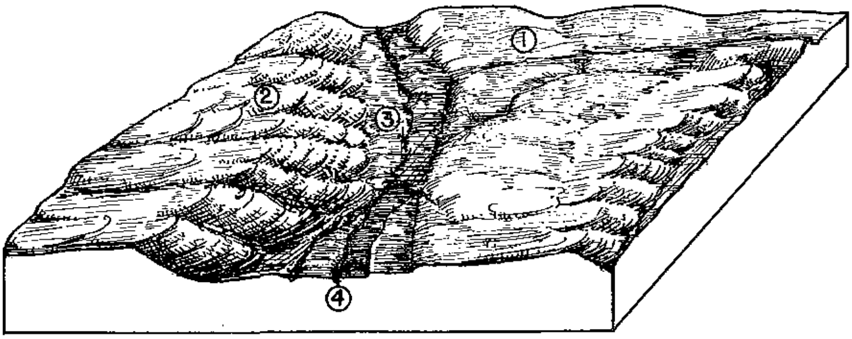
Broken limestone country (Plate 7, Fig. 2) in the north-east of the area, near Lucy Creek homestead.

Geology.—Flat-lying interbedded dolomite, limestone, shale, and sandstone. Lower Palaeozoic age, Georgina basin.

Geomorphology.—Partially dissected erosional weathered land surface: limestone plateaux and uplands, dissected up to 50 ft by an entrenched, branching pattern of superimposed drainage, with sparse, joint-controlled tributaries.

Water Resources.—Ground-water prospects variable, good limestone and dolomite aquifers are available in part of the area. Good to moderate-quality water throughout. Supplementary small surface catchments may be desirable for economic reasons.

Climate.—Nearest comparable climatic station is Urandangie.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Plateaux: up to 50 ft high; undulating stony summits with much calcrete and rock outcrop, broken by narrow joint clefts; sparse surface drainage; concave escarpments, 10–20%, with basal sand aprons	Mainly shallow red fine-grained clayey sands (3*b*) and/or stony soils near outcrop; and locally, shallow calcareous earths (6*b*) and red earths (4*b*)	Absent, sparse low trees, *A. kempeana* (witchetty bush), *A. georginae* (gidgee) or minor *A. kempeana* (witchetty bush)–*Cassia* spp. over short grasses and forbs, or minor *Triodia longiceps* (spinifex)
2	Medium	Rounded uplands and cuestas in areas of slight folding: up to 75 ft high; rocky stone-mantled hill slopes, 15–35%, with short V-shaped valleys	Outcrop with shallow, stony soil	
3	Medium	Valley floors: flat surfaces up to 400 yd wide, ill-drained locally and gullied in parts; minor low flanking calcrete terraces	Fine-grained red earths (4*d*, 4*e*)	*A. aneura* (mulga), *A. kempeana* (witchetty bush), *E. microtheca* (coolibah) or sparse low trees over short grasses and forbs; minor areas *Astrebla pectinata* (Mitchell grass)
4	Very small	Channels in unit 3: up to 20 yd wide, generally shallow and braiding, but locally incised up to 10 ft	——	Sparse low trees or *E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass), *Themeda australis* (kangaroo grass), *T. avenacea* (oat grass), *Chrysopogon fallax* (golden-beard grass), or *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(35) ILGULLA LAND SYSTEM (400 SQ. MILES)

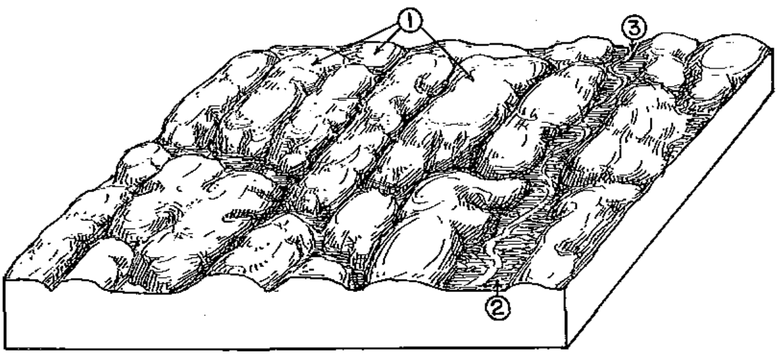
Very broken limestone country in the north-east of the area, near Lucy Creek homestead.

Geology.—Flat-lying interbedded dolomite, limestone, shale, and sandstone. Lower Palaeozoic age, Georgina basin.

Geomorphology.—Partially dissected erosional weathered land surface: limestone plateau remnants and uplands entrenched up to 100 ft by superimposed valleys and sparse joint-controlled tributaries.

Water Resources.—Ground-water prospects variable, good limestone and dolomite aquifers are available in part of the area. Good to moderate-quality water throughout.

Climate.—Nearest comparable climatic station is Urandangie.



Unit	Area	Land Form	Soil*	Plant Community
1	Very large	Uplands, strike ridges, and plateau remnants: up to 100 ft high and 400 yd wide; bevelled stony summits, and structurally benched marginal slopes up to 30%	Outcrop with shallow, stony soil	Absent, *A. kempeana* (witchetty bush), or minor *A. georginae* (gidgee) over short grasses and forbs
				Minor areas *Triodia longiceps* (spinifex)
2	Small	Flat valley floors: up to 200 yd wide	No records, but probably narrow strips of fine-grained red clayey sands (3*d*) bordering channels	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
3	Very small	Channels in unit 2: up to 50 yd wide, braiding locally	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass), minor short grasses and forbs

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(36) Chandlers Land System (1000 sq. miles)

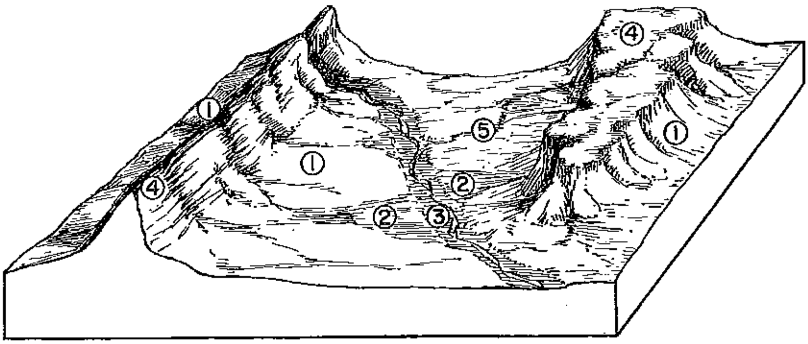
Flat-topped hills and stony lowlands, in the south of the area.

Geology.—Strongly deformed shale, limestone, and sandstone. Upper Proterozoic and lower Palaeozoic age, Amadeus trough (Pertatataka, Pertaoorrta, Larapintine "series"). Remnants of Tertiary "deep weathering profile".

Geomorphology.—Partially dissected erosional weathered land surface: sandstone cuestas and duricrusted shale mesas with stony piedmont slopes; closely spaced drainage vigorously incised, on upland margins, and passing into alluvial fans and valley plains down slope; relief up to 250 ft.

Water Resources.—Sandstone aquifers yield stock water in areas of good local recharge. Elsewhere ground water may be saline. Mesozoic sediments are above the water-table. Surface catchments may be required in areas of outcrop of limestones and shales.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Erosional slopes at the foot of unit 4: 1–7%, and up to 500 yd long; stony surfaces with minor outcrop bands, locally dissected up to 30 ft by narrow, steep-sided valleys	Texture-contrast soils (7*b* on pediments; with salt efflorescences, scalding, and rilling on outwash surfaces) and locally shallow soils near shows of country rock including calcareous earths (6*a*) near limestone	Absent or *Eremophila* spp.–*Hakea leucoptera* over *Bassia* spp., *Arthrocnemum* spp. (samphire), *Kochia astrotricha* (bluebush), *K. aphylla* (cotton-bush), or *Atriplex vesicaria* (saltbush)
2	Medium	Alluvial fans: extensively scalded surfaces up to 1 mile long, with much shallow gullying and small clay pans		
3	Small	Valley floors: up to 400 yd wide, gradients about 1 in 350; no incised channels, but ill-defined linear drainage depressions up to 150 yd wide, with scalded, locally gullied floors	Various soils, mainly coarse-textured, including red clayey sands (3*d*), red earths (4*d*, 4*e*), alluvial soils (1*d*, 1*i*), and scalded texture-contrast soils (7*e*)	*Eremophila* spp.–*Hakea leucoptera* over *Kochia aphylla* (cotton-bush), *Kochia astrotricha* (bluebush), or *Bassia* spp. In depressions *E. microtheca* (coolibah) over *Muehlenbeckia cunninghamii* (lignum)
4	Medium	Cuestas and mesas: flat or gently sloping stony summits up to 250 ft high; with silcrete duricrust; breakaways up to 30 ft high; concave hill slopes, 25–50%, with closely spaced gullies in soft, weathered rock	Outcrop and shallow, stony soils	Sparse shrubs and low trees, minor *A. aneura* (mulga), or *A. calcicola* (myall) over sparse forbs and grasses. Minor *A. kempeana* (witchetty bush) over short grasses and forbs; smaller areas *Kochia astrotricha* (bluebush)
5	Very small	Channels: up to 20 yd wide, vigorously dissecting units 1 and 4	——	Similar to unit 4 but with *A. aneura* (mulga) and *Themeda australis* (kangaroo grass) more common

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(37) Rumbalara Land System (900 sq. miles)

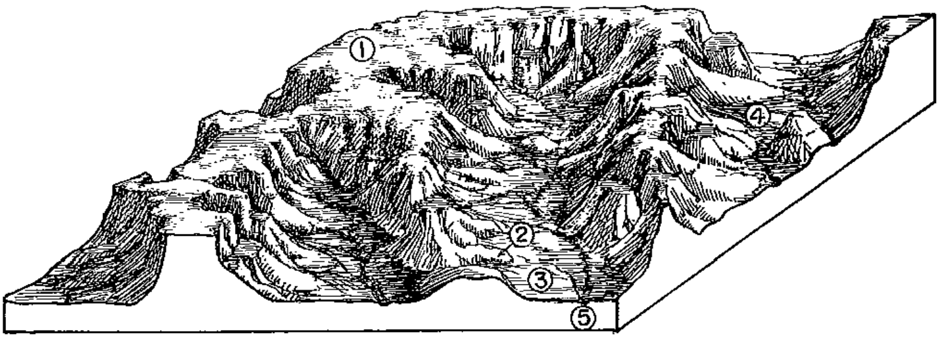
High stony plateaux (Plate 12, Fig. 2) in the south-east of the area.

Geology.—Tertiary "deep weathering profile" developed on shale, claystone, and fine-grained sandstone of Mesozoic age, Great Artesian basin (Rumbalara shale). Partially dissected to expose sandstone (De Souza sandstone) and boulder beds and silty sandstone (Finke "series") of Permian and Mesozoic age.

Geomorphology.—Partially dissected erosional weathered land surface: duricrusted plateaux and mesas up to 300 ft high; piedmont slopes with a close, vigorously dissecting drainage.

Water Resources.—Ground-water prospects are variable. Deep drilling likely throughout. Ground water is unobtainable in most of the eastern portion of Umbeara station. The area between Idracowra and Rumbalara yields stock and saline water only. Prospects are better on Andado. There are catchments suitable for surface storage.

Climate.—Comparable climatic stations are Charlotte Waters and Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Plateaux and mesas: broadly undulating stony summits with minor gilgais; steep breakaway margins of silcrete duricrust; concave hill slopes, 25–50%, with numerous gullies in soft, weathered rock; escarpments are indented up to ½ mile by narrow, winding valleys	Mainly shallow, stony soils; small occurrences near the centre of larger summits with texture-contrast soils (*7b*) and gilgais (*8a*)	Absent, sparse shrubs and low trees, or minor *A. aneura* (mulga) over sparse forbs and grasses Minor areas *Triodia longiceps* (spinifex)
2	Medium	Erosional slopes at the foot of unit 1: 0·5–10%, and up to ½ mile long; lower sectors are dissected up to 40 ft into stony, bevelled spurs, with convex marginal slopes up to 20%	Texture-contrast soils (*7b*)	Absent or sparse shrubs and low trees, or minor *A. aneura* over *Bassia* spp., *Atriplex vesicaria* (saltbush), minor *Kochia astrotricha* (bluebush), or *Arthrocnemum* spp. (samphire); *Eremophila* spp.–*Hakea leucoptera*, minor *A. kempeana* (witchetty bush), over short grasses and forbs
3	Small	Valley floors: stony, scalded surfaces up to 500 yd wide, with shallow gullies	Coarse-textured soils including red sands (*3f*), red clayey sands (*3d*), alluvial soils (*1h*), calcareous earths (*6d*), and texture-contrast soils (*7e*)	Absent, sparse low trees or *A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
4	Small	Alluvial fans: up to ½ mile long		
5	Very small	Channels: up to 50 yd wide; narrowly incised in upper sectors, shallow and braiding in unit 3	———	*A. aneura* (mulga) over *Chloris acicularis* (curly windmill grass) Treeless with *Bassia* spp.

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(38) Wilyunpa Land System (300 sq. miles)

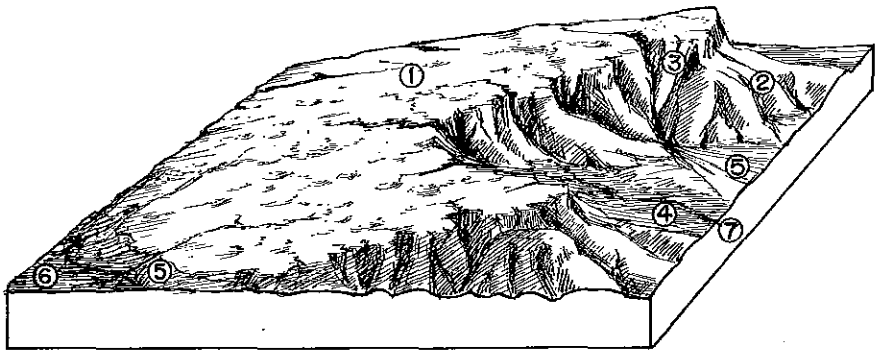
Stony tablelands with sparse saltbush (Plate 11, Fig. 1), in the south-east of the area.

Geology.—Tertiary "deep weathering profile". Developed on claystone and silty sandstone, Mesozoic age, Great Artesian basin (Rumbalara shale).

Geomorphology.—Partially dissected erosional weathered land surface: duricrusted plateaux up to 150 ft high, descending south-eastwards from north-facing escarpments and lacking organized surface drainage.

Water Resources.—Sub-artesian water is available from depths of 500 to 1000 ft. There are catchments suitable for surface storage on the margins of the land system.

Climate.—Nearest comparable climatic station is Charlotte Waters.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Tableland summits: regional slopes, 0·1–0·5%; stony surfaces with gilgais, and, in lower parts, disconnected linear depressions up to 300 yd wide and ¾ mile long	Mainly texture-contrast soils (7*b*), locally coarse-structured clay soils on or near gilgais (8*a*)	*Bassia* spp., *Atriplex vesicaria* (saltbush), or minor *Arthrocnemum* spp. (samphire)
2	Small	Erosional slopes at the foot of unit 3: stony slopes, 1–3% and up to 400 yd long, dissected up to 10 ft into flattish or rounded spurs with convex marginal slopes up to 20%		
3	Small	Escarpments: up to 150 ft high; silcrete breakaways up to 10 ft high, above stony concave hill slopes, up to 50%, with closely spaced gullies in soft, weathered rock	Outcrop and shallow, stony soils	*A. kempeana* (witchetty bush)–*Cassia* spp. over sparse forbs and grasses
4	Small	Valley floors: stony, scalded surfaces up to 300 yd wide, with widespread gullying	No records, but probably coarse-textured and/or texture-contrast soils	Treeless or *A. aneura* (mulga) over *Atriplex vesicaria* (saltbush)
5	Small	Alluvial fans: up to ½ mile long		As units 1 and 2
6	Very small	Alluvial basins: flat floors up to 1 mile in extent, with gilgais, clay pans, and networks of linear depressions where drainage enters	No records, but probably alluvial brown coarse-structured clay soils (1*f*)	*Atriplex nummularia* (old-man saltbush) or *Chenopodium auricomum* (bluebush)
7	Very small	Channels: up to 20 yd wide, narrowly incised in upper sectors, becoming shallow, braiding, and locally discontinuous down valley	———	*A. aneura* over *Atriplex vesicaria* (saltbush)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(39) INDIANA LAND SYSTEM (600 SQ. MILES)

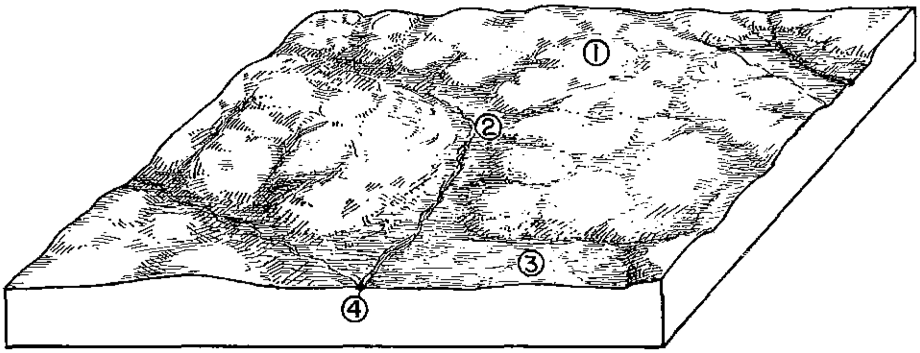
Undulating stony plains in the east central part of the area.

Geology.—Schist and gneiss. Pre-Cambrian age, Arunta block, MacDonnell–Harts Ranges.

Geomorphology.—Erosional surfaces formed below the weathered land surface: lightly dissected stony peneplain with a closely spaced, branching or pinnate pattern of valleys; relief up to 30 ft.

Water Resources.—Ground-water prospects are generally poor. Large supplies of stock or saline water available at shallow depths in the area north of Huckitta Creek. Elsewhere supplies of variable-quality water available from fracture zones and shallow alluvium. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to 400 yd wide and 30 ft high, attaining 50 ft as spurs from adjacent higher ground; bevelled, gravel-strewn crests with some outcrops; concave margins, up to 2%, with rounded valley heads lowered up to 10 ft	A range of soils—stony soils including texture-contrast soils (7*a*), calcareous earths (6*a*), and red earths (4*a*)	Sparse low trees over short grasses and forbs, *Bassia* spp., or (in rockier parts) sparse forbs and grasses
2	Small	Valley floors: up to 200 yd wide and ½ mile long; flat, unchannelled central tracts and gentle, concave marginal slopes	No records; probably mainly rather coarse-textured soils (3*d*, 4*d*)	Sparse low trees over short grasses and forbs
3	Medium	Alluvial plains: up to 500 yd wide		As unit 2, or sparse shrubs and low trees over *Triodia basedowii* (spinifex)
4	Very small	Channels: up to 20 yd wide, and 10 ft deep	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(40) Unca Land System (200 sq. miles)

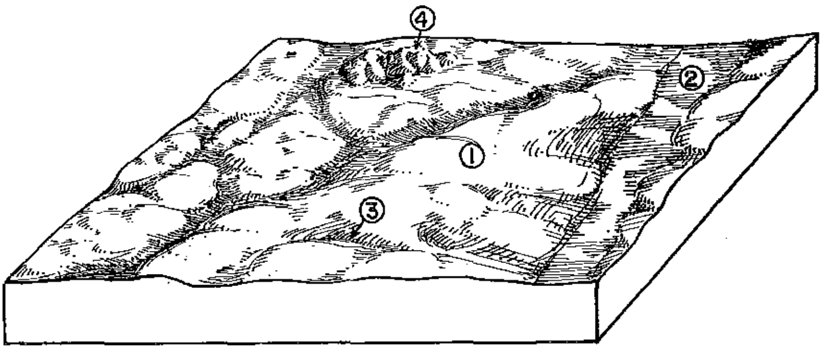
Gently undulating stony plains in the far east of the area.

Geology.—Lower Proterozoic granite and Pre-Cambrian schist and gneiss. Arunta block, MacDonnell–Harts Ranges.

Geomorphology.—Erosional surfaces formed below the weathered land surface: lightly dissected peneplain with an open, branching pattern of sandy valleys; relief up to 15 ft.

Water Resources.—Moderate supplies of stock water can be obtained from isolated aquifers. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Urandangie.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to ¼ mile wide and 15 ft high; slightly rounded stony crests, and steeper margins with rounded valley heads lowered to 5 ft	No records, but presumably shallow and stony soils over crests of interfluves	Absent, sparse low trees, or *A. kempeana* (witchetty bush) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
2	Medium	Valley plains: up to 1½ miles wide, without linear drainage	Rather coarse-textured soils including fine-grained red clayey sands (3*d*) and red earths (4*d*)	As unit 1 or sparse shrubs and low trees over *Triodia basedowii* (spinifex)
3	Small	Tributary valley floors: up to 250 yd wide and ½ mile long; flat, unchannelled central drainage zones with some scalding; gentle, concave marginal slopes		Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
4	Very small	Low hills, mainly in the west of the land system	Outcrops with pockets of shallow, gritty or stony soil	Sparse shrubs and low trees over sparse forbs and grasses

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(41) Jinka Land System (200 sq. miles)

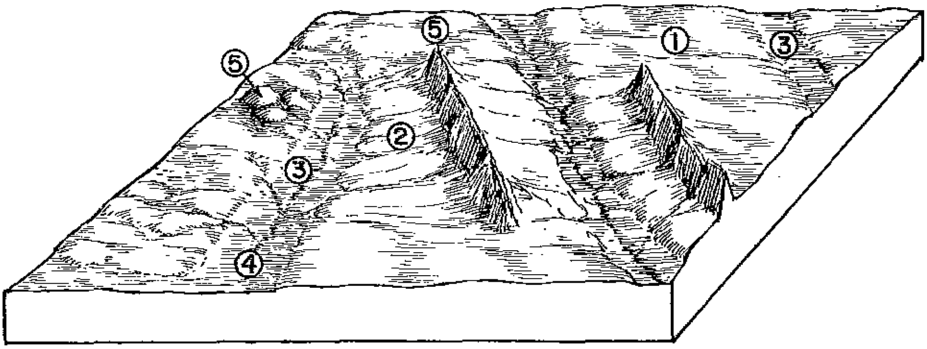
Undulating stony plains traversed by quartz reefs (Plate 1, Fig. 1), in the east central part of the area.

Geology.—Granite intruded by quartz reefs. Lower Proterozoic, Arunta block, MacDonnell–Harts Ranges.

Geomorphology.—Erosional surfaces formed below the weathered land surface: undulating plains with up to 30 ft relief traversed by prominent quartz reef ridges; moderately close branching drainage pattern.

Water Resources.—Ground-water prospects are generally poor. Variable supplies of good-quality to saline water may be obtained from fractured or weathered zones. There are catchments suitable for surface storages.

Climate.—Comparable climatic stations are Alice Springs and Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Interfluves: up to 500 yd wide and 30 ft high; slightly rounded stony crests, and steeper, lightly gullied margins	Shallow stony soils including texture-contrast soils (7*a*), and gritty red clayey sands (3*a*)	Sparse low trees over short grasses and forbs
2	Medium	Erosional slopes below unit 5: lower parts dissected by narrow V-shaped valleys into stony, flat-crested spurs up to 30 ft high		
3	Small	Valley floors: up to 200 yd wide; areas of ill-defined surface drainage	Gritty red clayey sands (3*d*) and red earths (4*d*)	Low trees over *Bothriochloa ewartiana* (desert blue grass)–*Eulalia fulva* (silky browntop) or *Chrysopogon fallax* (golden-beard grass)
4	Very small	Channels: up to 50 yd wide, shallow, and braiding locally	———	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)
5	Small	Hills: comprising quartz reef ridges with mural weathering, and lower granite hills with steep, boulder-covered slopes	Outcrop: pockets of shallow, gritty or stony soil	Sparse shrubs and low trees over sparse forbs and grasses

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(42) Barrow Land System (100 sq. miles)

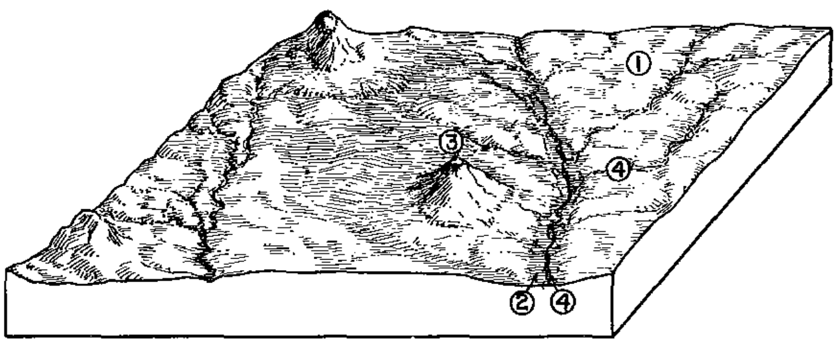
Open granite plains in the north of the area, mainly near Barrow Creek.

Geology.—Granite. Lower Proterozoic age, Warramunga geosyncline and Arunta block. Some outcrops weathered.

Geomorphology.—Erosional surfaces formed below the weathered land surface: plains with up to 10 ft relief and an open branching pattern of valleys.

Water Resources.—Prospects for obtaining supplies of ground water are poor. Surface catchment is recommended.

Climate.—Nearest comparable climatic station is Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to ½ mile wide and 10 ft high	Coarse-grained or gritty red clayey sands and red earths (probably mainly 3*a*, 4*a*, but substrata including gravels < 4 ft depth)	Absent or sparse low trees, or minor *A. aneura* (mulga) over short grasses and forbs; minor areas *Triodia longiceps* (spinifex)
2	Small	Valley floors: up to 200 yd wide		
3	Very small	Hills: rounded granite hills up to 50 ft high, and lower mesas of duricrusted weathered shales	Outcrops with pockets of shallow, stony or gritty soil	Sparse shrubs and low trees over *Triodia pungens* (spinifex)
				Small areas *A. aneura* (mulga) over sparse forbs and grasses
4	Very small	Channels: up to 50 yd wide, shallow, and winding	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(43) Anderinda Land System (200 sq. miles)

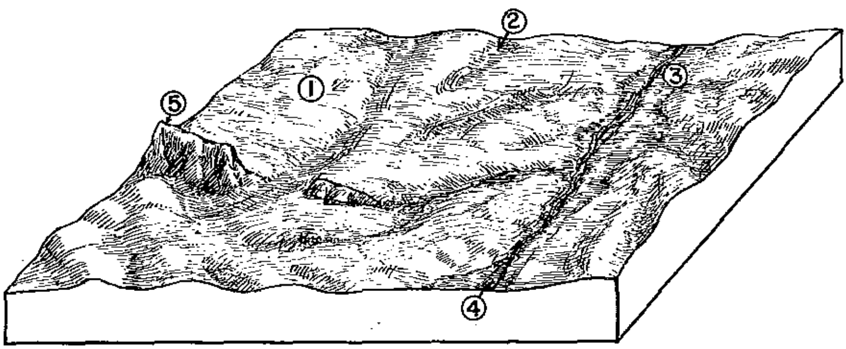
Undulating stony granite plains in the east central part of the area.

Geology.—Granite, schist, and gneiss. Pre-Cambrian age, Arunta block, MacDonnell–Harts Ranges.

Geomorphology.—Erosional surfaces formed below the weathered land surface: plains with up to 30 ft relief; traversed by narrow quartz reef ridges; fairly close, branching pattern of valleys.

Water Resources.—Isolated aquifers may yield limited supplies of ground water. There are catchments suitable for surface storage.

Climate.—Comparable climatic stations are Alice Springs and Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to $\frac{1}{2}$ mile wide and 30 ft high; convex stony crests, and steeper margins with some scalding	Texture-contrast soils (*7a*), and locally, red earths (*4a*)	Absent or sparse low trees over short grasses and forbs or *Bassia* spp.
2	Medium	Tributary valley floors: up to $\frac{3}{4}$ mile long, with rounded heads shallowly incised on the flanks of unit 1; no channel drainage	No records, but probably red earths as *4e*	
3	Medium	Main valley floors: up to 500 yd wide, with channel drainage in parts		*A. aneura* (mulga) over short grasses and forbs
	Very small	Channels: winding, shallow, and up to 30 yd wide	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass), *Bothriochloa ewartiana* (desert blue grass)–*Eulalia fulva* (silky browntop), or *Themeda avenacea* (native oat grass)
5	Very small	Narrow quartz reef ridges up to 1 mile long, on unit 1	Outcrop, very little soil	Sparse shrubs and low trees over sparse forbs and grasses

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(44) Peebles Land System (500 sq. miles)

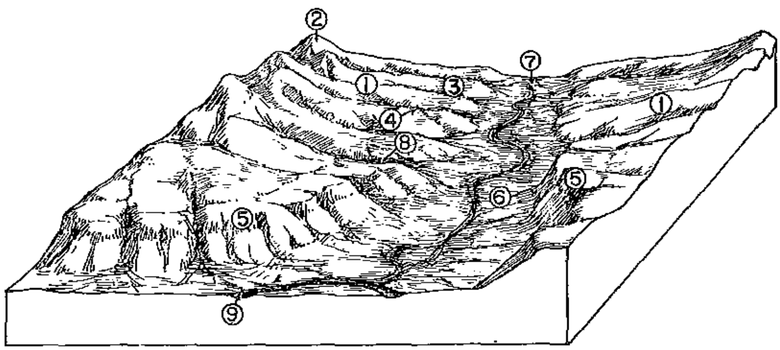
Sparse saltbush and southern bluebush on broken stony plains with steep hills (Plate 11, Fig. 2), in the far south of the area.

Geology.—Flat-lying sandstone and Tertiary "deep weathering profile" developed on shale, claystone, and fine-grained sandstone. Mesozoic age, Great Artesian Basin (De Souza sandstone, Rumbalara shale).

Geomorphology.—Erosional surfaces formed below the weathered land surface: hills, spurs, and erosional terraces, with entrenched flood-plains and vigorously dissecting, closely spaced tributary channels.

Water Resources.—Supplies of sub-artesian water available from depths ranging between 300 and 1000 ft (except in the upper reaches of Goyder Creek where surface catchment is recommended). Supplementary surface waters may be desirable for economic reasons.

Climate.—Nearest comparable climatic station is Charlotte Waters.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Spurs: up to $1\frac{1}{2}$ miles long, $\frac{1}{2}$ mile wide, 100 ft high, and sloping 2–5% from unit 2; bevelled stony crests; marginal slopes, 5–20%	Texture-contrast soils (*7b*, *7d*)	*Bassia* spp. or *Atriplex vesicaria* (saltbush)
2	Small	Hills: summits up to 150 ft high, with stony, concave slopes, 10–25%		
3	Medium	Erosional terraces: 1–2 miles wide, sloping at 0·5%, margins 10–20 ft high, slopes up to 5%, with closely-spaced gullies	Mainly red earths (*4f*, *4g*), and locally, shallow, stony soils on crests of some lateral interfluves	As units 1 and 2; sparse forbs and grasses; *A. aneura* over *Eragrostis eriopoda*; *A. georginae* over *Atriplex vesicaria*
4	Small	Drainage floors: up to 200 yd wide and lowered to 5 ft in unit 3; flat central tracts, channelled only in lower sectors; concave marginal slopes up to 0·25%	Red earths over e.g. calcrete crusting sandstone (*4b*); locally, red clayey sands (*3d*) and texture-contrast soils (*7e*)	Absent or *A. aneura* (mulga) over *Eragrostis eriopoda* (woollybutt) or *Aristida browniana* (kerosene grass)
5	Small	Calcreted gravel terraces: remnants up to 1 mile in extent; stony summits, low breakaways, and closely gullied, concave hill slopes, 15–35%	Exposed sediments with very little soil	Sparse shrubs and low trees over sparse forbs and grasses
6	Small	Flood-plains: up to 500 yd wide, with gravel banks, gilgais, scalds, and clay pans, and alluvial basins with shallow tributary flood channels	Restricted observations of coarse to medium-textured alluvial soils, some scalds and probably texture-contrast soils	*A. aneura* (mulga) over *Kochia aphylla* (cotton-bush)
7	Very small	Larger tributary channels: shallow, up to 50 yd wide	—	*A. calcicola* (myall) over short grasses and forbs
8	Very small	Incised minor channels: up to 10 yd wide and 10 ft deep	—	*Atriplex vesicaria* (saltbush)
9	Very small	Main channel: up to 300 yd wide and 15 ft deep	Sandy bed-loads	*E. camaldulensis*–*A. estrophiolata* over *Chloris acicularis*

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(45) LILLA LAND SYSTEM (300 SQ. MILES)

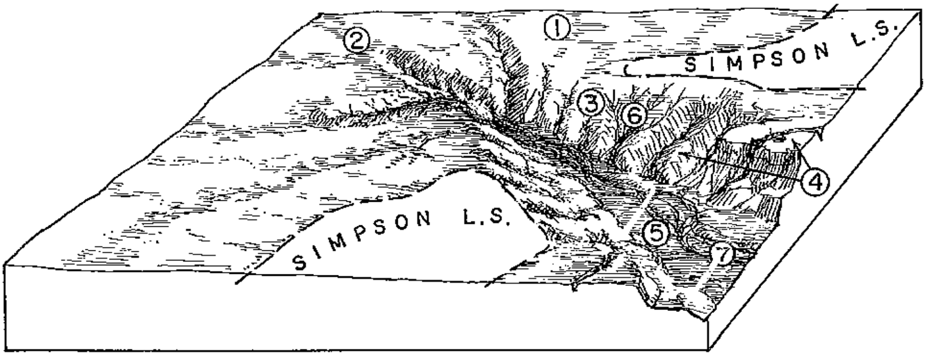
Broken stony plains with saltbush and southern bluebush, in the far south of the area.

Geology.—Flat-lying silty sandstone and pebble conglomerate. Permian and Mesozoic age, Great Artesian Basin (Finke "series").

Geomorphology.—Erosional surfaces formed below the weathered land surface: granite peneplain, passing down valley into erosional terraces along Lilla Creek and into gravel terraces near the Finke River; convergent shallow valleys above the limits of rejuvenation; Lilla Creek and its closely-spaced lower tributaries are incised up to 90 ft.

Water Resources.—Generally small supplies of good-quality to saline water available at shallow depths near major creeks. There are some catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Charlotte Waters.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Interfluves: up to ½ mile wide and 10 ft high, with regional descent less than 0·5%; bevelled stony crests with some calcrete cover	Thin-surfaced texture-contrast soils (7c), locally with hard pan (7i)	Absent or *Eremophila* spp.–*Hakea leucoptera* over *Kochia astrotricha* (bluebush) or *Bassia* spp.; minor *Arthrocnemum* spp. (samphire)
2	Small	Shallow valley floors through unit 1: flat, unchannelled surfaces up to 150 yd wide, liable to scalding		
3	Medium	Terraced margins of unit 1: dissected up to 20 ft in a zone up to ½ mile wide; dissection slopes, up to 5%, have numerous exposures of calcrete and bedrock	Shallow, gravelly soils, and on narrow bottoms, texture-contrast soils (7e)	Absent, sparse shrubs and low trees, or *A. kempeana* (witchetty bush)–*Cassia* spp. over *Atriplex vesicaria* (saltbush) or short grasses and forbs
4	Medium	River terraces: near the Finke—stony, calcrete-capped terraces, 22, 45, and 90 ft above river level, with 30-ft breakaways and closely gullied, concave hill slopes, up to 30%, in underlying "fill" and bedrock; along Lilla Creek—stony terrace spurs with some calcrete cover, sloping at 1–3%	Stony and gravelly soils, often calcareous; locally, red clayey sands (3d), texture-contrast soils (7b), and calcareous earths (6a)	Absent or very sparse shrubs over *Bassia* spp.
5	Small	Flood-plains: uneven, scalded surfaces 100–800 yd wide	Various soils—alluvial soils (1a, 1i, and, very locally, 1d) and texture-contrast soils (7e, 7i)	Absent, sparse low trees or minor *A. aneura* (mulga) over short grasses and forbs
6	Very small	Minor channels: up to 20 yd wide and incised up to 5 ft, commonly into calcrete and gravel	Bed-loads range from sand to cobbles on calcrete or bedrock	
7	Very small	Major channels: up to 300 yd wide and 10 ft deep, braiding locally, with low sandy islands; longitudinal gradients 1 in 500 to 1 in 1000	——	*E. camaldulensis* (red gum)– *A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass); minor *Zygochloa paradoxa* (sandhill cane grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(46) Ebenezer Land System (900 sq. miles)

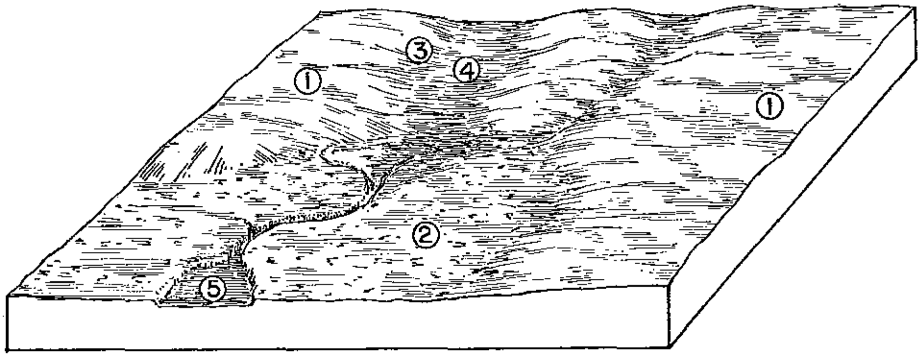
Undulating stony plains with saltbush and southern bluebush, in the south of the area.

Geology.—Claystone and sandstone, Mesozoic age, Great Artesian Basin; and Quaternary kunkar.

Geomorphology.—Erosional surfaces formed below the weathered land surface: peneplain, extensively mantled with surface limestones in its lower part, mainly shallow valleys.

Water Resources.—Good to moderate supplies of variable-quality water available from sand or kunkar aquifers generally at shallow depths. Some areas are underlain by saline water. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to 2 miles wide and 20 ft high; flat stony crests with some calcrete; marginal slopes, up to ½ mile long, attaining 2%; against unit 5 these may give place to breakaways up to 20 ft high, with stony slopes, 2–10%	Stony soils, partly texture-contrast soils (*7b*)	Absent, sparse shrubs and low trees, *A. kempeana* (witchetty bush), or minor *A. calcicola* (myall) over *Bassia* spp., short grasses and forbs, minor *Kochia astrotricha* (bluebush)
2	Medium	Calcrete plains: remnants up to ¾ mile wide, with partially stripped surfaces consisting of flat-crested, gravel-strewn rises up to 20 ft high, marginal slopes up to 2%, and flat-floored valleys up to 200 yd wide, tributary to unit 5; breakaway margins up to 30 ft high, with up to 15 ft of calcrete on gypseous lacustrine "fill"	Calcareous earths (*6b*)	
3	Medium	Erosional slopes below unit 1: 0·5–2%, and up to 500 yd long; stony surfaces, with some rock outcrop in upper parts and shallow scalding down slope		Absent or sparse shrubs over *Kochia astrotricha* (bluebush) or short grasses and forbs
4	Small	Shallow valley floors in units 1 and 2: flat, unchannelled surfaces up to 500 yd wide, with scalding and shallow gullying; longitudinal gradients 1 in 150 to 1 in 250	Various soils — calcareous earths (*6b*), red earths (*4d*), and texture-contrast soils with scalds (*7e*)	*A. aneura* (mulga) or *A. brachystachya* (mulga) over *Bassia* spp. or short grasses and forbs *Kochia aphylla* (cotton-bush)
5	Very small	Entrenched valley floors: ill-drained, locally saline flats up to 300 yd wide, with flanking kopi and calcrete escarpments up to 30 ft high	Kopi and saline soils	Bare or sparse *Arthrocnemum* spp. (samphire)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(47) HUCKITTA LAND SYSTEM (600 SQ. MILES)

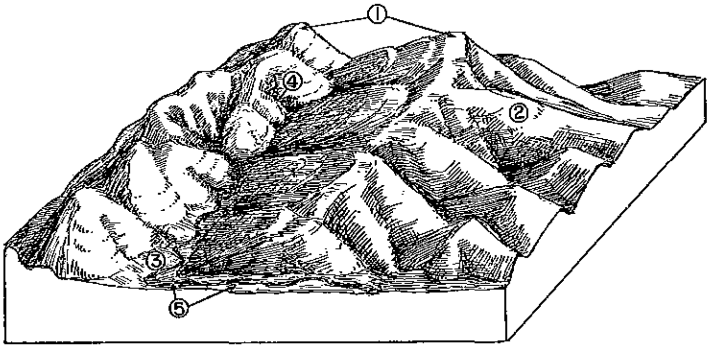
Rugged limestone ranges, mainly in the east central part of the area.

Geology.—Steeply dipping dolomite, limestone, shale, and minor sandstone. Upper Proterozoic age, Amadeus trough (Bitter Springs limestone), lower Palaeozoic age, Amadeus trough (Pertaoorrta "series"), Georgina basin.

Geomorphology.—Erosional surfaces formed below the weathered land surface: mountain ranges with up to 750 ft relief; trellised drainage with transverse trunk elements.

Water Resources.—Ground water of variable quality is available from limestone and sandstone aquifers.

Climate.—Comparable climatic stations are Alice Springs and Tea Tree Well.



Unit	Area	Land Form	Soil	Plant Community
1	Large	Strike ridges: narrow undulating crests, with very restricted summit bevelling, forming subconical hills and rounded saddles up to 750 ft high; rectilinear, stony hill slopes, 45–60%, broken by structural terracettes, and indented by parallel valleys to form rounded salients; ridges are separated by narrow, V-shaped strike valleys up to ½ mile long, and are broken by transverse gorges	Outcrop with shallow, stony and sandy soils	Sparse shrubs and low trees, *A. kempeana* (witchetty bush)–*Cassia* spp., minor *E. oleosa* var. *glauca*, or *A. georginae* (gidgee), over *Triodia longiceps* (spinifex) or sparse forbs and grasses
2	Medium	Lower uplands, foothills, and lower spurs: rounded stony crests, and gullied steeper margins, 15–40%, closely dissected by narrow valleys		*A. kempeana* (witchetty bush) or *A. georginae* (gidgee) over short grasses and forbs
3	Very small	Erosional slopes at the foot of units 1 and 2: 2–10% and up to 200 yd long; rock outcrops in upper sectors, extensive shallow gullying down slope		
4	Very small	Minor channels: up to 30 yd wide and incised up to 20 ft, commonly into calcreted sands and gravels	Bed-loads range from sand to boulders, commonly on bedrock	Sparse low trees or *E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass), *Bothriochloa ewartiana* (desert blue grass)–*Eulalia fulva* (silky browntop), or *Themeda australis* (kangaroo grass)
5	Very small	Major channels: up to 100 yd wide and 10 ft deep, winding and locally braiding, with low islands	———	

(48) Allua Land System (600 sq. miles)

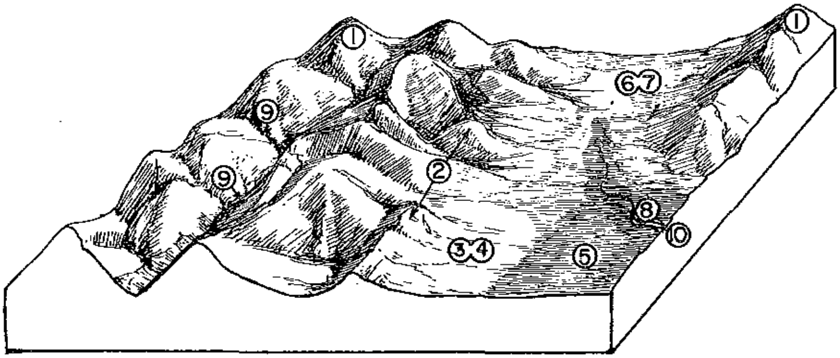
Limestone mountain ridges and vales (Plate 15, Fig. 2), in the eastern MacDonnell Ranges.

Geology.—Steeply dipping dolomite, limestone, and shale, minor sandstone. Upper Proterozoic and lower Palaeozoic age, Amadeus trough (Bitter Springs limestone, Pertatataka and Pertaoorrta "series").

Geomorphology.—Erosional surfaces formed below the weathered land surface: multiple or single ridges, and strike vales with alluvial fill; relief up to 500 ft; trellised drainage.

Water Resources.—Limestones and sandstones generally yield good supplies of moderate-quality water.

Climate.—Comparable climatic stations are Alice Springs and Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Strike ridges: narrow crests, saddles, and subconical summits up to 500 ft high; rectilinear hill slopes, 36–60%, broken by many structural terracettes and indented by parallel valleys to form broadly rounded salients; narrow, V-shaped strike valleys and transverse gorges	Outcrop, very little soil	Sparse shrubs and low trees, minor *E. oleosa* var. *glauca* over *Triodia longiceps*; *A. kempeana*, *A. kempeana*–*Cassia* spp., or sparse shrubs and low trees over sparse forbs and grasses or short grasses and forbs; minor *A. georginae* over short grasses and forbs
2	Small	Foothills, spurs, and lower strike ridges: bevelled stony crests, and rocky hill slopes, 15–30%		Similar to unit 1 but also minor *Atriplex vesicaria* (saltbush)
3	Small	Erosional lower slopes at the foot of units 1, 2: concave stony slopes up to 400 yd long attaining 5%; outcrops of bedrock and calcrete in upper sectors, scalding and shallow gullying down slope	Shallow, stony soils and red clayey sands (3*b*)	Sparse low trees over short grasses and forbs, *Eragrostis eriopoda*, or *Aristida browniana*
4	Very small		Calcareous earths (6*a*, 6*b*)	Absent, *A. georginae* (gidgee), sparse low trees, or *E. oleosa* var. *glauca* over bare ground, short grasses and forbs, minor *Triodia longiceps* (spinifex), or *Atriplex vesicaria* (saltbush)
5	Small	Alluvial plains: scalded surfaces up to 1 mile wide, with little channel drainage		
6	Medium	Alluvial fans: generally of calcreted sands and gravel; up to 1 mile long, gradients 1 in 40 to 1 in 200; dissected up to 5 ft on lower margins; undulating in cross-profile, up to 10 ft relief, flat-floored drainage depressions up to 300 yd wide		
7	Small		Red clayey sands and coarser-textured red earths	*A. aneura* (mulga) or sparse low trees over short grasses and forbs, *Eragrostis eriopoda* (woollybutt), or *Aristida browniana* (kerosene grass)
8	Small	Flood-plains: hummocky surfaces, with shallow flood channels and low levees	Alluvial brown sands (1*a*)	Sparse low trees over short grasses and forbs, *Bassia* spp. or *Kochia aphylla*
9	Very small	Tributary channels: up to 20 yd wide and incised up to 15 ft	——	Absent, *E. microtheca*, *A. aneura*, or *E. camaldulensis*–*A. estrophiolata* over *Chloris acicularis*
10	Very small	Major channels: up to 100 yd wide and 5 ft deep, braiding locally	——	

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(49) Coghlan Land System (<50 sq. miles)

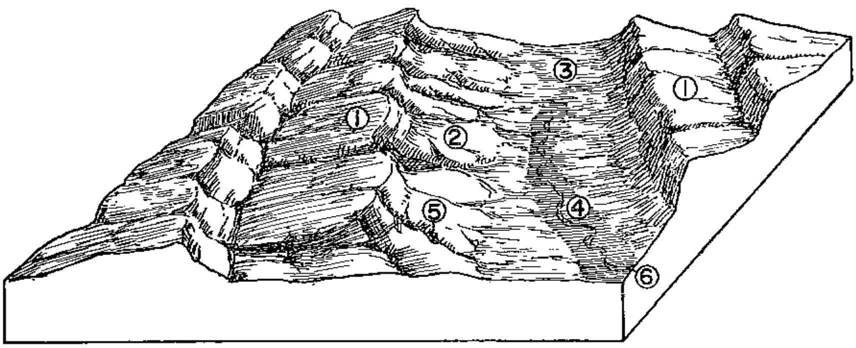
Low sandstone uplands in the eastern MacDonnell Ranges, near Ringwood homestead.

Geology.—Interbedded shale, limestone, and sandstone with moderate dips. Upper Proterozoic age, Amadeus trough (Pertatataka "series").

Geomorphology.—Erosional surfaces formed below the weathered land surface: dissected low uplands and flanking erosional and alluvial plains; relief up to 50 ft; closely-spaced, pinnate drainage.

Water Resources.—Supplies of ground water available from sandstone aquifers. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Parallel cuestas or plateaux: up to 50 ft high; rocky dip slopes, 2–5%, with low structural terraces; escarpments, up to 20%, with small rock faces	Outcrop with very little soil	Sparse shrubs and low trees or *A. aneura* (mulga), over sparse forbs and grasses
2	Small	Erosional slopes at the foot of unit 1: stony surfaces, 2–5% and up to 300 yd long, locally dissected into spurs up to 20 ft high, with steep valley margins		
3	Small	Alluvial fans, locally coalescing down slope as alluvial vales: up to 500 yd long, gradients 1 in 50 to 1 in 125	No records but probably mainly coarse-textured soils—red clayey sands over gravel or stone (3*d*) and calcareous earths (6*a*)	Absent or *A. georginae* (gidgee), over short grasses and forbs
4	Small	Flood-plains: up to ¾ mile wide, with flood zones marked by linear scalded tracts	Observations restricted to texture-contrast soils with surface pavements	*Eremophila* spp.–*Hakea leucoptera* over *Bassia* spp. or minor *Kochia aphylla* (cotton-bush)
5	Very small	Incised channels: up to 10 yd wide, longitudinal gradients about 1 in 50	——	As units 1 and 2
6	Very small	Major channels: up to 50 yd wide and 5 ft deep, with winding, locally braiding courses	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(50) Renners Land System (300 sq. miles)

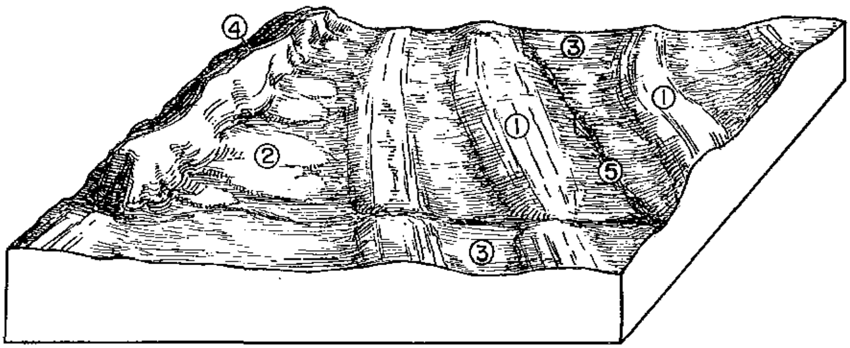
Undulating limestone country with southern bluebush (Plate 8, Fig. 1), in the south central part of the area.

Geology.—Strongly deformed interbedded limestone, shale, and some thin sandstone. Lower Palaeozoic age, Amadeus trough (Pertaoorrta "series").

Geomorphology.—Erosional surfaces formed below the weathered land surface: broadly undulating, banded outcrop terrain with a very open drainage pattern, relief up to 50 ft, higher ridges locally.

Water Resources.—Ground-water prospects generally poor. Sandstone aquifers yield stock water in areas of good local recharge. Elsewhere ground water may be saline. Surface catchments may be required in areas of outcrop of limestones and shales.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Strike rises: up to 50 ft high; stony surfaces throughout, with outcrop bands on crests; concave marginal slopes, 2–5%	Mainly shallow, stony soils, calcareous earths (*6e*, minor *6a*), and intergrades to texture-contrast soils (*7b*)	Absent or sparse shrubs, or minor *A. kempeana* (witchetty bush) over *Kochia astrotricha* (bluebush), short grasses and forbs, or minor *Eragrostis xerophila* (neverfail)
2	Small	Erosional slopes at the foot of unit 4: stony slopes, 2–10% and up to 300 yd long; rock outcrops in upper sectors, shallow gullying down slope		
3	Medium	Strike valley floors: flat central tracts with scalding and shallow gullying, and typically with discontinuous channel drainage; concave marginal slopes, up to 2%, passing into unit 1		
4	Small	Ridges: narrow crests up to 200 ft high; structurally benched slopes, 15–45% with some scree	Outcrop with shallow, stony soil	Sparse shrubs and low trees over sparse forbs and grasses
5	Very small	Channels: up to 50 yd wide and 5 ft deep	Non-calcareous soils including red clayey sands (*3d*), red earths (*4d*), and alluvial variants. Bed-loads mainly sand	*A. aneura* (mulga), *E. microtheca* (coolibah), or *A. kempeana* (witchetty bush), over short grasses and forbs or *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(51) MULLER LAND SYSTEM (400 SQ. MILES)

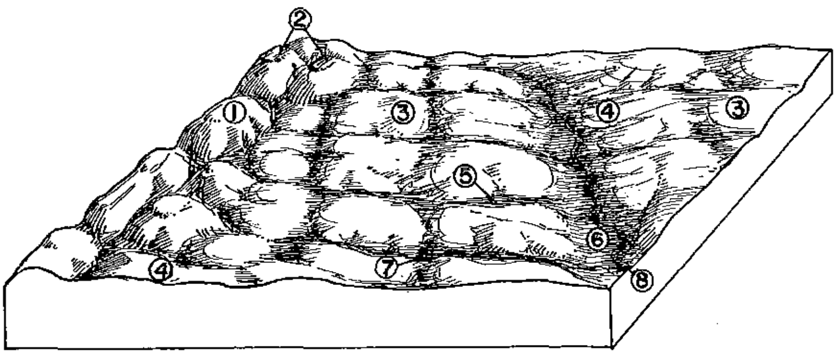
Open, low hilly or undulating limestone country south of the MacDonnell Ranges, mainly between Hermannsburg and Alice Springs.

Geology.—Calcareous conglomerate and sandstone. Upper Palaeozoic age, Amadeus trough (Pertnjara "series").

Geomorphology.—Erosional surfaces formed below the weathered land surface: low hilly or undulating terrain, with an open pattern of branching valleys and strike-controlled tributaries; relief up to 75 ft.

Water Resources.—Little or no prospect of obtaining useful supplies of ground water. Surface catchments recommended.

Climate.—Comparable climatic stations are Hermannsburg and Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Hills: flattish crests up to 75 ft high, with calcreted residual gravels; convex stony hill slopes, 3–15%, indented by blunt strike valleys up to 400 yd long	Shallow, stony soils with calcrete crusts	Absent, *A. kempeana* (witchetty bush)–*Cassia* spp., *A. kempeana* (witchetty bush), or minor *A. calcicola* (myall) over short grasses and forbs or minor *Bassia* spp.
2	Very small	Calcrete terrace remnants: cappings, with up to 15 ft of calcreted gravels, forming flat stony summits, or benches with low breakaways above hill slopes as in unit 1		Sparse shrubs and low trees over *Triodia clelandii* (spinifex); *A. kempeana* (witchetty bush)–*Cassia* spp. over sparse forbs and grasses
3	Large	Strike rises: up to 20 ft high and 400 yd wide; flattish or gently rounded stony crests with calcreted residual gravel mantles; concave marginal slopes, up to 10%	Calcareous earths (6*a*, minor 6*e*)	Similar to unit 1 but also *Triodia clelandii* (spinifex)
4	Medium	Erosional slopes at the foot of units 1 and 3: stony surfaces up to 200 yd long, slopes up to 2%; extensive shallow gullying in lower sectors		
5	Small	Tributary valley floors: extensively scalded surfaces up to 400 yd wide, longitudinal gradients 1 in 250 to 1 in 500; flat central floors with discontinuous channelling, and gently concave marginal slopes	Mainly coarse-textured soils—red clayey sands (3*d*) and red earths (4*d*), locally, texture-contrast soils (7*e*)	*A. aneura* (mulga) or sparse low trees over short grasses and forbs, *Eragrostis eriopoda*, *Bassia* spp., or minor *Muehlenbeckia cunninghamii* (lignum)
6	Small	Main valley floors: up to ½ mile wide, longitudinal gradients 1 in 500 to 1 in 750; soft, locally hummocky surfaces with stony, scalded areas		
7	Very small	Minor channels: up to 5 yd wide and incised up to 2 ft in unit 5	——	Sparse low trees over *Chloris acicularis* (curly windmill grass), or minor short grasses and forbs
8	Very small	Major channels: up to 50 yd wide and incised up to 10 ft in unit 6; flanking levees of calcreted gravel and sands up to 10 ft high	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(52) Endinda Land System (800 sq. miles)

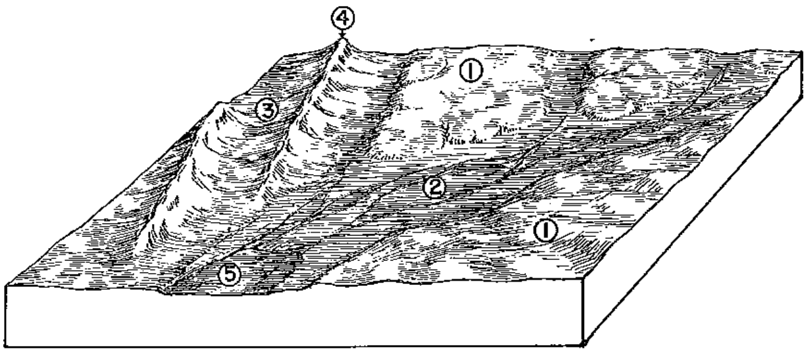
Undulating stony plains with saltbush and southern bluebush (Plate 10, Fig. 1), in the south-east of the area.

Geology.—Flat-lying shale, claystone, and fine-grained sandstone. Mesozoic age, Great Artesian Basin (including Rumbalara shale).

Geomorphology.—Erosional surfaces formed below the weathered land surface: undulating stony plains with up to 30 ft relief; open, branching pattern of ill-drained shallow valleys with gilgais.

Water Resources.—Sub-artesian water is available from depths to 500 to 1000 ft on Andado and New Crown. Elsewhere the ground-water prospects are poor. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Charlotte Waters.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Interfluves: up to 1 mile wide and 30 ft high; flattish stony crests, with gilgais and some shallow gullies; concave marginal slopes, 1–5%, with stonier, closely gullied surfaces	Texture-contrast soils (*7b*, *7d*)	Absent, or very sparse shrubs with *Atriplex vesicaria* (saltbush), *Kochia astrotricha* (bluebush), or *Bassia* spp.
2	Medium	Valley floors: hummocky, stony surfaces up to 200 yd wide, with restricted channel drainage, linear gilgais, shallow gullies, scalds, and small clay pans	Texture-contrast soils as in unit 1 (less pavement stone), and locally, a coarse-structured clay soil	Similar to unit 1, minor *A. georginae;* also small areas *Astrebla pectinata* (Mitchell grass), *Kochia aphylla* (cottonbush) or *Arthrocnemum* spp. (samphire)
3	Small	Interdune corridors: up to 1 mile wide, with flat central tracts with sand cover broken by outcrops of calcrete or by stony pan surfaces, and sandier margins sloping up to 2% towards flanking dunes		*Atriplex vesicaria* (saltbush), *Bassia* spp., or short grasses and forbs
4	Small	Dunes: northerly-trending, parallel linear dunes up to 400 yd wide and 70 ft high; moderately stable flanks, 10–25%, uneven crests and loose slip faces, up to 75%, liable to sand blowing; steeper flanks and slip faces are on eastern sides	Red sands (*3f*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex); crests with *Zygochloa paradoxa* (cane grass)
5	Very small	Alluvial basins, up to 1 mile in extent	Coarse-structured clay soils (*8b*)	Treeless or small areas *E. microtheca* (coolibah) with *Chenopodium auricomum* (bluebush), *Atriplex nummularia* (old-man saltbush), or minor *Astrebla pectinata* (Mitchell grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(53) Dinkum Land System (600 sq. miles)

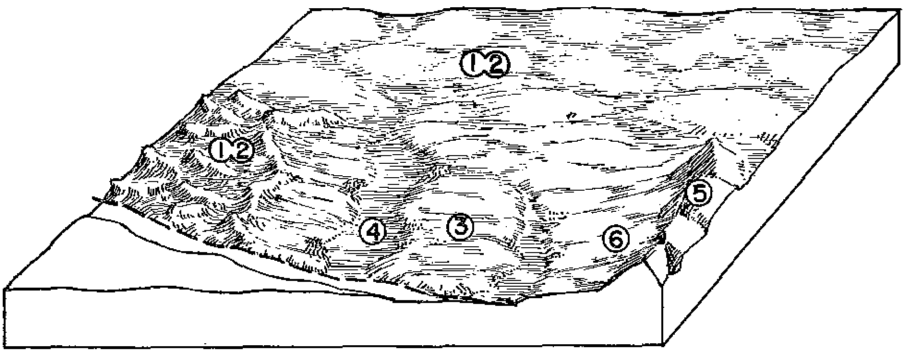
Hummocky sandy plains with small stony tracts, in the east central part of the area.

Geology.—Quaternary aeolian sand overlying and with some outcrops of Pre-Cambrian schist and gneiss.

Geomorphology.—Erosional surfaces formed below the weathered land surface: sand plain and stony plains with low ridges; relief mainly up to 30 ft; sparse, disconnected local drainage restricted to sand-free parts.

Water Resources.—Shallow alluvial and fracture aquifers may yield supplies of saline to good-quality ground water. There are catchments suitable for surface storage.

Climate.—Comparable climatic stations are Alice Springs and Urandangie.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Sand plain: hummocky surfaces with up to 10 ft local relief; generally stable, but low dunes with loose sand occur near large drainage channels	Mainly rather coarse-textured soils—red clayey sands (*3a*, *3d*) and red earths (*4a*, *4d*); shallow stony soils on low rises	Sparse low trees, smaller areas *A. aneura* (mulga), or *A. georginae* (gidgee) over short grasses and forbs
2	Very small			Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
3	Small	Interfluves: up to 1 mile wide and 20 ft high; flattish or rounded stony crests with some calcrete cover, and slightly scalded steeper margins		Similar to unit 1, also minor areas *A. kempeana* (witchetty bush)
4	Small	Valley floors: up to ½ mile wide, with short tributary embayments on the flanks of unit 3		Sparse low trees over short grasses and forbs or *Chrysopogon fallax* (golden-beard grass)
5	Small	Low rocky ridges of schists or quartz reef, with short colluvial aprons	Outcrop with very shallow stony soils	Sparse shrubs and low trees or *A. aneura* (mulga) over sparse forbs and grasses or short grasses and forbs
6	Small	Erosional slopes; at the foot of unit 5; up to 200 yd long	Shallow very stony or gritty soil on pediments; alluvial brown sands (*1a*)	Similar to unit 1, also minor *Aristida browniana* (kerosene grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(54) Angas Land System (400 sq. miles)

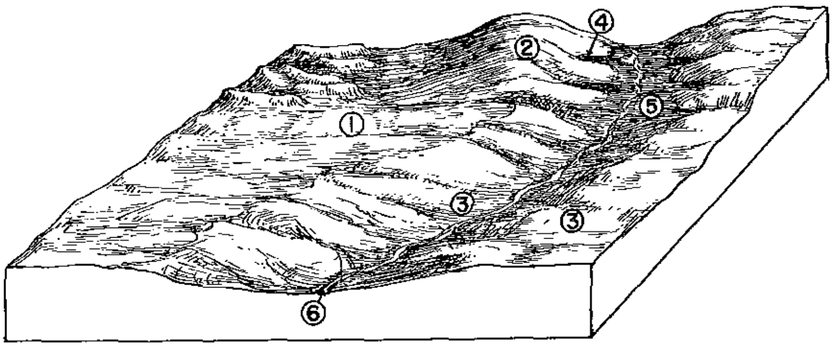
Sand plain and strongly undulating, stony plains, in the south-west of the area.

Geology.—Folded sandstone, shale, and limestone. Lower Palaeozoic age, Amadeus trough (Pertaoorrta "series"). Several areas with Tertiary "deep weathering profile".

Geomorphology.—Erosional surfaces formed below the weathered land surface: undulating or low hilly terrain with extensive sand-covered lower areas; relief up to 50 ft; closely-spaced tributary drainage on higher ground, passing into unchannelled valleys down slope.

Water Resources.—Sandstones and limestones yield good supplies of variable-quality ground water. Surface catchments may be required in areas of outcrop of limestones and shales.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Sand plain with some low dunes: traversed by ill-defined drainage floors up to ¼ mile wide	Red clayey sands (3*d*) on sand plain, red sands (3*f*) in dunes	Sparse shrubs and low trees over *Triodia basedowii* (spinifex); smaller areas *A. aneura* (mulga) or *Cassia eremophila* over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
2	Medium	Strike ridges, broader rises, and mesas: up to ½ mile wide and 50 ft high; flat or gently rounded stony crests with minor silcrete duricrusts; moderately steep hill slopes or gentle margins of lower rises, closely dissected by short branching valleys	Shallow, stony soils	Absent or *A. kempeana* (witchetty bush) over short grasses and forbs, *Bassia* spp., or *Kochia astrotricha* (bluebush)
3	Medium	Slopes at the foot of unit 2: stony surfaces up to ½ mile long	A range of soils—red earths (4*c*, 4*d*, 4*f*) and texture-contrast soils (7*b*, 7*c*)	Short grasses and forbs, *Bassia* spp., or *Kochia astrotricha* (bluebush)
4	Small	Tributary valley floors: largely unchannelled flat floors up to 200 yd wide		*Bassia* spp. or *Kochia aphylla* (cottonbush)
5	Small	Alluvial plains: strike vales between unit 2, mainly in the west of the land system, lightly scalded, stony surfaces with restricted channel drainage		
6	Very small	Channels: discontinuous, shallow, and winding, up to 50 yd wide	——	

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(55) Kalamerta Land System (200 sq. miles)

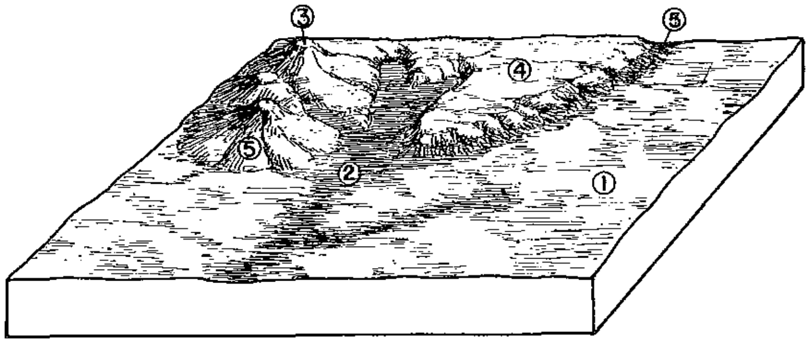
Sand plain with mulga over saltbush, in the far south of the area.

Geology.—Flat-lying arkose and claystone. Mesozoic age, Great Artesian Basin.

Geomorphology.—Erosional surfaces formed below the weathered land surface: sand plain and dissected stony margins with up to 50 ft relief; widely-spaced shallow valleys.

Water Resources.—Good supplies of stock quality to saline water are available at moderate depths. There are few areas suitable for surface catchment.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Sand plain: flat or gently undulating surfaces with minor calcrete exposures and with little surface drainage; relief less than 5 ft	Mainly a range of rather coarse-grained, coarse-textured soils including red clayey sands (3*b*, 3*d*), red earths (4*b*, 4*d*), red calcareous earths (6*c*), and texture-contrast soils (7*e*)	*A. aneura*, minor *A. brachystachya* (mulga) or treeless over *Atriplex vesicaria* (saltbush), short grasses and forbs, *Eragrostis eriopoda* (woollybutt), or *Aristida browniana* (kerosene grass); minor *Triodia basedowii* (spinifex)
2	Small	Drainage floors: up to 200 yd wide, following braiding courses in unit 1; scalded surfaces in upper sectors; restricted channel drainage; longitudinal gradients about 1 in 500	No records, but probably mainly coarse-textured soils	*A. aneura* (mulga) over *Eragrostis eriopoda* (woollybutt)
3	Very small	Mesas: duricrusted stony summits, up to 50 ft high, low breakaways, and gullied, concave hill slopes, 15–40%	Outcrop with shallow, stony soils	*Atriplex vesicaria* (saltbush); minor *A. kempeana* (witchetty bush) over short grasses and forbs
4	Small	Broad rises: gravel-strewn flat crests up to 25 ft high, and steeper margins attaining 5%	Stony soils, (?) partly over structured clays (cf. 7*c*)	*Atriplex vesicaria* (saltbush), smaller areas *Kochia astrotricha* (bluebush)
				Small areas *A. calcicola* (myall) over *Atriplex vesicaria* (saltbush), *Kochia astrotricha* (bluebush), *Bassia* spp., or short grasses and forbs
				A. aneura (mulga) over *Kochia astrotricha* (bluebush)
5	Very small	Slopes at the foot of units 3 and 4: 0·5–2·5%, and up to ½ mile long; stony surfaces, liable to shallow gullying	Texture-contrast soils (7*e*, 7*f*) occasional gilgais (8*a*)	Treeless, small areas *A. aneura* (mulga) over *Kochia aphylla* (cotton-bush) or *Kochia astrotricha* (bluebush)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(56) Weldon Land System (100 sq. miles)

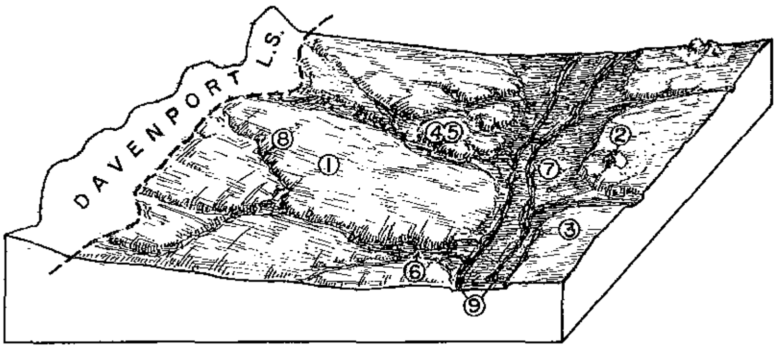
Gravel terraces with spinifex and undulating plains in the north-west of the area.

Geology.—Quaternary terrace gravel overlying, and with outcrop of, Pre-Cambrian schist and gneiss.

Geomorphology.—Depositional surfaces: piedmont terraces and undulating plains, strike drainage with parallel, branching tributaries.

Water Resources.—Ground-water prospects are poor. The gravels lie above the water-table. Isolated fracture aquifers in the metamorphic rocks may yield supplies of water suitable for stock.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Terraces: extending up to 1½ miles from backing quartzite ranges, slopes 1–2%, dissected up to 40 ft into lobes up to ½ mile wide; up to 20 ft of unconsolidated boulder gravels with stony, locally sandy surfaces	Mainly very stony red earths (4*h*), less stony on lower slopes	Sparse shrubs and low trees over *Triodia spicata* (spinifex)
2	Very small	Low hills on unit 3	Outcrop with pockets of shallow, gritty or stony soil	
3	Medium	Interfluves: up to 20 ft high and ¾ mile wide, with gently rounded or flat stony crests	Mainly red earths (?4*a*, ?4*g*), locally red clayey sands (3*a*) and stony soils including texture-contrast soils (7*a*)	Sparse low trees or *A. aneura* (mulga) over *Eragrostis eriopoda* (woollybutt) or short grasses and forbs
4	Very small	Uneven rocky surfaces formed by stripping of units 1 and 3: up to ½ mile in extent, with exposures of weathered and fresh rock, and with low calcrete rises in lower parts	Shallow, stony calcareous earths (6*a*)	*A. kempeana* over short grasses and forbs
5	Small		Various, including shallow, stony soils, texture-contrast soils (7*a*), and red coarse-structured clay soils with gilgais (8*a*)	*Eremophila* spp.–*Hakea leucoptera* over *Bassia* spp.; minor *Kochia aphylla*, *Eragrostis xerophila*, or *Astrebla pectinata*
6	Small	Tributary valley floors: up to ¼ mile wide, longitudinal gradients 1 in 100 to 1 in 150; some scalding on gentle marginal slopes	Mainly red earths (4*e*), locally stony soils on upper parts	*A. aneura* over short grasses and forbs, *Eragrostis eriopoda*, or *Themeda australis*
7	Small	Flood-plains: up to ½ mile wide, with tributary embayments in unit 6	No records but probably mainly alluvial soils	Sparse low trees over short grasses and forbs
8	Very small	Minor channels: up to 10 yd wide and incised up to 10 ft in unit 1, locally into bedrock	——	*A. aneura*, *E. camaldulensis*–*A. estrophiolata* or minor *A. calcicola* over *Chloris acicularis*, short grasses and forbs, or (in rockier parts) *Triodia pungens*
9	Very small	Major channels: up to 150 yd wide and 5 ft deep	——	*E. camaldulensis*–*A. estrophiolata* over *Chloris acicularis*

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(57) Reynolds Land System (100 sq. miles)

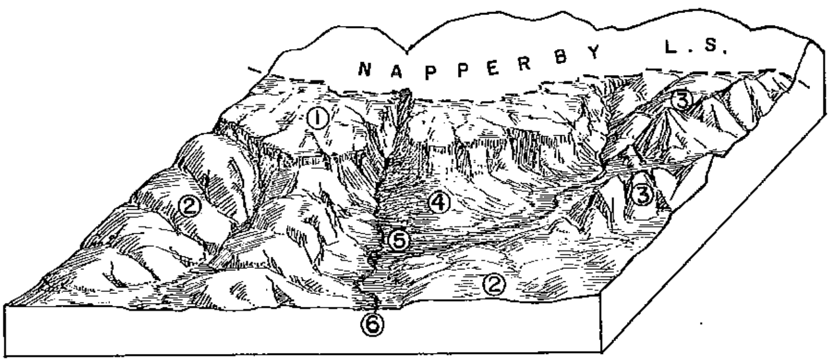
Spinifex on gravel terraces and rocky lowlands, north of Napperby homestead.

Geology.—Tertiary "deep weathering profile". Developed on Pre-Cambrian schist and gneiss. Remnants of Quaternary terrace gravels.

Geomorphology.—Depositional surfaces: gravel-capped piedmont terraces and dissected, stripped terrain; relief up to 50 ft; closely spaced, branching drainage pattern.

Water Resources.—Ground-water prospects poor, surface catchments recommended.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Piedmont terraces: extending up to 1½ miles from backing hills, with slopes approximately 2%; steep, gullied marginal escarpments up to 50 ft high	Mainly stony red earths (4*h*); locally coarse-structured clay soils with gilgais on lower slopes	Sparse shrubs and low trees over *Triodia longiceps* (spinifex) or minor *T. spicata* (spinifex)
2	Medium	Gravel-strewn rounded hills and rises: up to 20 ft high, slopes up to 5%		
3	Medium	Rocky tracts: forming interfluves up to 1 mile wide, with up to 50 ft relief; stony surfaces, with numerous schist ridges and narrow, V-shaped valleys	Shallow, stony soils including texture-contrast soils (7*a*)	
4	Small	Slopes at the foot of units 1 and 2: 0·25–5%, with scalded, lightly gullied surfaces	Severely scalded, saline stony soils tending to a texture-contrast type, patches of sandy topsoil	
5	Small	Valley floors: flat, scalded surfaces up to 300 yd wide	Coarse-textured soils, possibly with a deep subsoil pan in places	*Eremophila* spp.–*Hakea leucoptera* over *Bassia* spp.
6	Very small	Channels: small, shallow, and braiding	Bed-loads mainly sand and grit	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(58) Berrys Pass Land System (100 sq. miles)

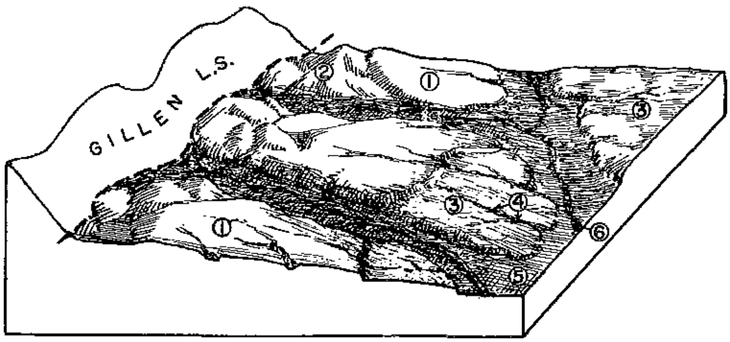
Spinifex-covered gravel terraces west of Haasts Bluff.

Geology.—Quaternary terrace gravels overlying Tertiary "deep weathering profile" developed on Pre-Cambrian schist and gneiss and Proterozoic and Palaeozoic sandstone, siltstone, and dolomite.

Geomorphology.—Depositional surfaces: weathered and unconsolidated boulder gravel fans and terraces; relief up to 150 ft; strike-controlled major drainage with incised, parallel tributaries.

Water Resources.—Ground-water prospects are variable. Supplies of good-quality ground water can be obtained from sandstones and sands where they occur below the water-table, which may be deep. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Hermannsburg.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Upper terraces and undissected piedmont aprons: extending up to 1½ miles from backing ranges, slopes 2–5%; partly dissected up to 150 ft into spurs up to 1 mile wide; locally forming secondary watersheds headwards of strike valley dissection; loose, boulder-strewn surfaces; steep, dissected escarpments, 10–30%, in ferricreted gravels and weathered bedrock	Little soil with strew of boulders or stone	Sparse shrubs and low trees over *Triodia spicata* (spinifex), *T. clelandii* (spinifex), or minor *Plectrachne schinzii* (spinifex)
2	Small	Boulder fans: of indurated, coarse boulders between re-entrants in mountain front; slopes 10–45%; commonly dissected along contact with backing hill slopes		
3	Medium	Lower terraces: up to 50 ft high, occupying drainage re-entrants in unit 1; stony terrace surfaces slope valleywards at 1–3%; steep, dissected margins		
4	Very small	Drainage floors: unchannelled surfaces up to 30 yd wide and lowered to 10 ft in unit 3	Mainly stony, locally a red earth (4*f*) or a texture-contrast soil	
5	Small	Alluvial plains: up to ½ mile wide; forming strike vales or occurring down slope from undissected piedmont aprons	No records; probably a range of coarse and finer-textured soils—red clayey sands (3*d*) and red earths (4*d*, 4*e*)	*A. aneura* (mulga) over *Eragrostis eriopoda* (woollybutt)
6	Very small	Channels: shallow, braiding, and up to 50 yd wide	Bed-loads range from sand to cobble gravels	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Themeda australis* (kangaroo grass), *Bothriochloa ewartiana* (desert blue grass)–*Eulalia fulva* (silky browntop), or *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(59) Stokes Land System (700 sq. miles)

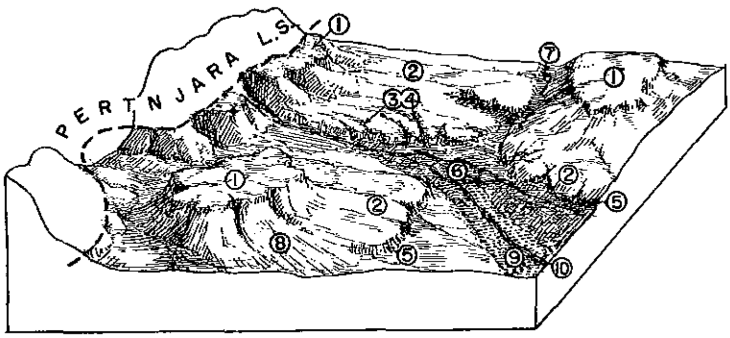
Gravel terraces with mulga and spinifex in the western MacDonnell Ranges.

Geology.—Quaternary terrace gravels overlying Tertiary "deep weathering profile" developed on Pre-Cambrian schist and gneiss and Proterozoic and Palaeozoic sandstone, siltstone, and dolomite.

Geomorphology.—Depositional surfaces: calcreted piedmont gravel terraces and weathered higher terrace remnants, relief up to 80 ft; entrenched parallel valleys with short, incised tributaries.

Water Resources.—Ground-water prospects are poor. Limestone, sandstone, and shallow alluvial aquifers may yield supplies of stock or saline water. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Hermannsburg.



Unit	Area	Land Form	Soil*	Plant Community
1	Small	High terrace mesas and benches: duricrusted summits up to 80 ft high, capped by gravels; low breakaways; concave slopes up to 15%	Mainly stony red earths (4h), less stony on parts of lower terraces	Sparse shrubs and low trees over *Triodia clelandii* (spinifex)
2	Large	Lower terraces: up to 50 ft high, extending up to 3 miles from backing ranges with slopes 0·5–1%; undulating stony surfaces in lobes up to 1 mile wide		Sparse shrubs and low trees or *A. aneura* (mulga) over *Triodia clelandii* (spinifex) or (with mulga) short grasses and forbs
3	Small	Stripped margins of unit 2: up to ¼ mile wide, with elongate gravelly rises, and linear drainage flats up to 150 yd wide; local relief 5 ft		
4	Very small		Red or brown coarse-structured clay soils (cf. 8a)	*Astrebla pectinata* (Mitchell grass) or *Eragrostis xerophila*
5	Small	Lower terrace faces: stony slopes, 3–5%, indented up to 300 yd by narrow valleys	Stony mantles over exposures of soils or their weathered substrata	Sparse shrubs and trees of *E. oleosa* var. *glauca*, over *Triodia clelandii* (spinifex)
6	Very small	Alluvial fans: up to 1 mile long, gradients 1 in 150 to 1 in 250; active drainage tracts with shallow distributary depressions, and more stable inter-drainage zones	Mainly texture-contrast soils (7e), locally red clayey sands (3d), red earths (4d), and calcareous earths (6a, ?6d)	*Eremophila* spp.–*Hakea leucoptera*, minor *A. aneura* (mulga), or sparse low trees over *Bassia* spp., *Kochia aphylla* (cotton-bush), or *Atriplex vesicaria* (saltbush); minor *Astrebla pectinata* (Mitchell grass), *Eragrostis xerophila* (neverfail), or short grasses and forbs
7	Small	Valley floors: up to ½ mile wide, concave marginal slopes 0·5–2%		
8	Small	Erosional hill-foot slopes: stony surfaces up to 400 yd long, with shallow gullying		
9	Small	Flood-plains, up to 500 yd wide	Coarse-textured alluvial soils (1a, 1h)	Sparse low trees over short grasses and forbs
10	Very small	Channels: up to 50 yd wide and 10 ft deep, braiding locally; narrow levees of sand and gravels	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(60) Santa Teresa Land System (100 sq. miles)

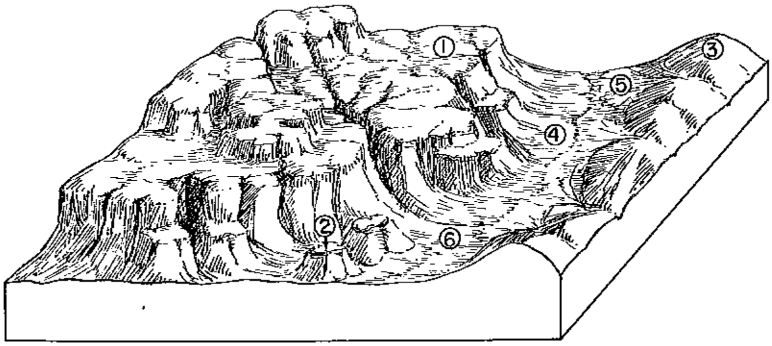
Limestone plateaux in the eastern MacDonnell Ranges.

Geology.—Tertiary chalcedony and calcareous siltstone. Overlying Tertiary "deep weathering profile" developed on lower Palaeozoic shale, limestone, and sandstone.

Geomorphology.—Depositional surfaces: limestone plateaux up to 300 ft high; vigorously dissecting, short drainage channels.

Water Resources.—Bores and dams are not needed because of the inaccessible nature of the country.

Climate.—Nearest comparable climatic station is Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Limestone plateaux: rocky summits up to 2 miles in extent, with regional slopes less than 1%; breakaways of hardened limestone up to 40 ft high; stony rectilinear hill slopes, approximately 40%, with minor structural ledges; escarpments indented up to ¾ mile by narrow winding valleys and branching tributary re-entrants	Outcrop with shallow stony soils	Sparse shrubs and low trees over *Triodia longiceps* (spinifex)
2	Small	Benches and mesas: up to 150 ft high and ¼ mile in extent; laterite cappings with low breakaways; closely gullied, concave hill slopes, 25–50%, in weathered rock		Sparse shrubs and low trees over sparse forbs and grasses
3	Small	Narrow ridges: up to 150 ft high, with remnant laterite cappings		
4	Small	Erosional slopes at the foot of units 1, 2, and 3: concave stony slopes, 1–3% and up to ½ mile long, with close gullying in lower sectors	Calcareous earths (6*a*, 6*b*)	*A. georginae* (gidgee) or *A. kempeana* (witchetty bush) over short grasses and forbs
5	Very small	Alluvial fans: up to ½ mile long, gradients less than 1 in 100; scalded, stony surfaces with few drainage channels	Coarse-textured soils including red clayey sands (3*d*)	Sparse low trees over short grasses and forbs
6	Very small	Winding channels, up to 100 yd wide and 5 ft deep	Bed-loads of coarse sand and grit	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(61) Table Hill Land System (300 sq. miles)

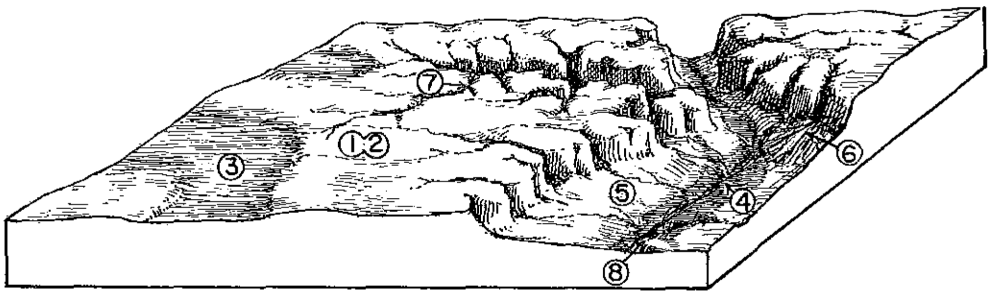
Low limestone plateaux in the east centre of the area.

Geology.—Tertiary chalcedony and calcareous silt.

Geomorphology.—Depositional surfaces: limestone plateaux up to 150 ft high; branching, incised drainage on plateau margins, more open valleys on summits and fringing lowlands.

Water Resources.—Ground-water prospects are good where the Tertiary sediments are below the water-table, but because of the inaccessible nature bores and dams would not be needed.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Plateaux: uneven, stony summits 30–150 ft high, regional slopes less than 1%, with little surface drainage; marginal breakaways up to 20 ft high, indented up to $\frac{3}{4}$ mile by entrenched valleys up to 200 yd wide with branching tributary re-entrants; concave, stony hill slopes, 10–30%	Outcrop with pockets of shallow, stony, calcareous soil	Sparse shrubs and low trees, or *A. kempeana–Cassia* spp., over sparse forbs and grasses; minor *A. georginae* with bare ground or very sparse short grasses and forbs
2	Small		Calcareous earths (*6b*)	*A. georginae* (gidgee) over short grasses and forbs
3	Small	Alluvial plains in shallow basins in unit 1: up to $\frac{3}{4}$ mile in extent, gradients about 1 in 500; unchannelled surfaces with gilgais, stony scalded tracts, and shallow gullies	Red coarse-structured clay soils (*8a*), in places in a complex with texture-contrast soils (*7g*)	Treeless or with small patches of *A. georginae* (gidgee) with *Astrebla pectinata* (Mitchell grass) or *Eragrostis xerophila* (neverfail)
4	Small	Valley floors: up to 400 yd wide, locally broadening into plains up to $\frac{1}{2}$ mile wide; flat central floors and gentle concave marginal slopes; stony surfaces, liable to scalding and shallow gullying	A range of soils including red earths (?*4b*), calcareous earths (*6b*), and red coarse-structured clay soils (*8a*)	*A. georginae* (gidgee), *A. aneura* (mulga), *A. kempeana* (witchetty bush), or sparse low trees, over short grasses and forbs, or minor *Atriplex vesicaria* (bladder saltbush)
5	Small	Erosional slopes at the foot of units 1 and 2: 1–3%, and up to 300 yd long; stony surfaces liable to shallow gullying locally dissected up to 10 ft into flat-crested spurs with convex marginal slopes up to 10%		
6	Very small	Alluvial fans: slope up to 200 yd long, liable to scalding and shallow gullying		
7	Very small	Minor channels: up to 10 yd wide and 2 ft deep, commonly braiding	——	*A. aneura* (mulga) over short grasses and forbs
8	Very small	Major channels: up to 75 yd wide and 2 ft deep	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(62) Ambalindum Land System (200 sq. miles)

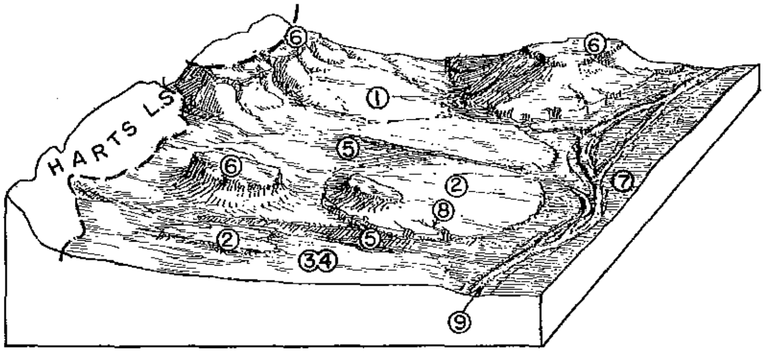
Terraces and plains in the east centre of the area, mainly near Ambalindum homestead.

Geology.—Tertiary "deep weathering profile" developed on Mesozoic sandstone and Pre-Cambrian schist and gneiss. Remnant of Tertiary chalcedony and calcareous silt.

Geomorphology.—Depositional surfaces: intermont terraces of two cycles; surfaces formed by shallow dissection of extensive calcareous lower terrace; relief up to 150 ft on margins, 30 ft in central parts.

Water Resources.—Supplies of ground water are available from sand and gravel aquifers in the alluvium and weathered and fractured metamorphic rocks. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Slopes at the foot of unit 6: severely scalded surfaces, closely dissected by shallow branching gullies	Mainly texture-contrast soils (7g), locally stony soils, either gravelly or calcareous, near breakaways or margins of terraces	*Eremophila* spp.–*Hakea leucoptera* over *Bassia* spp.
2	Medium	Lower terraces: extending up to 2½ miles from backing ranges with average slopes 0·4%; undulating in cross section, with alluvial basins in lower parts; dissected up to 25 ft into lobes up to 1 mile wide, with steep breakaway margins		*Atriplex vesicaria* (saltbush), *Bassia* spp., or *Arthrocnemum* spp. (samphire) On breakaways *A. kempeana* (witchetty bush)–*Cassia* spp. or minor *A. georginae* (gidgee) over short grasses and forbs
3	Small	Stripped lower terrace surface: gently sloping surfaces up to 1½ miles in extent; no local drainage, but numerous gilgais		As unit 1; minor *Arthrocnemum* spp. (samphire)
4	Medium		Texture-contrast soils, less scalded than in units 1 to 3, in a complex with red coarse-structured clay soils (8a)	*Astrebla pectinata* (Mitchell grass), *Eragrostis xerophila* (neverfail), *Kochia aphylla* (cotton-bush), *Atriplex nummularia* (old-man saltbush), or *Bassia* spp.
5	Small	Alluvial basins and tributary drainage floors: basins, up to ¾ mile wide, occupy lower parts of unit 2; drainage floors with flat or gently concave unchannelled surfaces, 100–300 yd wide, lead from these basins, and are shallowly incised in units 3 and 4, but entrenched up to 20 ft through higher parts of unit 2		
6	Small	Higher terrace remnants: duricrusted benches and mesas, up to 150 ft high	Outcrop with pockets of shallow, stony soil	*A. aneura* (mulga) or *E. oleosa* var. *glauca* over sparse forbs and grasses or *Triodia longiceps* (spinifex)
7	Small	Flood-plains: up to ¾ mile wide, with low levees flanking unit 9	Alluvial brown sands (1a)	Sparse low trees over short grasses and forbs
8	Very small	Tributary channels, incised in unit 2: up to 50 yd wide	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)
9	Very small	Major channels: up to 200 yd wide and 15 ft deep; locally braiding, with low sandy islands	——	

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(63) LINDAVALE LAND SYSTEM (1100 SQ. MILES)

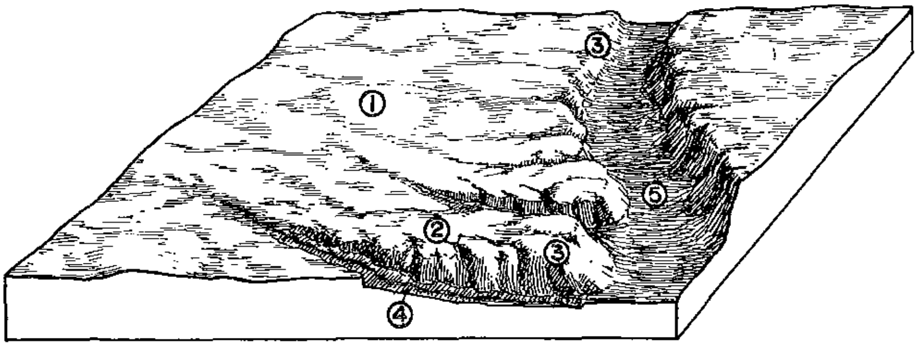
Sandy limestone plains with spinifex, in the south-west of the area.

Geology.—Quaternary kunkar and alluvium and Tertiary chalcedony and calcareous and gypsiferous silt.

Geomorphology.—Depositional surfaces: limestone plains with much sand cover, plains marginally stripped and dissected up to 30 ft; surface drainage absent except for entrenched valleys on margins.

Water Resources.—Supplies of variable-quality ground water are available at shallow to moderate depths from alluvial and chalcedony aquifers.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Limestone plains: gently sloping surfaces with less than 5 ft local relief, with almost complete sand cover and little surface drainage	Mainly red clayey sands (3*b*), locally calcareous earths (e.g. 6*c*)	*A. aneura* (mulga), minor *A. calcicola* (myall), *Cassia eremophila*, or absent, over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
				Sparse shrubs and low trees or minor *Casuarina decaisneana* (desert oak) over *Triodia basedowii* (spinifex)
2	Small	Limestone rises: up to ½ mile wide and 20 ft high; flat stony crests, and concave marginal slopes, 1–2%	Shallow stony and sandy soils around exposures	*A. kempeana* (witchetty bush), absent, or minor *E. oleosa* var. *glauca* over short grasses and forbs or *Bassia* spp.
				Treeless or *A. calcicola* (myall) with *Kochia astrotricha* (bluebush)
3	Small	Escarpments bounding unit 1: up to 30 ft high, with breakaways up to 15 ft high and stony slopes, above 20%, in softer underlying rock		Absent or *A. kempeana* (witchetty bush) with short grasses and forbs or *Bassia* spp.
4	Small	Tributary valley floors incised below unit 2 on stripped margins of unit 1: flat floors up to 200 yd wide, without channel drainage	Red earths (4*b*), locally with concentrations of ferruginous nodules	*A. aneura* (mulga) over short grasses and forbs or *Bassia* spp.
5	Small	Entrenched main valley floors: flat, ill-drained surfaces up to 200 yd wide, without channel drainage	——	*E. microtheca* (coolibah) over *Muehlenbeckia cunninghamii* (lignum)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(64) Titra Land System (600 sq. miles)

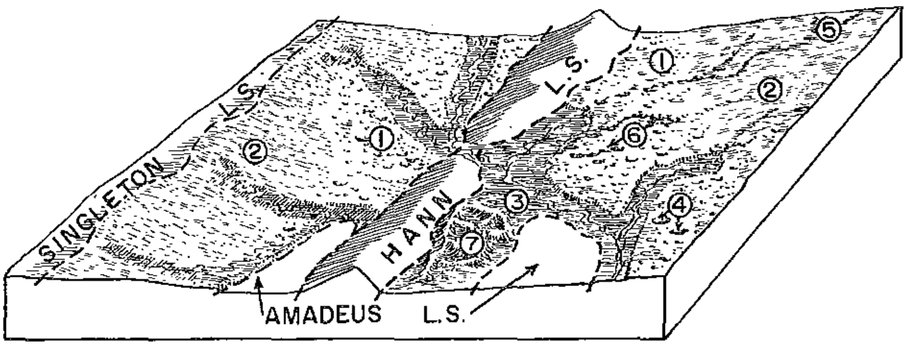
Sandy limestone plains and saline tracts in the north-west of the area.

Geology.—Quaternary kunkar and alluvium.

Geomorphology.—Depositional surfaces: limestone plains with moderate sand cover and disorganized surface drainage; lightly dissected margins with up to 10 ft relief.

Water Resources.—Large supplies of moderate-quality water are available at shallow depths from sand and kunkar aquifers.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Stony limestone rises: up to ¼ mile wide and 10 ft high, marginal slopes up to 2%	Shallow, stony and sandy soils around exposures of calcrete, red clayey sands (3*b*) on marginal slopes	Sparse shrubs and low trees or *A. kempeana* (witchetty bush)–*Cassia* spp. over short grasses and forbs
2	Medium	Limestone plains: much sand cover and numerous rock exposures	As for unit 1 but overall, with a greater proportion of coarse-textured soils—with significant alkalinity and salinity where drainage is restricted and, locally, texture-contrast soils (7*i*), and shallow, sandy soil on a soft mealy marl	*A. kempeana* (witchetty bush) or *Cassia eremophila*, over short grasses and forbs
				Sparse shrubs and low trees over *Triodia pungens* (spinifex)
				Sparse low trees or small thickets of *Melaleuca glomerata* (tea-tree) over *Bassia* spp. or *Atriplex vesicaria* (saltbush)
3	Small	Valley floors: flat, ill-drained surfaces up to 400 yd wide, entrenched up to 10 ft below unit 1		Bare or short grasses and forbs; fringed by *Melaleuca glomerata* (tea-tree) over bare ground or *Triodia pungens* (spinifex)
4	Small	Enclosed depressions in unit 2: isolated or linked, circular or crescentic depressions up to 300 yd in diameter and 10 ft deep; swamp or pan floors, locally with gilgais		*Atriplex vesicaria* (saltbush) or *Arthrocnemum* spp. (samphire)
				Melaleuca glomerata (tea-tree) over *Bassia* spp.
5	Very small	Shallow drainage floors traversing unit 2: up to 300 yd wide and 1 mile long	Red earths (probably 4*b*)	*A. aneura* (mulga) over short grasses and forbs
6	Very small	Entrenched valley floors: up to 100 yd wide, connecting unit 4	No records, but probably alkaline and saline soils	As unit 5
7	Very small	Hummocky, sandy areas in unit 3	Red clayey sands (3*b*)	Very sparse shrubs over short grasses and forbs

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(65) Woolla Land System (600 sq. miles)

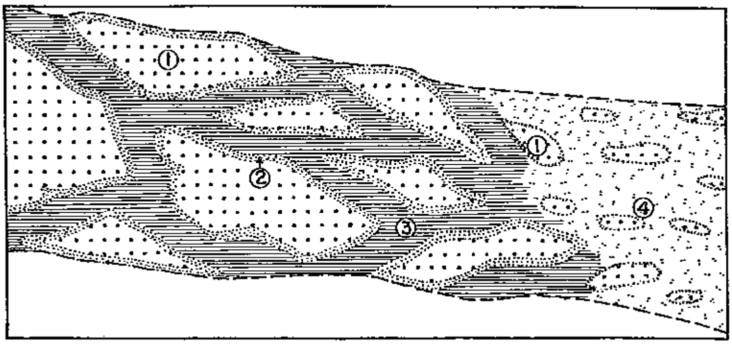
Limestone belts (Plate 1, Fig. 2) in the north-west of the area.

Geology.—Quaternary kunkar and alluvium.

Geomorphology.—Depositional surfaces: lightly dissected limestone valley trains up to 3 miles wide; relief up to 10 ft, decreasing down valley, where the land system is extensively sand-covered.

Water Resources.—Large supplies of moderate-quality water are available at shallow depths from kunkar aquifers. Some prospects for irrigation.

Climate.—Comparable climatic stations are Tea Tree Well, Barrow Creek, and Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Limestone platforms: up to 400 yd wide and 10 ft high, extending up to 1 mile down valley; stony surfaces with numerous limestone exposures; slightly indented marginal slopes up to 5%	Exposures of calcrete with shallow, stony and sandy soils (both calcareous and non-calcareous)	Sparse low trees or *A. kempeana* (witchetty bush) over short grasses and forbs
2	Very small	Colluvial aprons flanking unit 1: sandy slopes, 1–5% and up to 50 yd long	Rather coarse-textured soils—red clayey sands (3*b*) and red earths (4*b*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
3	Medium	Drainage floors: up to 200 yd wide, longitudinal gradients 1 in 500 to 1 in 1000; flat central drainage zones, and gentle concave marginal slopes with minor calcrete exposures	Red earths (4*b*)	Sparse low trees, minor *A. aneura* (mulga), *A. kempeana* (witchetty bush), or *E. microtheca* (coolibah) over short grasses and forbs, or minor *Eragrostis eriopoda* (woollybutt)
4	Medium	Sand plain	Red clayey sands (3*b*) presumably over calcrete near exposures	Sparse shrubs and low trees over *Triodia pungens* (spinifex)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(66) Karee Land System (900 sq. miles)

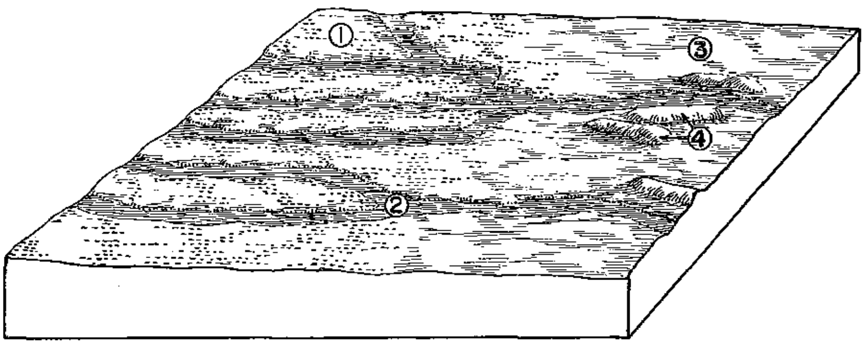
Mulga-covered sandy plains in the far south of the area.

Geology.—Quaternary soils with areas of aeolian sand. Overlying Pre-Cambrian metamorphic rock and Mesozoic sediments.

Geomorphology.—Depositional surfaces: stable plains of coarse-textured alluvium; lower parts extensively wind-modified; gradients about 1 in 500.

Water Resources.—Supplies of good to moderate-quality ground water can be obtained from the Mesozoic sands where they occur below the water-table. Saline water generally occurs in areas marginal to outcrop of Pre-Cambrian rocks. There are some catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Henbury.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Inter-drainage sectors: up to ½ mile wide	Red clayey sands (3*d*) and red earths (4*d*)	*A. aneura* (mulga) or sparse shrubs and low trees over *Eragrostis eriopoda* (woollybutt) or minor *Bassia* spp.
2	Medium	Drainage floors: up to 300 yd wide		
3	Medium	Sand plain		
4	Small	Sand dunes: wind-modified alluvial trains up to 10 ft high, with flat or rounded crests up to 200 yd wide, and continuous for some miles down slope; flanking slopes up to 10%, somewhat steeper on eastern sides; surfaces fixed by vegetation	Red sands (3*f*)	Sparse shrubs and low trees over *Eragrostis eriopoda* (woollybutt) or *Triodia basedowii* (spinifex)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(67) Bushy Park Land System (6400 sq. miles)

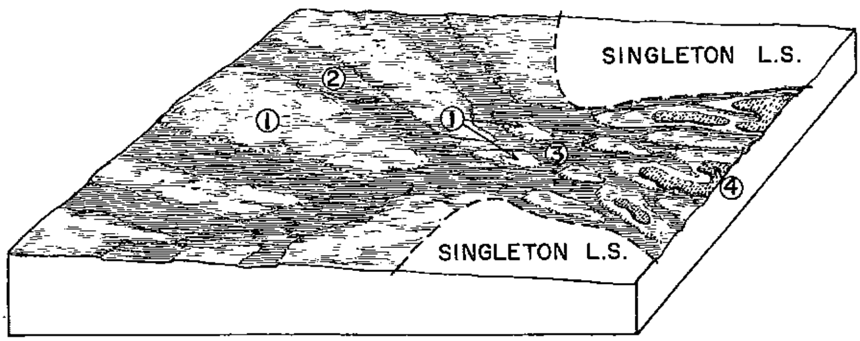
Mulga plains with red earth soils (Plate 6, Fig. 1; Plate 7, Fig. 1) in the northern half of the area.

Geology.—Quaternary soil. Overlying Pre-Cambrian metamorphic and igneous rocks of Proterozoic to Quaternary age.

Geomorphology.—Depositional surfaces: stable alluvial plains; gradients 1 in 500 to 1 in 1000.

Water Resources.—Ground-water prospects are extremely variable because of the wide variety of underlying rocks. Supplies of ground water may be obtained from aquifers in alluvium, sandstones, limestones, and some metamorphic rocks.

Climate.—Comparable climatic stations are Alice Springs, Tea Tree Well, Barrow Creek, and Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Inter-drainage sectors: up to ½ mile wide and less than 5 ft above unit 2; very gentle rises with flattish or slightly convex crests, narrowing and braiding with unit 3 down slope	Red earths (mainly 4*e*, locally 4*d*)	*A. aneura* (mulga), minor *A. kempeana* (witchetty bush), or sparse low trees over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
2	Medium	Tributary drainage floors: up to 500 yd wide, with flat unchannelled central drainage tracts and very gently concave marginal slopes with some scalding		
3	Medium	Main drainage floors: up to ½ mile wide, surfaces as in unit 2		*A. aneura* (mulga), minor *A. kempeana* (witchetty bush), sparse low trees, or *E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood), over short grasses and forbs, *Eragrostis eriopoda* (woollybutt), or minor *Chloris acicularis* (curly windmill grass)
4	Small	Sand-banks: wind-modified alluvial trains up to 400 yd wide, 5 ft high, and extending up to 3 miles down slope, branching locally, to pass into broad rises in the Singleton land system; surfaces fixed by vegetation	Mainly red clayey sands (3*d*), locally red earths (4*d*)	Sparse shrubs and low trees or minor *A. aneura* (mulga) over *Triodia basedowii* (spinifex), *T. pungens* (spinifex), *Plectrachne schinzii* (spinifex), or minor *Eragrostis eriopoda* (woollybutt)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(68) Leahy Land System (100 sq. miles)

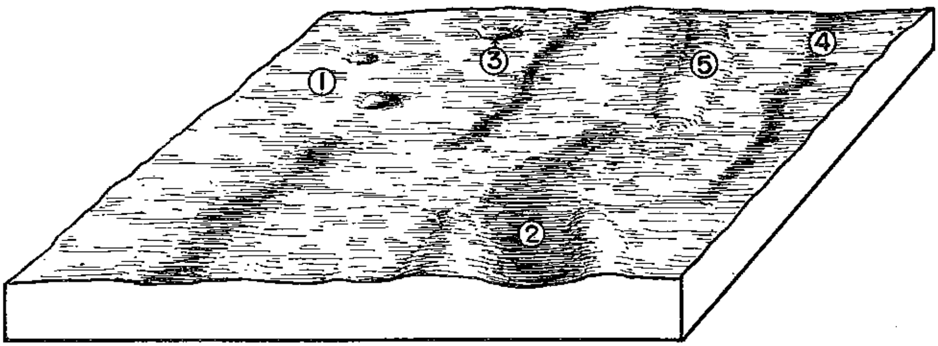
Sandy plains in the east centre of the area.

Geology.—Quaternary alluvium and soil. Overlying Pre-Cambrian metamorphic rocks.

Geomorphology.—Depositional surfaces: stable plains of coarse-textured alluvium, gradients about 1 in 500.

Water Resources.—Supplies of ground water may be obtained in some areas from shallow alluvial aquifers or fractured and weathered zones in metamorphic rock.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Hummocky plains: somewhat loose surfaces, with scalds and small clay pans; up to 2 ft microrelief	Red clayey sands (3*d*) and red earths (4*d*)	*A. aneura* (mulga), or minor *A. georginae* (gidgee) over short grasses and forbs
2	Small	Younger alluvial flats: disconnected alluvial plains and sinuous flood zones up to ½ mile in extent, occupying lower areas; scalded surfaces with small clay pans, and with gilgais locally	Observations restricted to red earths (4*e*) with locally alluvial soils (1*f*)	*A. aneura* (mulga) over short grasses and forbs
3	Very small	Alluvial basins: generally circular, up to ¼ mile in extent, and up to 2 ft below unit 1		*E. microtheca* (coolibah) or *A. aneura* (mulga), over *Muehlenbeckia cunninghamii* (lignum)
4	Small	Drainage floors: discontinuous flat surfaces up to 200 yd wide, and up to 2 ft below unit 1	No records, but probably red earths	*A. aneura* (mulga) over short grasses and forbs
5	Small	Sand-banks: wind-modified alluvial trains up to 500 yd wide, 5 ft high, and extending up to 3 miles down slope; locally anastomosing or branching; surfaces fixed by vegetation	Red sands (3*f*) or red clayey sands (3*d*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(69) Ringwood Land System (500 sq. miles)

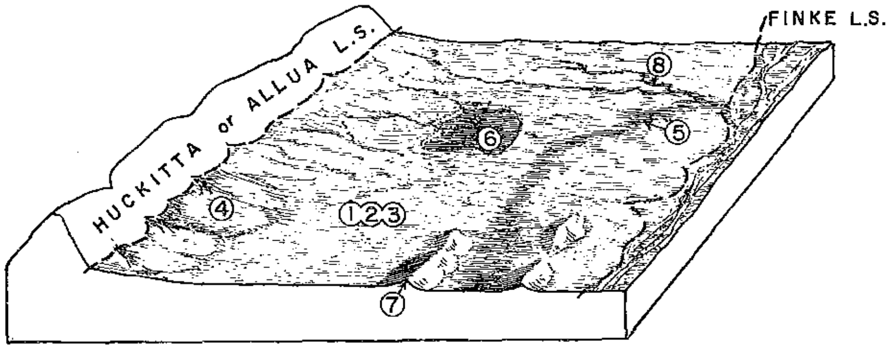
Plains carrying gidgee, mainly in the eastern MacDonnell Ranges.

Geology.—Quaternary alluvium and wash. Overlying Upper Proterozoic sedimentary rocks and Pre-Cambrian metamorphic rocks.

Geomorphology.—Depositional surfaces: stable calcareous alluvial plains and vale fills; gradients 1 in 250 to 1 in 500.

Water Resources.—Supplies of moderate-quality to saline ground water are available at shallow to moderate depths from alluvium, sandstones, limestones, and weathered metamorphics. There are some catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Small	Alluvial plains: gently sloping surfaces liable to scalding, shallow gullying, wind-blowing, and induced erosion	Red earths (4*b*)	*A. aneura* (mulga), or *A. kempeana* (witchetty bush) over short grasses and forbs, or minor *Eragrostis eriopoda* (woollybutt)
2	Medium			Absent, *A. georginae* (gidgee), minor sparse low trees, or *A. kempeana* (witchetty bush) over short grasses and forbs or *Bassia* spp.
3	Large		Calcareous earths (6*a*, 6*b*)	
4	Small	Alluvial fans: up to ½ mile long, gradients 1 in 30 to 1 in 100; loose, or stony surfaces with shallow distributary drainage channels up to 50 yd wide	Red clayey sands (3*d*) over gravels.	
5	Very small	Drainage floors in units 1, 2, and 3: up to 150 yd wide and 2 ft deep; flat central floors and gentle concave marginal slopes with minor calcrete exposures; longitudinal gradients 1 in 500 to 1 in 750	Red earths as in unit 1 but often eroded exposing the calcareous substrata	*A. georginae* (gidgee) or *A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
6	Small	Alluvial basins: up to 1 mile in extent, 1–5 ft below units 1, 2, and 3; very gently sloping surfaces, less than 0·2%, with stony scalded tracts, linear gilgais, and shallow gullying (includes alluvial flats derived from Table Hill land system)	Mainly coarse-structured clay soils (8*a*) in complexes with texture-contrast soils (7*g*); locally alluvial coarse-structured clay soils (1*f*)	*E. microtheca* (coolibah) over *Bassia* spp., *Eragrostis xerophila* (neverfail); minor *Chenopodium auricomum* (bluebush), or *Arthrocnemum* spp. (samphire)
7	Small	Sand dunes and swales: small dunes, up to 5 ft high and irregular in form, although generally parallel with drainage; surfaces fixed by vegetation, with some scalding in swales	Red sands (3*f*), red clayey sands (3*d*), and red earths (4*b*)	Sparse low trees, or minor *A. georginae* (gidgee) over *Eragrostis eriopoda* (woollybutt), or *Aristida browniana* (kerosene grass)
8	Very small	Flood channels: flat scalded floors up to 100 yd wide, entrenched up to 10 ft in the lower parts of units 1, 2, and 3	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(70) Pulya Land System (300 sq. miles)

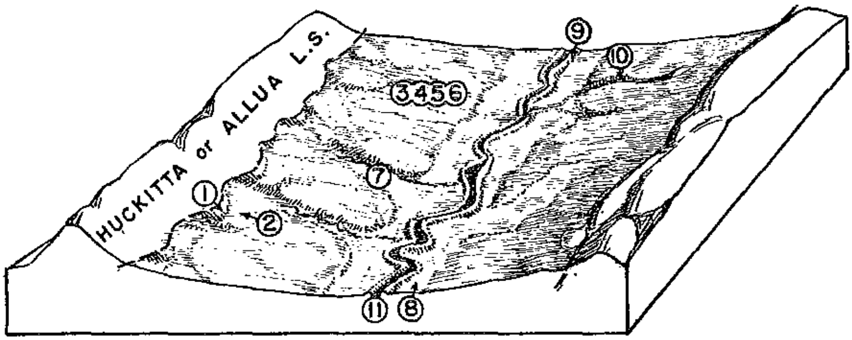
Plains carrying gidgee in the eastern MacDonnell Ranges.

Geology.—Thin Quaternary alluvium. Overlying calcareous shale, limestone, and sandstone, Upper Proterozoic and lower Palaeozoic age, Amadeus Trough (Bitter Springs limestone, Pertatataka, and Pertaoorrta "series"). One small area of Pre-Cambrian granite.

Geomorphology.—Depositional surfaces: stable piedmont fans and vale fills of calcareous alluvium and calcreted gravels; surfaces are undulating in cross section, with shallow transverse valleys tributary to major strike drainage.

Water Resources.—Ground water prospects are generally poor. Sandstone and limestone aquifers may yield supplies of good quality to stock water in areas of good local recharge. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Very small	Colluvial aprons: stony surfaces up to 200 yd long, slopes 3–10%	Shallow stony and sandy soils	*A. aneura* over short grasses and forbs, *Eragrostis eriopoda*, or minor sparse forbs and grasses; *A. kempeana* over short grasses and forbs; *A. georginae* over short grasses and forbs or minor *Atriplex vesicaria; A. vesicaria*
2	Very small	Erosional slopes at the foot of backing ranges: surfaces up to 300 yd long, slopes 1–5%; rock outcrops in upper sectors, widespread shallow gullying down slope		Absent or *A. georginae* (gidgee) over short grasses and forbs
3	Medium	Alluvial fans and plains: stony slopes, 0·8–3% and up to 1 mile long, broken by tributary drainage into lobes up to 1 mile wide	Red clayey sands (3*d*) over gravels	Absent or sparse low trees over short grasses and forbs, *Eragrostis eriopoda*, or *Aristida browniana*
4	Small		Calcareous earths (6*a*)	*A. georginae* over short grasses and forbs
5	Small		Red earths (4*d*, 4*e*)—sand fractions mainly fine-grained	*A. aneura* or *A. georginae* over short grasses and forbs or *Eragrostis eriopoda*
6	Very small		Texture-contrast soils with surface pavements	Absent or *A. georginae* over short grasses and forbs or *Bassia* spp.; *Kochia aphylla*
7	Small	Tributary valleys: up to 300 yd wide and lowered to 10 ft through units 3, 4, 5, and 6; flat floors, and concave marginal slopes	Fine-grained red clayey sands (3*d*), red earths (4*d*, 4*e*), and calcareous earths (6*a*)	Absent or *A. georginae* over short grasses and forbs or *Eragrostis eriopoda*
8	Small	Food-plains: surfaces up to ½ mile wide, with extensive scalding and shallow gullying		
9	Very small	Levees: up to 100 yd wide and 5 ft high; back slopes 0·25–1%	Fine-grained red clayey sands (3*d*)	Sparse low trees over short grasses and forbs or *Eragrostis eriopoda*
10	Very small	Tributary channels: up to 20 yd wide and incised up to 15 ft into calcreted sands and gravels	——	*E. camaldulensis–A. estrophiolata* over *Chloris acicularis, Themeda australis, Bothriochloa ewartiana–Eulalia fulva;* minor *E. microtheca* over *Muehlenbeckia cunninghamii*
11	Very small	Main channels: up to 100 yd wide and 10 ft deep; longitudinal gradients 1 in 500 to 1 in 1000	——	

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(71) SIMPSON LAND SYSTEM (37,800 SQ. MILES)

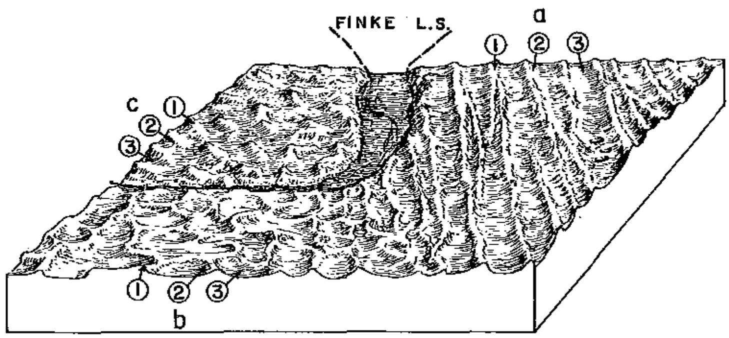
Spinifex-covered sand dunes (Plate 3, Fig. 2) mainly in the southern half of the area.

Geology.—Quaternary aeolian sand. Overlying Pre-Cambrian metamorphic and igneous rocks and sedimentary rocks of Proterozoic to Quaternary age.

Geomorphology.—Depositional surfaces: dune fields of three main types; (*a*) parallel linear dunes in the Simpson Desert and in the west of the area, up to 70 ft high, ¼–¾ mile apart, and orientated NNW.–SSE. or westerly, with flat, mainly sandy swales; (*b*) reticulate dunes up to 40 ft high, made up of braiding sand ridges or connected smaller dunes, and typical of the desert margins; (*c*) irregular or aligned short dunes.

Water Resources.—Ground-water prospects are extremely variable because of the wide variety of underlying rocks. Sub-artesian water is available from depths of 300 to 1000 ft in the Simpson Desert. Elsewhere variable supplies of good-quality to saline water are available at varying depths from alluvium, sandstone, limestone, and fractured metamorphic aquifers. There is little prospect of obtaining supplies of ground water on the Missionary Plain and to the north of Deep Well.

Climate.—Comparable climatic stations are Charlotte Waters, Henbury, Hermannsburg, Alice Springs, Tea Tree Well, and Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Small	Dune crests: hummocky surfaces locally unstable and eroding attaining up to 20 ft above unit 2; slopes generally above 25%, with small slip-faces exceeding 60% on eastern and northern sides	Red sands (3*f*)	*Zygochloa paradoxa* (desert cane grass)
2	Large	Dune flanks: smooth, stable slopes, up to 300 yd long and attaining 20% on the west and south, up to 150 yd long and attaining 35% on the east and north		Sparse shrubs and low trees, or minor *Casuarina decaisneana* (desert oak) over *Triodia basedowii* (spinifex), minor *Plectrachne schinzii* (spinifex), *Aristida browniana* (kerosene grass), or *Eragrostis eriopoda* (woollybutt)
3	Medium	Swales: flat or concave surfaces up to 400 yd wide; mainly sandy, with small clay pans, minor calcrete exposures, few drainage channels, and minor alluvial flats associated with through-going drainage	Mainly red clayey sands (3*d*), locally red earths (4*d*), texture-contrast soils (7*e*), calcareous earths (6*c*), and shallow sandy soils (3*b*) over soft calcareous and/or gypsiferous deposits ("kopi")	Mainly as unit 2. Minor variable including *A. aneura* (mulga), *E. microtheca* (coolibah), or sparse low trees over *Bassia* spp., *Arthrocnemum* spp. (samphire), or *Atriplex nummularia* (old-man saltbush)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(72) Ewaninga Land System (600 sq. miles)

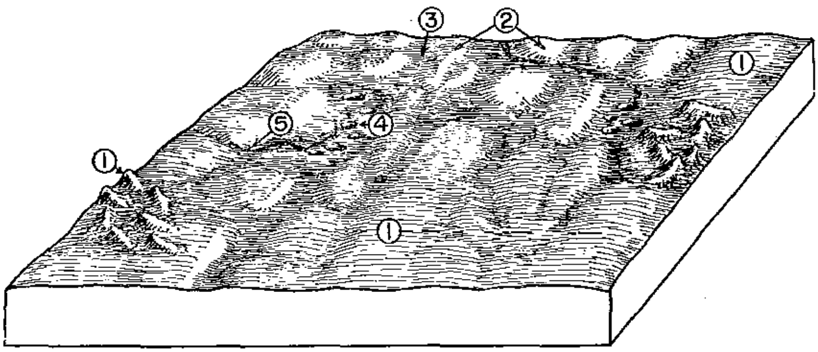
Undulating and sandy country with spinifex and mulga, on the southern margin of the MacDonnell Ranges.

Geology.—Quaternary aeolian sand and scattered outcrops of calcareous conglomerate and sandstone, upper Palaeozoic age, Amadeus trough (Pertnjara "series").

Geomorphology.—Depositional surfaces: undulating country with sand cover and low dunes and minor limestone hills; surface drainage largely disorganized; relief up to 30 ft.

Water Resources.—Little or no prospects of obtaining useful supplies of ground water. There are catchments suitable for surface storage.

Climate.—Comparable climatic stations are Henbury and Hermannsburg.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Dune-capped or sand-covered rises: up to 30 ft high, 300 yd wide, and elongated along the strike; irregular convex sandy crests; marginal slopes 2–5%	Red sands (3*f*)	*A. aneura* (mulga) or minor sparse shrubs and low trees over *Triodia basedowii* (spinifex)
2	Small	Stony hills and lower slopes: flat crests up to 20 ft high capped by calcreted gravels; marginal slopes up to 5%	Shallow, stony and sandy calcareous earths (including 6*a*)	Mainly absent, minor *A. kempeana* (witchetty bush) over short grasses and forbs
3	Small	Valley floors: flat, mainly unchannelled surfaces up to 200 yd wide and 1 mile long	Fine-grained red clayey sands (3*d*) and red earths (4*d*)	*A. aneura* (mulga) or minor sparse low trees, over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
4	Very small	Clay pans: dune-ringed, and up to 300 yd dia.; isolated, or in lines marking disorganized drainage	No records	*Muehlenbeckia cunninghamii* (lignum)
5	Very small	Channels: up to 50 yd wide and 5 ft deep (only near high ground or through-going drainage)	Sandy bed-loads	Sparse low trees over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(73) SINGLETON LAND SYSTEM (38,100 SQ. MILES)

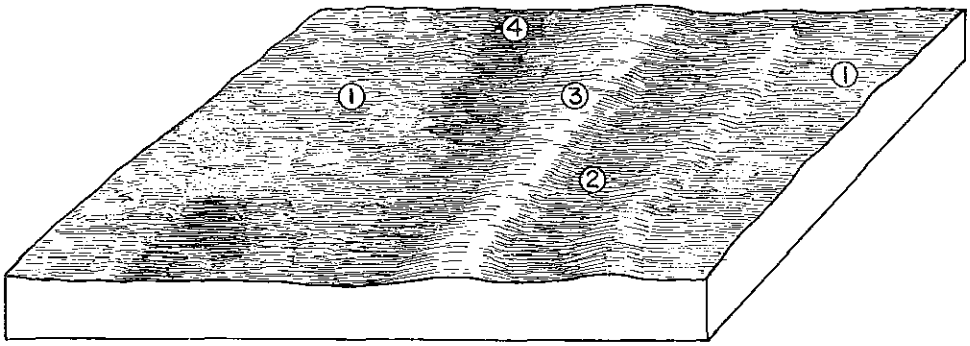
Spinifex sand plain (Plate 2, Figs. 1 and 2) mainly in the northern half of the area.

Geology.—Quaternary aeolian sand. Overlying Pre-Cambrian metamorphic and igneous rocks and sedimentary rocks of Proterozoic to Quaternary age.

Geomorphology.—Depositional surfaces: flat or gently undulating sand plain; surface drainage absent or disorganized.

Water Resources.—Ground-water prospects are extremely variable because of the wide range of underlying rocks. Variable supplies of good-quality to saline water available at varying depths from alluvium, sandstones, limestones. Prospects in metamorphic rocks are generally poor but isolated fractures may yield ground water.

Climate.—Comparable climatic stations are Charlotte Waters, Henbury, Hermannsburg, Alice Springs, Tea Tree Well, Barrow Creek, and Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Sand plain: hummocky surfaces fixed by vegetation	Red clayey sands (3*d*, minor 3*b*, 3*e*) and in the north-western part of the area, rather coarse-textured red earths (4*d*, 4*f*): the sands are mainly coarse-grained except in parts of the eastern side of the area	Sparse shrubs and low trees or minor *Casuarina decaisneana* (desert oak), over *Triodia basedowii* (spinifex), *Plectrachne schinzii* (spinifex), minor *Triodia pungens* (spinifex), or *Plectrachne pungens* (spinifex)
				Minor *A. aneura* (mulga) over short grasses and forbs, *Eragrostis eriopoda* (woollybutt), or *Aristida browniana* (kerosene grass)
2	Medium	Swales: flat floors up to 300 yd wide		As unit 1
3	Medium	Sand rises: up to 5 ft high, 600 yd wide and continuous for many miles following the prevalent southerly and easterly winds; flat or broadly rounded crests; marginal slopes may attain 2% on steeper north and east flanks; surfaces fixed by vegetation	Red sands (3*f*)	Sparse shrubs and low trees over *Triodia* or *Plectrachne* (spinifex), minor *Zygochloa paradoxa* (desert cane grass)
4	Small	Alluvial flats: linear drainage floors and plains up to 1 mile in extent	Red earths (4*d*)	*A. aneura* (mulga) or *E. microtheca* (coolibah) over short grasses and forbs, *Eragrostis eriopoda* (woollybutt), or *Aristida browniana* (kerosene grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(74) McDills Land System (200 sq. miles)

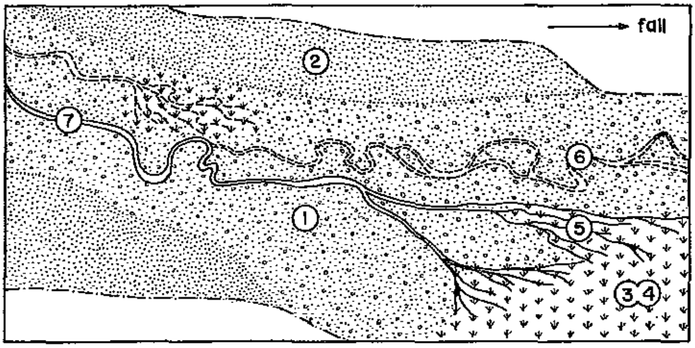
River plains and swamps in the far south of the area.

Geology.—Quaternary fine-textured alluvium. Overlying Mesozoic sediments.

Geomorphology.—Depositional surfaces: lower flood-plains up to 5 miles wide, with flood-out basins of moderate extent; longitudinal gradients less than 1 in 1000.

Water Resources.—Supplies of moderate-quality sub-artesian water are available from depths of 300 to 600 ft. Surface storage may be desirable for economic reasons.

Climate.—Nearest comparable climatic station is Charlotte Waters.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Active inner plains: scalded stony surfaces with minor clay pans, with some gullying near incised channels	Silty alluvial soils (e.g. 1*g* and possibly locally 1*f*)	Mainly absent, minor *A. georginae* (gidgee) over *Bassia* spp. or short grasses and forbs
2	Medium	Outer plains: scalded surfaces, with sand or gravel hummocks up to 2 ft high		Absent, *A. georginae* (gidgee), or *A. aneura* (mulga) over *Bassia* spp., short grasses and forbs, or *Atriplex vesicaria* (saltbush)
3	Medium	Alluvial basins: lateral basins up to ½ mile wide and terminal basins up to 3 miles in extent; up to 3 ft lower than unit 1 adjoining; gilgais are common in areas of more enclosed drainage; elsewhere, local drainage is by close, branching small creeks connecting with unit 7		*Kochia aphylla* (cotton-bush) or *Atriplex nummularia* (old-man saltbush), minor with *E. microtheca* (coolibah)
4	Small			*Chenopodium auricomum* (southern bluebush)
5	Small	Flood-out zones: up to ½ mile wide, with numerous discontinuous channels up to 10 yd wide, 3 ft deep, and ½ mile long, separated by low sandy banks	Various coarse-textured and silty alluvial soils, locally texture-contrast soils (7*g*) with gilgais (8*a*)	*A. aneura* (mulga) over *Bassia* spp.
6	Very small	Distributary channels: up to 50 yd wide and 5 ft deep; meandering, with numerous cut-offs	——	Absent or *A. georginae* (gidgee) with *Kochia aphylla* (cotton-bush)
7	Very small	Main channels: up to 50 yd wide and 20 ft deep, with steep banks; winding and locally anastomosing, with alternate deep and shallow sectors	——	*E. microtheca* over short grasses and forbs

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(75) FINKE LAND SYSTEM (700 SQ. MILES)

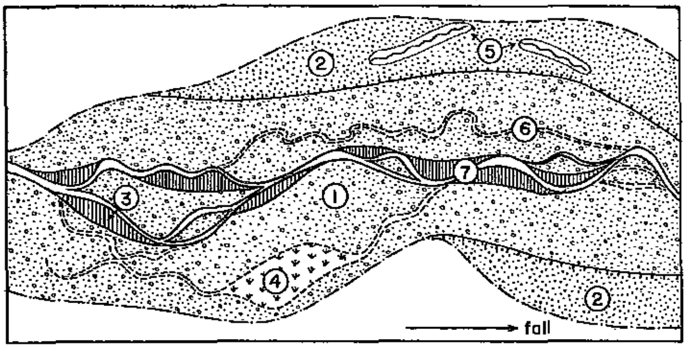
Sandy river plains (Plate 4, Fig. 2) in the south of the area.

Geology.—Quaternary coarse-textured alluvium.

Geomorphology.—Depositional surfaces: upper and middle flood-plains, typically up to 2 miles wide; longitudinal gradients 1 in 500 to 1 in 1000.

Water Resources.—Supplies of soakage water are available at shallow depths from the river alluvium. Seasonal fluctuations in supply and salinity are expected. Supplies of sub-artesian water are expected at depths from 300 to 1000 ft to the south-east of Finke.

Climate.—Comparable climatic stations are Charlótte Waters, Henbury, and Hermannsburg.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Active inner plains: scalded surfaces, with small clay pans, much stone, and some gullying near drainage channels	Texture-contrast soils (*7e*), topsoils are frequently unstable with scalds and wind-piling of sand; and as unit 2	*Bassia* spp., *Kochia aphylla* (cottonbush), bare ground, or as unit 2
2	Medium	Outer plains: hummocky surfaces with some wind resorting, separated by low banks from unit 1	Coarse-textured soils including alluvial soils (*1a*, *1h*) and calcareous earths (*6d*)	Sparse low trees or minor *E. papuana* (ghost gum), over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
3	Very small	Levees: single or multiple banks in discontinuous zones up to ½ mile wide flanking unit 7; up to 5 ft high, back slopes 0·25–1%		
4	Very small	Alluvial basins: flat alluvial surfaces up to 1 mile wide, typically elongate down valley, and up to 2 ft below unit 1; minor gilgais	Alluvial brown medium and fine-textured soils (*1e*, *1f*)	*E. microtheca* (coolibah) over short grasses and forbs or *Atriplex nummularia* (old-man saltbush)
5	Very small	Dunes: up to 15 ft high, typically elongate down valley; rounded crests, and marginal slopes up to 10%; fixed by vegetation	Reddish sands (*3f*)	Sparse shrubs and low trees over *Zygochloa paradoxa* (cane grass) or minor *Triodia basedowii* (spinifex)
6	Very small	Distributary flood channels: rounded cross sections up to 30 yd wide and 5 ft deep	Alluvial silty soils (*1e*)	*E. microtheca* (coolibah) or *E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass) or minor *Zygochloa paradoxa* (cane grass)
7	Small	Main channels: up to 200 yd wide and 20 ft deep, with steep banks, commonly eroded in calcreted sands and gravels; typically anastomosing to enclose islands of coarse sands and gravels	Bed-loads of coarse sand and grit, with minor gravel banks	

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(76) McGrath Land System (300 sq. miles)

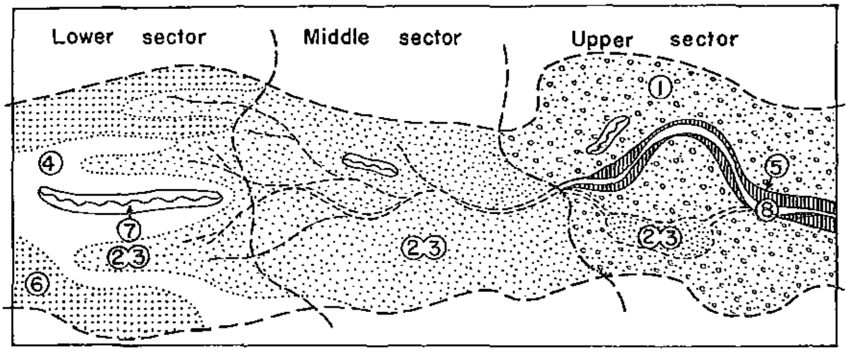
River plains, mainly in the central part of the area.

Geology.—Quaternary alluvium.

Geomorphology.—Depositional surfaces: flood-plains up to $1\frac{1}{2}$ miles wide, with restricted channel drainage; longitudinal gradients less than 1 in 500.

Water Resources.—Supplies of moderate-quality ground water are available at shallow to moderate depths from sands and gravels where these lie below the water-table. Where metamorphic rocks occur above the water-table, prospects are poor. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Stable plains in upper sectors: scalded, stony surfaces up to 1 mile wide	Finer-textured soils including red earths (e.g. 4*e*) and texture-contrast soils (7*g*); locally, red coarse-structured clay soils (8*a*), and alluvial soils (e.g. 1*d*)	Absent, sparse low trees, minor *A. georginae* (gidgee), or *E. microtheca* (coolibah) over short grasses and forbs
2	Large	Active alluvial plains: restricted to small basins in upper sectors, attaining $\frac{1}{2}$ mile wide and 2 miles long in middle sectors, narrowing and branching in lower sectors; moderately scalded surfaces, less than 2 ft below unit 1, with closely-spaced, branching distributary channels up to 20 yd wide and 1 ft deep		
3	Small			Mainly treeless with *Astrebla pectinata* (Mitchell grass), *Eragrostis xerophila* (neverfail), minor *Kochia aphylla* (cotton-bush), *Bassia* spp., or short grasses and forbs. Locally *E. microtheca* (coolibah) over *Eragrostis xerophila* (neverfail)
4	Small	Drainage zones marginal to units 2 and 3 in lower sectors: up to 300 yd wide		Similar to units 1 and 2, also minor *A. aneura* (mulga) and minor *Chloris acicularis* (curly windmill grass)
5	Very small	Levees: up to 50 yd wide and 2 ft high, with back slopes less than 2%	No records, but probably alluvial soils (1*i*)	As units 1 and 2
6	Small	Stable plains in lower sectors	Red earths (4*e*)	*A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
7	Small	Sand banks: wind-modified alluvial trains, up to 5 ft high, 400 yd wide, and continuous up to 2 miles down valley; gently rounded forms, with sand surfaces fixed by vegetation	Red clayey sands (3*d*) or red earths (4*d*)	Sparse low trees or *A. kempeana* (witchetty bush) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
8	Very small	Channels: up to 200 yd wide and 5 ft deep; narrowing, anastomosing, and terminating in distributaries down channel	Bed-loads of sand and coarse grit	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass) or *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(77) Ammaroo Land System (500 sq. miles)

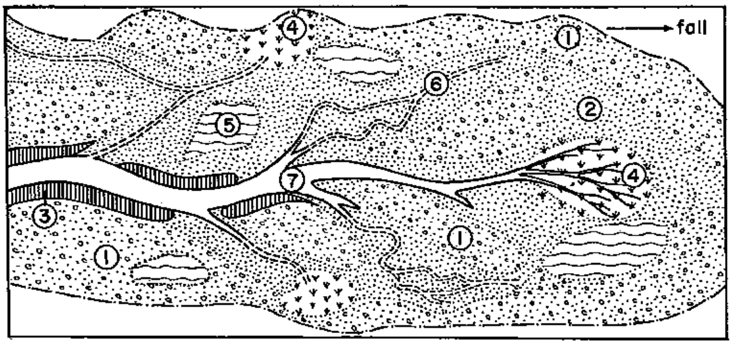
River plains and swamps in the north-east of the area.

Geology.—Quaternary fine-textured alluvium.

Geomorphology.—Depositional surfaces: lower flood-plains and flood-out basins up to 8 miles wide; longitudinal gradients less than 1 in 500.

Water Resources.—To the south and west of the Davenport Range supplies of variable-quality ground water are available at relatively shallow depths with some prospects for irrigation. To the north and east the alluvium lies above the water-table but supplies of good to moderate-quality ground water may be available at depths of 200 to 800 ft from Cambrian limestones where these lie below the water-table. There are catchments suitable for surface storage.

Climate.—Comparable climatic stations are Barrow Creek, Urandangie, and Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Stable outer plains: hummocky, scalded surfaces, also forming islands up to $\frac{3}{4}$ mile in extent in unit 2	Mainly red earths (4*e*), and minor yellow earths (5*a*)	Absent, sparse low trees, or minor *A. aneura* (mulga) over short grasses and forbs
2	Medium	Active inner plains or flood floors in complex with unit 4: scalded, stony surfaces with small clay pans; regressive gullying near large channels		
3	Very small	Levees: up to 100 yd wide and 5 ft high; scalded back slopes, 0·25–2%	Alluvial soils (e.g. 1*i*)	
4	Small	Alluvial basins: up to $\frac{1}{2}$ mile wide and extending up to 2 miles down valley; flat floors with minor gilgais, locally drained by a close network of very small channels	Alluvial brown coarse-structured clay soils (1*f*)	*Astrebla pectinata* (Mitchell grass), *A. lappacea* (Mitchell grass), or minor *Chenopodium auricomum* (bluebush)
5	Small	Sand banks: up to $\frac{1}{2}$ mile wide and elongate down valley; flat crests up to 5 ft high; surfaces fixed by vegetation	Red clayey sands (3*d*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
6	Very small	Distributary channels: up to 200 yd wide and 5 ft deep, with flat floors and steep concave margins; winding, discontinuous courses	Alluvial soils (e.g. 1*d*)	*E. camaldulensis* (red gum)– *A. estrophiolata* (ironwood) or *E. microtheca* (coolibah) over *Chloris acicularis* (curly windmill grass), *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop), *Themeda avenacea* (native oat grass), or *Chrysopogon fallax* (golden-beard grass)
7	Very small	Main channels: up to 50 yd wide and 20 ft deep, narrowing down valley; alternate deep and shallow sectors	——	

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(78) Sandover Land System (1700 sq. miles)

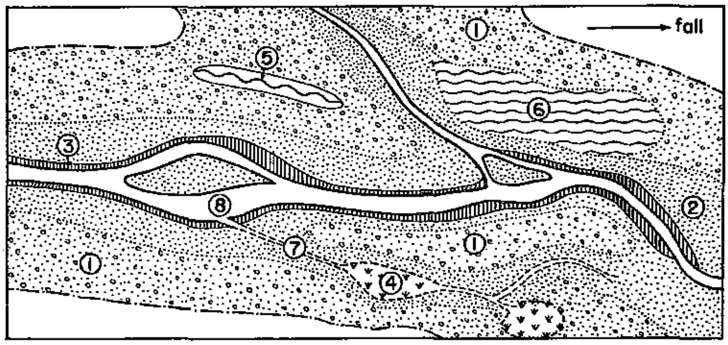
Sandy river plains (Plate 4, Figs. 1 and 2) in the northern half of the area.

Geology.—Quaternary coarse-textured alluvium.

Geomorphology.—Depositional surfaces: upper and middle flood-plains, up to 3 miles wide; longitudinal gradients 1 in 500 to 1 in 1000.

Water Resources.—Ground-water prospects are variable. Supplies of soakage water are available at shallow depths along some major watercourses. Some areas on Woodforde, Hanson, and Lander Rivers have prospects for irrigation. Elsewhere, dependent on local geological conditions, aquifers may be found at varying depths in the underlying rocks. There are some areas suitable for surface catchment.

Climate.—Comparable climatic stations are Alice Springs, Tea Tree Well, Barrow Creek, and Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Outer plains: up to 2 miles wide, with low sand and gravel rises, scalds, and clay pans; little surface drainage	A range of mainly coarse-textured soils including alluvial soils (1*h*), red earths (typically 4*d*, also 4*b* on the Sandover River catchment), and texture-contrast soils (7*e*) on north side of the Reynolds Range	Sparse low trees, minor *A. aneura* (mulga), *A. kempeana* (witchetty bush), *A. georginae* (gidgee), *E. microtheca* (coolibah), or *E. papuana* (ghost gum) over short grasses and forbs, minor *Eragrostis eriopoda* (woollybutt), *Triodia pungens* (spinifex), *Zygochloa paradoxa* (sandhill cane grass), or bare ground
2	Medium	Active inner plains: up to 1 mile wide; scalds, clay pans and stony surfaces near inner margins, which are gullied locally		
3	Small	Levees: up to 100 yd wide and 5 ft high; back slopes, 0·4–2%, severely scalded in lower parts	Alluvial brown sands (1*a*) and reddish clayey sands (1*h*)	
4	Very small	Alluvial basins: up to ½ mile in extent, in lower parts of land system, on former drainage lines or outer margins	Various soils over a wide textural range including alluvial soils (1*c*, 1*h*), coarse-structured clay soils, and very locally greyish, medium to fine-textured soils with gley features (periodically waterlogged soils)	*E. microtheca* over short grasses and forbs, *Eragrostis xerophila*, *E. eriopoda*, *Chrysopogon fallax*, *Themeda avenacea*, *Muehlenbeckia cunninghamii*, or bare ground; minor absent with *Eragrostis xerophila* or *Chenopodium auricomum*
5	Very small	Sand dunes: up to 10 ft high; stable rounded crests and slopes up to 10%	Red sands (3*f*)	Sparse shrubs and low trees over *Triodia basedowii*, *T. pungens*, or *Plectrachne schinzii*
6	Small	Flat-crested sand banks: up to 5 ft high and ½ mile in extent	Pale-coloured, coarse sands	Absent or sparse low trees over short grasses and forbs, minor *Eragrostis eriopoda*, *Aristida browniana*, or *Zygochloa paradoxa*
7	Very small	Distributary flood channels: up to 200 yd wide and 5 ft deep; steep banks and flat floors	Alluvial soils (including 1*c*)	*E. microtheca*, minor absent, *E. papuana*, or *A. aneura* over short grasses and forbs, *Chloris acicularis*, or minor *Muehlenbeckia cunninghamii*
8	Small	Major channels: up to 300 yd wide, incised to 5 ft into alluvium or calcreted gravels; longitudinal gradients 1 in 500 to 1 in 750	Bed-loads of sand to grit, up to small boulders locally	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass) or minor *Zygochloa paradoxa* (sandhill cane grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(79) Amulda Land System (100 sq. miles)

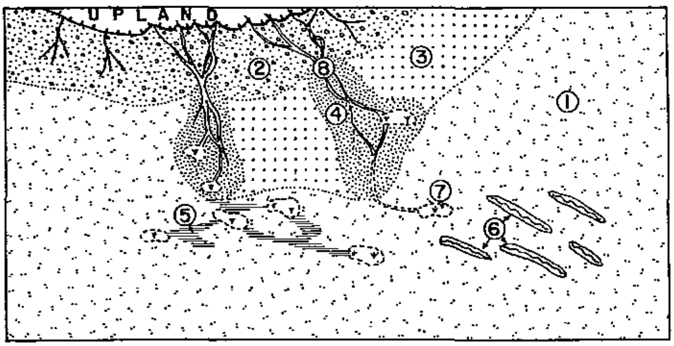
Spinifex-covered sandy plains adjacent to ranges through the centre of the area.

Geology.—Quaternary wash derived from sandstone.

Geomorphology.—Depositional surfaces: alluvial fans up to 5 miles long; upper sectors with braiding and distributary drainage; middle sectors with active alluvial zones and intervening more stable areas; lower sectors with sand plain and dunes; gradients above 1 in 250.

Water Resources.—Supplies of good to moderate-quality water are available at moderate to large depths from sandstones underlying the shallow alluvium. There are catchments suitable for surface storage.

Climate.—Comparable climatic stations are Hermannsburg and Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Sand plain	Red clayey sands (3*d*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex) or *T. pungens* (spinifex)
2	Small	Upper fans: up to 1 mile long, gradients more than 1 in 150; more than 25% occupied by braiding or distributary channels up to 20 yd wide and 2 ft deep	Coarse-textured soils including red clayey sands (3*d*) and alluvial reddish clayey sands (1*h*)	Similar to unit 1 but also minor sparse low trees over short grasses and forbs
3	Small	Inter-drainage sectors: up to 1 mile long, gradients 1 in 150 to 1 in 250; little channel drainage		
4	Small	Active alluvial lobes: extensively scalded surfaces up to ½ mile wide adjacent to unit 8		Short grasses and forbs
5	Very small	Drainage floors in unit 1: up to 300 yd wide		Sparse low trees or minor *A. aneura*, over short grasses and forbs
6	Very small	Dunes: isolated, or parallel short dunes, with rounded crests up to 15 ft high, and 10–20% slopes; surfaces fixed by vegetation	Red sands (3*f*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
7	Very small	Pans	No records	Bare
8	Very small	Channels: up to 100 yd wide and 5 ft deep; winding, locally braiding courses with low sand banks; typically flooding out in unit 4, but locally persisting to connect with strike drainage	Bed-loads mainly coarse sand	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass) or *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(80) KANANDRA LAND SYSTEM (1300 SQ. MILES)

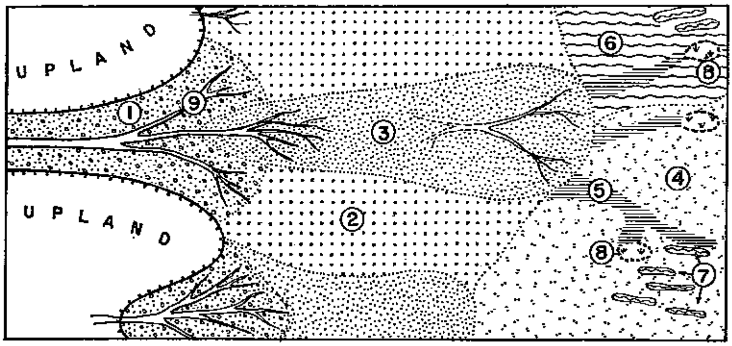
Sparsely timbered, sandy plains, mainly on the north edge of the Harts Range.

Geology.—Quaternary wash derived from metamorphic and igneous rocks. Overlying minor basins and piedmonts and Pre-Cambrian metamorphic rocks.

Geomorphology.—Depositional surfaces: alluvial fans up to 2 miles long; upper sectors with closely spaced distributary drainage; middle sectors with alternating active and more stable zones; lower sectors, mainly alluvial plains, with minor sand plain, dunes, and terminal flood-outs; gradients 1 in 150 to 1 in 350.

Water Resources.—Large supplies of good to moderate-quality water are available from suitably developed sands and gravels lying below the water-table, at depths from 100 to 500 ft. Where metamorphic rocks occur above the water-table ground water may be saline and supplies small. There are catchments suitable for surface storage.

Climate.—Comparable climatic stations are Alice Springs and Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Small	Upper fans: up to 1 mile long, gradients above 1 in 150; more than 25% occupied by distributary channels up to 30 yd wide and 1 ft deep	Coarse-textured alluvial soils (*1a*, *1h*); no records for unit 3 but texture-contrast soils (*7e*) could occur on such situations	Sparse low trees over *Aristida browniana* (kerosene grass), minor *Eragrostis eriopoda* (woollybutt), or short grasses and forbs
2	Medium	Inter-drainage sectors: 1–3 miles long, gradients 1 in 150 to 1 in 250; hummocky surfaces, with scalding, small clay pans, and shallow gullies		
3	Medium	Active alluvial lobes down slope from main flood-outs: up to 1½ miles long and ½ mile wide		
4	Medium	Lower alluvial plains: up to 5 miles in extent, gradients less than 1 in 250; little surface drainage	Gradual transitions from the soils of units 1 and 2 to red clayey sands (*3d*) and red earths (*4d*)	Similar to units 1, 2, and 3, also *A. aneura* (mulga), minor *A. kempeana* (witchetty bush) and *Bassia* spp.
5	Small	Drainage floors: shallow, flat-floor depressions up to 300 yd wide in units 4 and 6	Red clayey sands (*3d*)	As units 1, 2, and 3
6	Small	Sand plain: flat, or locally undulating, with up to 10 ft relief		Sparse shrubs and low trees over *Aristida browniana* (kerosene grass) or *Triodia basedowii* (spinifex)
7	Very small	Dunes: up to 10 ft high, generally elongate down slope; surfaces fixed by vegetation	Red sands (*3f*)	Sparse shrubs and low trees over *Zygochloa paradoxa* (cane grass)
8	Very small	Alluvial basins: drainage terminals up to ¼ mile in extent	No records	Short grasses and forbs, *Bassia* spp., *Eragrostis xerophila* (neverfail), *Kochia aphylla* (cotton-bush), or *Muehlenbeckia cunninghamii* (lignum)
9	Very small	Channels: up to 100 yd wide and 5 ft deep; commonly anastomosing, with low flood banks	Bed-loads mainly coarse sand	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(81) TODD LAND SYSTEM (300 SQ. MILES)

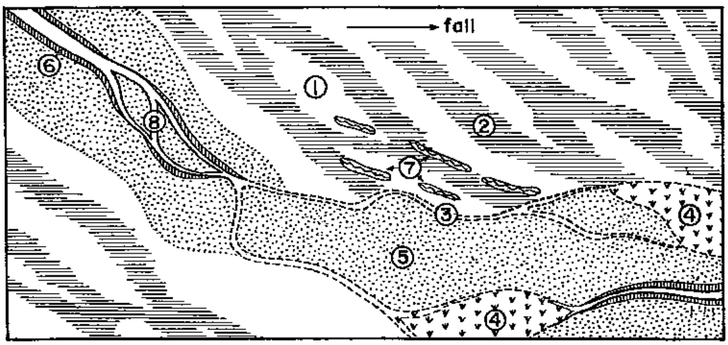
Sparsely timbered plains and flood-outs of the Todd River (Plate 5, Fig. 1) on the south side of the MacDonnell Ranges.

Geology.—Quaternary wash derived mainly from igneous and metamorphic rocks. Overlying minor basins and piedmonts.

Geomorphology.—Depositional surfaces: coalescent flood-plains of the Todd River and its tributaries; gradient of main channel about 1 in 750, tributary gradients above 1 in 350.

Water Resources.—Ground-water prospects are generally good. Large supplies of good to moderate-quality water are available from suitably developed sand and gravel aquifers at depths from 30 to 500 ft.

Climate.—Nearest comparable climatic station is Alice Springs.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Outer plains: inter-drainage sectors up to ½ mile wide; flat, or gently undulating surfaces originating as parallel or interlacing flood-banks in tracts up to 5 miles wide	Rather coarse-textured alluvial soils (*1a*, *1b*, *1h*, *1i*) and red clayey sands (*3d*)	Sparse low trees or *A. kempeana* (witchetty bush) over short grasses and forbs or minor *Eragrostis eriopoda* (woollybutt)
2	Medium	Drainage depressions through unit 1: up to 400 yd wide and 5 ft deep; flat central tracts with scalded, stony surfaces; gentle, concave marginal slopes	Medium-textured alluvial soils (*1d*, ?, *1c*)	Sparse low trees or minor *A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
3	Very small	Distributary channels: flat floors up to 200 yd wide and incised up to 5 ft in unit 5		Sparse low trees over short grasses and forbs or *Chloris acicularis* (curly windmill grass)
4	Small	Alluvial basins: up to 1 mile in extent		*Kochia aphylla* (cotton-bush), some areas with *E. microtheca* (coolibah)
5	Medium	Inner plains: extensively scalded, flat surfaces up to 1 mile wide	Coarse to medium-textured alluvial soils as for the above units	Sparse low trees or minor *A. georginae* (gidgee) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
6	Very small	Levees: up to 100 yd wide and 5 ft high; back slopes 0·25–0·5%	Coarse-textured alluvial soils (*1a*)	Sparse low trees over short grasses and forbs or *Chloris acicularis* (curly windmill grass)
7	Very small	Dunes: up to 10 ft high, with rounded crests, and 10–20% marginal slopes; surfaces fixed by vegetation	Red sands (*3f*)	Sparse shrubs and low trees over *Aristida browniana* (kerosene grass) or *Eragrostis eriopoda* (woollybutt)
8	Very small	Main channels: up to 250 yd wide and 5 ft deep: commonly anastomosing, with low flood banks	Bed-loads mainly of sand and grit, with gravel banks	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) or *E. microtheca* (coolibah) over *Chloris acicularis* (curly windmill grass), *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop), or *Aristida browniana* (kerosene grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(82) Woodduck Land System (600 sq. miles)

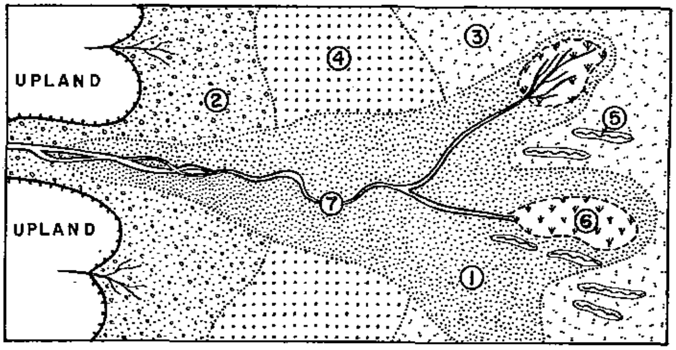
Sandy plains adjacent to uplands in the northern part of the area.

Geology.—Quaternary wash derived mainly from sandstone.

Geomorphology.—Depositional surfaces: alluvial fans up to 2 miles long, locally coalescing to form intermont plains; upper sectors with slightly incised distributary drainage; middle sectors with alternating active and more stable zones; lower sectors with sand plain, dunes, and terminal basins; gradients 1 in 100 to 1 in 250.

Water Resources.—Supplies of ground water depend on the geology of the rocks underlying the shallow alluvium. There are catchments suitable for surface storage.

Climate.—Comparable climatic stations are Urandangie, Tea Tree Well, Barrow Creek, and Tennant Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Active alluvial lobes flanking larger drainage channels: scalded surfaces up to 1 mile wide, with small clay pans and shallow gullying	Coarse-textured soils—including red clayey sands (3*d*) and alluvial soils (1*h*)	Sparse low trees over short grasses and forbs, minor *Aristida browniana* (kerosene grass), or *Eragrostis eriopoda* (woollybutt)
2	Medium	Upper fans: up to ¾ mile long, gradients above 1 in 150		Sparse shrubs and low trees or minor *E. microtheca* (coolibah) over *Triodia pungens* (spinifex) or *T. basedowii* (spinifex) or *Plectrachne schinzii* (spinifex)
3	Medium	Sand plain		
4	Small	Inter-drainage sectors: up to ¾ mile long, gradients less than 1 in 150; no channel drainage		*A. aneura* (mulga) over short grasses and forbs
5	Very small	Dunes: up to 15 ft high and extending up to ½ mile down slope; surfaces fixed by vegetation	Red sands (3*f*)	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
6	Very small	Alluvial basins: up to ½ mile in extent	Yellow clayey sands (5*b*) and coarse-textured yellow earths (5*a*)	*E. microtheca* (coolibah) over *Chrysopogon fallax* (golden-beard grass) or *Themeda avenacea* (oat grass)
7	Very small	Channels: up to 150 yd wide and 5 ft deep; braiding, with low flood banks in upper sectors, narrowing down slope; only the larger channels persist through unit 1, where they split into shallow distributaries feeding unit 6	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass), *Themeda avenacea* (native oat grass), or *Bothriochloa ewartiana* (desert blue grass)–*Eulalia fulva* (silky browntop)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(83) Adnera Land System (100 sq. miles)

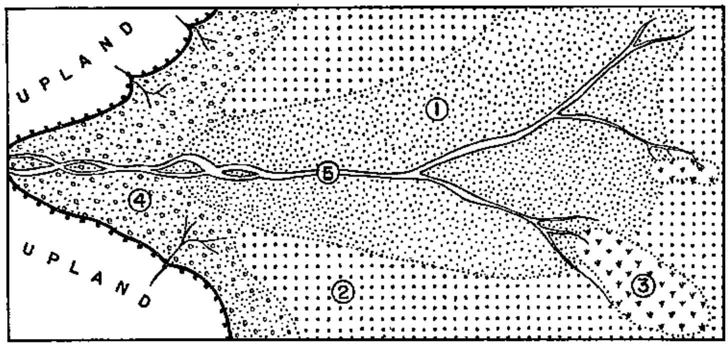
Small plains with mulga, adjacent to uplands in the north-east of the area.

Geology.—Quaternary wash derived mainly from sedimentary rocks.

Geomorphology.—Depositional surfaces: alluvial fans up to 5 miles long; upper sectors in valley re-entrants, with short feeder drainage and braiding main channels; middle and lower sectors with extensive stable plains and active alluvial lobes and basins; gradients 1 in 50 to 1 in 350.

Water Resources.—Ground-water prospects variable. Supplies of good to moderate-quality water may be available from shallow alluvium or underlying sandstones where these are present. There are catchments suitable for surface storage.

Climate.—Nearest comparable climatic station is Barrow Creek.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Active alluvial lobes: up to 4 miles long, and widening down slope to 1 mile; scalded surfaces with minor clay pans; gradients less than 1 in 150	Red earths (4*e*), and transitions to yellow earths (5*a*)	Sparse low trees or minor *A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
2	Large	Stable inter-drainage sectors down slope from unit 1: up to 2 miles wide, gradients 1 in 150 to 1 in 350		*A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
3	Small	Alluvial basins: generally elongate and up to ½ mile wide	Soils with features indicating some periodic, prolonged saturation, e.g. a texture-contrast soil (7*h*)	*E. microtheca* (coolibah) or *E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Bassia* spp., short grasses and forbs, *Chrysopogon fallax* (goldenbeard grass), or *Themeda avenacea* (native oat grass)
4	Medium	Upper fans and aprons: up to ½ mile long, gradients above 1 in 150	No records, possibly sandy and/or stony soils	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
5	Very small	Channels: up to 50 yd wide and 2 ft deep; main channels are typically braiding in upper sectors, narrowing and distributing down slope	———	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) or *E. microtheca* (coolibah) over *Chloris acicularis* (curly windmill grass), *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop), or *Muehlenbeckia cunninghamii* (lignum)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(84) Deering Land System (100 sq. miles)

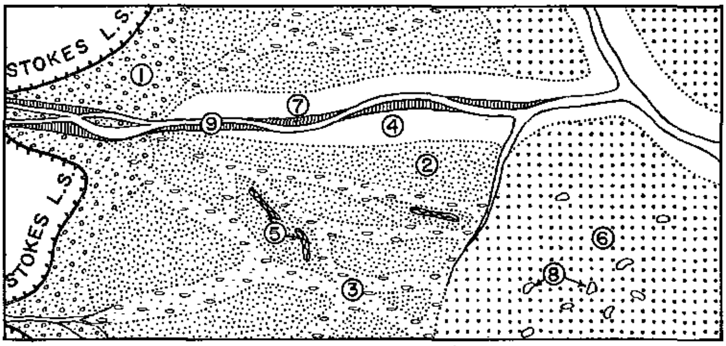
Open plains in the western MacDonnell Ranges.

Geology.—Quaternary wash.

Geomorphology.—Depositional surfaces: alluvial fans up to 6 miles long; upper sectors with little channel drainage; middle sectors with stable plains traversed by active flood-plains; lower sectors mostly sand plain; gradients 1 in 150 to 1 in 350.

Water Resources.—Ground-water prospects variable. Supplies of stock water may be obtained from shallow alluvial aquifers. Surface catchment may be necessary.

Climate.—Nearest comparable climatic station is Hermannsburg.



Unit	Area	Land Form	Soil*	Plant Community
1	Small	Upper fans: up to ½ mile long, gradients above 1 in 150	Mainly severely scalded texture-contrast soils (*7e*), very locally, red clayey sands (*3d*)	Bare and scalded, *Bassia* spp., minor *Kochia aphylla* (cotton-bush), *Atriplex vesicaria* (saltbush), *Astrebla pectinata* (Mitchell grass), or *Eragrostis xerophila* (neverfail), some areas with *Eremophila* spp.–*Hakea leucoptera*
2	Medium	Inter-drainage sectors: up to 3 miles long, gradients 1 in 150 to 1 in 250; split into tracts up to ½ mile wide by unit 3		
3	Medium	Distributary drainage tracts: scalded tracts up to 500 yd wide through unit 2		
4	Small	Active flood-plains: up to 500 yd wide flanking main channels		
5	Very small	Sand banks: wind-modified alluvial trains up to 10 ft high, 100 yd wide, and extending up to 1 mile down slope	Texture-contrast soils as for units 1 to 4 but less scalded and with deep (e.g. >2 ft depth) subsoil pans on low rises	Sparse low trees or *Acacia aneura* (mulga) over *Bassia* spp.
6	Medium	Sand plain: hummocky surfaces with up to 5 ft relief		
7	Very small	Levees: single or multiple banks in zones up to 200 yd wide bordering unit 9	Coarse-textured alluvial soils (*1a*, *1h*)	Sparse low trees over short grasses and forbs
8	Very small	Pans: up to 200 yd in extent in units 3 and 6	No records	Bare ground
9	Very small	Channels: up to 50 yd wide, generally shallow, braiding locally	——	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(85) Hamilton Land System (400 sq. miles)

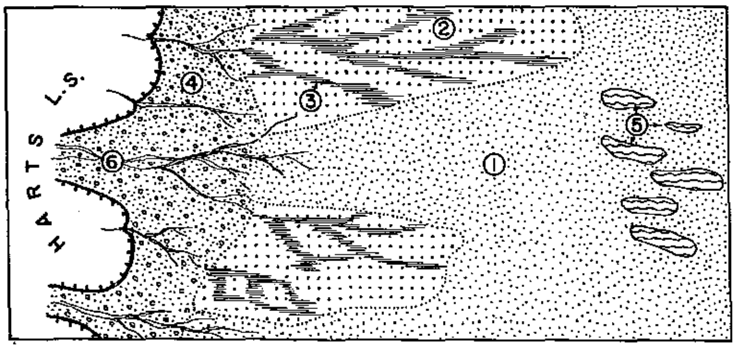
Plains, treeless or with mulga, on the north flank of the MacDonnell Ranges.

Geology.—Quaternary wash derived from igneous and metamorphic rocks.

Geomorphology.—Depositional surfaces: alluvial fans up to 6 miles long; upper sectors with short distributary drainage; middle sectors with alternating active and more stable zones; lower sectors with extensive active alluvial plains; gradients 1 in 500 to 1 in 1000.

Water Resources.—Ground-water prospects generally good. Sands and gravels yield supplies of good to moderate-quality water where they lie below the water-table.

Climate.—Comparable climatic stations are Alice Springs and Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Active alluvial lobes and plains: tracts up to ½ mile wide below larger drainage flood-outs, broadening down slope into extensive alluvial plains; scalded stony surfaces, clay pans, shallow gullying, and minor gilgais in lower parts	Mainly texture-contrast soils (7*e*, 7*g*), locally replaced by or in a complex with red coarse-structured clay soils (8*a*)	Short grasses and forbs, minor *Bassia* spp., *Eragrostis xerophila* (neverfail), *Chenopodium auricomum* (bluebush), or *Kochia aphylla* (cotton-bush); small areas with *A. aneura* (mulga)
2	Medium	Stable inter-drainage sectors: 1–3 miles long, gradients less than 1 in 150; hummocky, scalded surfaces traversed by unit 3	Red earths (4*e*)	*A. aneura* (mulga) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
3	Very small	Distributary drainage tracts: ill-defined flat drainage floors up to 300 yd wide and lowered to 2 ft in unit 2		*A. aneura* (mulga) over short grasses and forbs, *Eragrostis eriopoda* (woollybutt), or minor *Chloris acicularis* (curly windmill grass)
4	Small	Upper fans: 1 mile long, gradients 1 in 150; up to 25% occupied by shallow distributary channels	No records; probably mainly coarse-textured alluvial soils	Sparse low trees or minor *A. kempeana* (witchetty bush) over short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
5	Very small	Sand banks: up to 5 ft high and 100 yd wide, commonly near the lower margins of the land system	No records, possibly texture-contrast soils with deep sandy topsoils	Short grasses and forbs or *Eragrostis eriopoda* (woollybutt)
6	Very small	Channels: up to 50 yd wide and 2 ft deep	Bed-loads mainly sand and grit	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood) over *Chloris acicularis* (curly windmill grass)

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(86) UTOPIA LAND SYSTEM (<50 SQ. MILES)

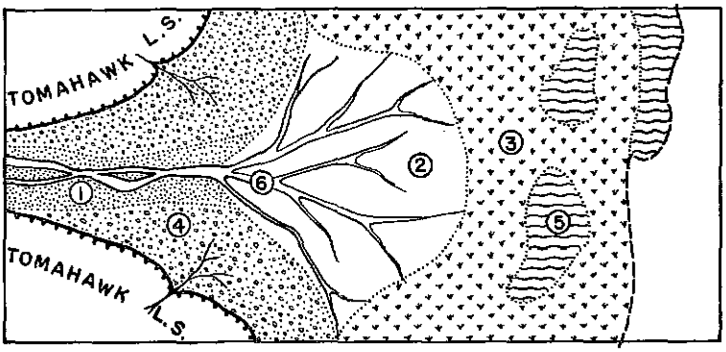
Plains with bluebush swamps (Plate 5, Fig. 2) in the north-east of the area, near Utopia homestead.

Geology.—Quaternary alluvium.

Geomorphology.—Depositional surfaces: alluvial fans up to 4 miles long; upper sectors with short feeder channels and braiding larger channels with flanking flood-plains and terminal delta fans; lower sectors with alluvial basins and flanking sand banks; gradients 1 in 50 to 1 in 350.

Water Resources.—Supplies of moderate-quality ground water are available from alluvial, kunkar, and sandstone aquifers to supplement natural surface storage.

Climate.—Nearest comparable climatic station is Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Small	Flood-plains: up to 200 yd wide	No records	Sparse low trees over short grasses and forbs
2	Small	Delta fans: stony surfaces up to ½ mile long, with closely spaced small drainage channels extending in linear gilgais; gradients 1 in 250 to 1 in 350	Greyish coarse-structured clay soils (8*b*)	*Chenopodium auricomum* (bluebush)
3	Medium	Alluvial basins: up to 1 mile in extent; flat floors, and concave marginal slopes up to 300 yd long and attaining 1%		
4	Medium	Alluvial fans: up to ½ mile long, gradients above 1 in 150	No records, but probably sandy and/or stony soils	Sparse shrubs and low trees over *Triodia basedowii* (spinifex)
5	Small	Sand banks: up to 500 yd in extent, with flat crests up to 5 ft high; surfaces fixed by vegetation; forming islands in, or bounding, unit 3	Sands (colour not known)	*E. camaldulensis* (red gum)–*A. estrophiolata* (ironwood), or minor *E. microtheca* (coolibah) over *Chloris acicularis* (curly windmill grass), *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop), or minor *Muehlenbeckia cunninghamii* (lignum)
6	Very small	Channels: up to 50 yd wide and 2 ft deep, braiding in uppermost sectors, breaking into distributaries down slope		

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(87) Undippa Land System (100 sq. miles)

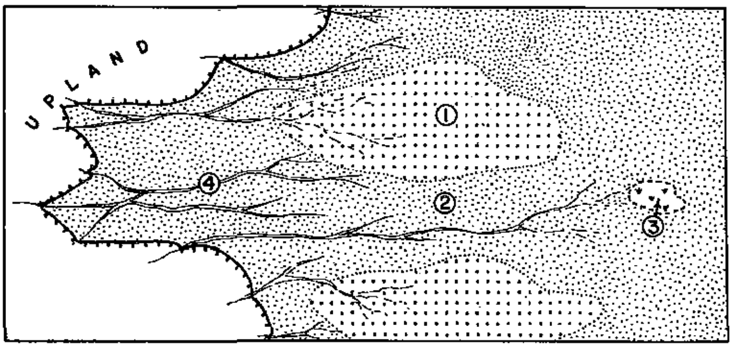
Mitchell grass plains (Plate 9, Fig. 1) mainly on the north flank of the MacDonnell Ranges.

Geology.—Quaternary wash derived from igneous and metamorphic rocks.

Geomorphology.—Depositional surfaces: lobate alluvial fans up to 4 miles long; gradients about 1 in 250.

Water Resources.—Large supplies of good to moderate-quality ground water are available from alluvial aquifers at depths from 100 to 300 ft near Mt. Hay. At Undippa moderate-quality water may be available from underlying weathered metamorphic rocks.

Climate.—Comparable climatic stations are Alice Springs and Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Medium	Stable inter-drainage sectors: up to 1½ miles long; upper parts seamed with small distributary channels, lower parts unchannelled, but extensively scalded	Red coarse-structured clay soils (8*a*)	*Astrebla pectinata* (Mitchell grass) or *Eragrostis xerophila* (neverfail)
2	Large	Active alluvial plains: up to 3 miles long, narrowing up slope into individual fans between unit 1; prominent gilgais in lowest parts; little channel drainage, but shallow gullying locally		
3	Very small	Alluvial basins: up to ½ mile in extent	Red and brown coarse-structured clay soils	*Chenopodium auricomum* (bluebush)
4	Very small	Channels: up to 25 yd wide and 5 ft deep, generally anastomosing in uppermost sectors, breaking into distributaries down slope	——	Absent

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

(88) Amadeus Land System (1800 sq. miles)

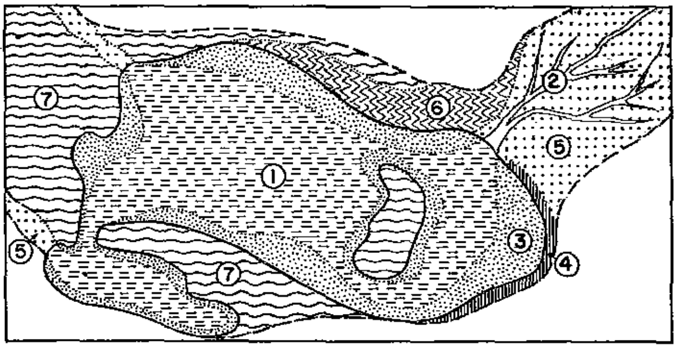
Salt pans and fringing dunes (Plate 13, Fig. 2).

Geology.—Quaternary evaporite and clay and aeolian sand.

Geomorphology.—Depositional surfaces: saline pans and their marginal features; surface and subsurface drainage foci.

Water Resources.—Moderate-quality to saline ground water is available at shallow depth.

Climate.—Comparable climatic stations are Henbury and Tea Tree Well.



Unit	Area	Land Form	Soil*	Plant Community
1	Large	Central pan floors: flat, locally salt-encrusted surfaces	Waterlogged saline clays	Bare ground
2	Very small	Channels: through unit 5; up to 20 yd wide and 5 ft deep		
3	Small	Pan margins: gentle slopes, locally dissected by tributary channels	Gypseous and calcareous sands	*Melaleuca glomerata* (tea-tree) and/or *Arthrocnemum* spp. (samphire), minor *Bassia* spp.
4	Very small	Banks: of unconsolidated gypseous and calcareous sands, commonly with surface crusts; up to 10 ft high and 20 yd wide		
5	Small	Tributary alluvial flats: severely scalded surfaces with clay pans and shallow gullies	Texture-contrast soils (7*e*, 7*i*)—mostly unstable with saline scalds and wind-piling	*Bassia* spp. or minor *Atriplex nummularia* (old-man saltbush)
6	Very small	Calcrete terraces: up to 25 ft high and ½ mile wide; stony flat upper surfaces; marginal breakaways up to 15 ft high, of hardened calcrete, and steep loose slopes in underlying soft fill or weathered bedrock	Deposits with very little soil	*Bassia* spp. or minor *Kochia astrotricha* (bluebush)
				Sparse shrubs and low trees or *A. kempeana* (witchetty bush) over short grasses and forbs
7	Medium	Dunes: up to 40 ft high; single ridges, or multiple dunes in tracts up to ½ mile wide; on windward margins they form stable fringing dunes, but on leeward shores they are irregular in form, with significant amounts of moving sand; in larger pans they may form crescentic islands	Red sands (3*f*)	Sparse shrubs and low trees, minor *Melaleuca glomerata* (tea-tree), or *Casuarina decaisneana* (desert oak), over *Triodia basedowii* (spinifex), minor *T. pungens* (spinifex), or *Plectrachne pungens* (spinifex)
				Cassia eremophila over short grasses and forbs

* The numbers in parentheses in this column refer to soil groupings in Part VIII.

PART III. CLIMATE OF THE ALICE SPRINGS AREA

By R. O. Slatyer*

I. Introduction

On a climatic basis the whole area falls into the arid classification of Meigs (1953). Meigs defines an arid region as one in which the rainfall is not adequate for the regular production of crops and this description is appropriate for the Alice Springs area.

The Commonwealth Bureau of Meteorology (personal communication) regards the general weather pattern in the area as being controlled by two factors, the geographical location of the area in the centre of a continent and the seasonal march of the pressure systems.

When the sun is furthest north (the winter solstice) the subtropical belt of high pressure is centred usually between latitudes 30°S and 35°S. Alice Springs lies in the northern parts of this high-pressure belt, the so-called "south-easterly trades" region. This high-pressure belt is not a continuous area of high pressure but is broken up into high-pressure cells with a trough of lower pressure lying around each cell. As the sun moves south so the pressure systems move southward until by the summer solstice the main high-pressure centres are to the south of the continent. Even during this season the Alice Springs area is still dominated by the south-easterly trades but, being further removed from the high-pressure centre, they are not so strong and persistent and frequently low-pressure troughs extending southward from the tropical low-pressure belt affect the area. This seasonal progression makes possible the recognition of four main synoptic types:

(*a*) The south-easterly trade situation.

(*b*) The passage of low-pressure troughs between the high-pressure centres during winter.

(*c*) The passage of low-pressure troughs from the tropical low during summer.

(*d*) The tropical cyclone situation.

The south-easterly trade is most persistent throughout the year with a frequency of occurrence averaging between 40 and 50%. During the months April to October, the situation is characterized by bright clear skies and usually excellent visibility. From November to March, with the sun more nearly overhead and the pressure belts displaced southward, the weather is characterized by greater cloudiness and higher temperatures. Although many of the days are cloudless, moist tropical air masses in the upper levels penetrate the area more frequently and there is often high and middle-level cloud present. Day-time temperatures are high and the higher temperatures and lower humidities make the soil more susceptible to wind movement. Dust haze is more marked during this season.

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During the winter months this south-easterly situation is interrupted every 7 to 10 days by the passage of a trough associated with a depression centred well to the south. On most occasions the passage of the trough is barely noticeable. Ahead of the trough the wind becomes more easterly, sometimes backing to north-west for a few hours. With the passage of the trough the wind backs to south, then rapidly to south-east. Temperatures are usually below normal and frosts occur regularly for several days. There is usually some high and middle-level cloud; on occasions the passage of these southern troughs coincides with a marked inflow of moist air aloft and some rain may occur. On very rare occasions the rainfall will be heavy with falls of 1 in. to 2 in. over a large area.

During the summer months the south-easterly situation is interrupted by the intrusion of moist air from the tropics in a trough of low pressure. These intrusions result in a marked increase in humidity often persisting for several days. Sporadic heavy rainfall from violent convectional thunderstorms occurs. Rainfall of this type comprises most of the annual rainfall and accounts for the high variability of the summer rainfall in the area.

The fourth synoptic type, the tropical cyclone situation, occurs only during the summer months and then only rarely, the average being less than once per year. The situation is of extreme importance from a land-use point of view in that the widespread very substantial rainfalls are associated with these cyclones. Cyclones move into the area from Queensland or the Darwin area, less commonly from Western Australia. By the time they reach Alice Springs the wind strength has normally abated to some extent. Humidity is high but temperatures are below normal, hence conditions are not uncomfortable. Rain persists for 24 to 48 hr usually as a light steady fall interspersed with occasional heavy thunderstorm showers. Total rainfalls of 4 to 8 in. can be received.

II. General Climatic Characteristics

(a) *Rainfall*

Average annual rainfall increases from 5 in. at the south-eastern extremity of the area to 14 in. along the northern margins, the seasonal regime showing a summer maximum which becomes progressively more marked towards the north. Superimposed on this general pattern is a definite topographic influence caused by the ridge of higher country across the centre of the area and the relatively higher altitude of the land north of the ranges.

As has been described in other sections of this report, the MacDonnell Ranges traverse the centre of the area from east to west rising to heights of about 5000 ft. The increase in altitude from the south side of the ranges is quite abrupt and a definite rain shadow effect is evident in the summer rainfall pattern, the October–March values decreasing from 7·5 to 5·2 in. over 100 miles south of Alice Springs.

The winter-rainfall pattern also shows a marked dependence on topography. In general, winter rain decreases from about 2·5 in. in the south-western corner of the area to about 1·3 in. in the northern margins. However, no areas of less than 1000 ft altitude receive more than 2 in., and even Charlotte Waters on the southern border at 700 ft receives only 1·7 in.

TABLE 1

AVERAGE MONTHLY AND SEASONAL RAINFALL (IN.) AT SELECTED STATIONS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Oct.–Mar.	Apr.–Sep.
Tennant Creek	4·04	3·54	2·08	0·35	0·21	0·35	0·25	0·06	0·11	0·40	1·07	1·39	13·85	12·52	1·33
Barrow Creek	2·53	2·09	1·52	0·37	0·48	0·28	0·34	0·11	0·17	0·66	1·30	1·60	11·45	9·70	1·75
Tea Tree Well	1·96	1·94	1·17	0·49	0·50	0·36	0·32	0·12	0·14	0·78	1·38	2·00	11·16	9·23	1·93
Alice Springs	1·74	1·32	1·09	0·39	0·60	0·52	0·29	0·31	0·28	0·71	1·15	1·53	9·93	7·54	2·39
Urandangie	2·05	2·26	0·96	0·29	0·50	0·51	0·43	0·12	0·25	0·47	0·83	0·97	9·64	7·54	2·10
Hermannsburg	1·54	1·15	0·75	0·42	0·65	0·48	0·20	0·27	0·21	0·68	1·04	1·45	8·84	6·61	2·23
Henbury	1·26	0·96	0·64	0·33	0·62	0·52	0·17	0·22	0·31	0·62	0·89	1·29	7·83	5·66	2·17
Charlotte Waters	0·74	0·62	0·60	0·43	0·34	0·40	0·18	0·21	0·18	0·32	0·47	0·59	5·08	3·34	1·74

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

The main peak in the annual rainfall distribution is in January and February and the main trough in August and September. There is a minor peak in the winter-rainfall period in May and June. These general features of the annual rainfall regime are illustrated in Table 1 and Figures 2 and 3 where histograms of monthly and seasonal rainfall are superimposed on isohyet maps.

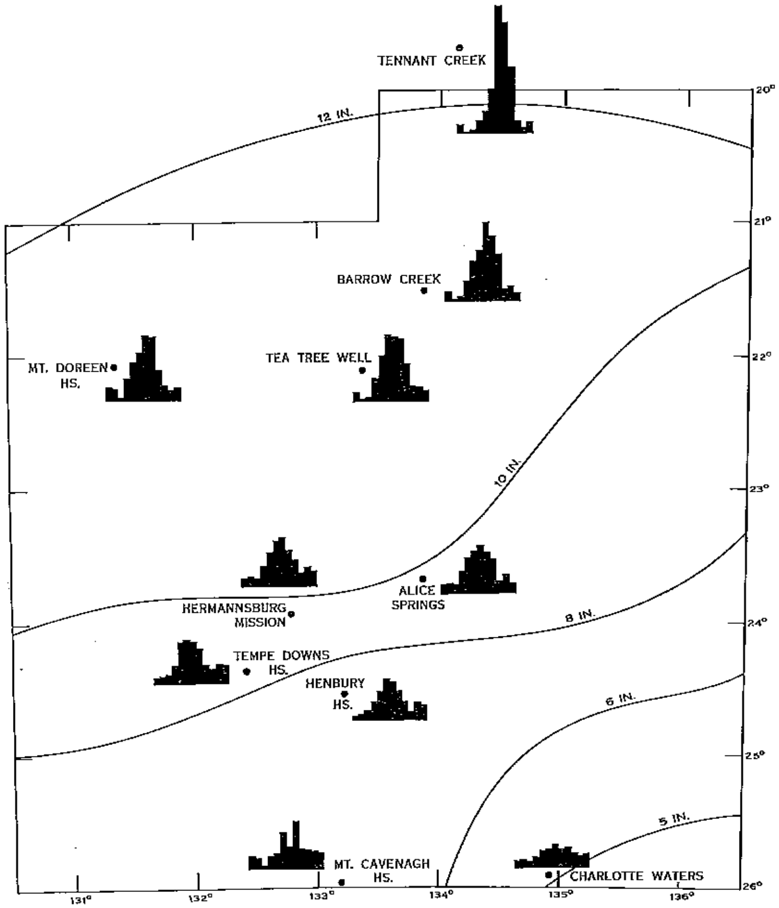

Fig. 2.—Isohyets and histograms of annual rainfall distribution (July to June) at recording stations.

In general the number of rainy days increases from south to north as total rainfall increases and intensity of rain per wet day likewise increases with increase in the proportion of the rainfall received from summer-rainfall sources. At Tennant Creek and Charlotte Waters, for example, the annual rainfalls of 13·9 in. and 5·1 in. are received over 30 and 25 days respectively. Thus the rain per wet day ranges from 0·46 to 0·20 in.

Although about half of the rainy days are isolated occurrences, the remainder occur as wet days in periods of rainy weather. Rainy weather does not usually persist

TABLE 2

EXPECTED NUMBER OF WET PERIODS OF DURATION EXCEEDING THAT INDICATED*

Duration (days)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Oct.–Mar.	Apr.–Sept.
								Tennant Creek						
0	2·58	1·94	1·24	0·72	0·36	0·66	0·48	0·24	0·52	1·24	1·96	2·39	11·35	2·98
2	1·16	0·98	0·42	0·18	0·12	0·16	0·12	—	—	0·43	0·65	1·02	4·66	0·58
5	0·34	0·44	0·24	—	—	—	—	—	—	0·10	0·14	0·33	1·59	—
								Alice Springs						
0	1·70	1·28	1·20	0·87	0·67	1·07	0·74	0·74	0·74	1·44	1·83	1·68	9·13	4·83
2	0·57	0·76	0·42	0·17	0·26	0·26	0·22	0·28	0·20	0·54	0·72	0·70	3·71	1·39
5	0·17	0·26	0·17	0·06	0·11	0·06	0·09	0·06	—	0·11	0·24	0·31	1·26	0·38
								Charlotte Waters						
0	1·17	0·77	0·80	0·77	1·00	1·07	0·73	1·00	0·80	1·43	1·70	1·27	7·14	5·37
2	0·23	0·23	0·10	0·10	0·10	0·27	0·20	0·20	0·10	0·30	0·30	0·30	1·46	0·97
5	0·07	0·10	—	—	—	0·07	0·07	—	—	—	—	—	0·17	0·14

*Source of data: daily rainfall records.

for more than five days, however, and the frequency of occurrence of wet periods decreases with increase in their duration. In Table 2 and Figure 4 these data are summarized. Table 2 gives the expected number of wet periods of specified duration at Tennant Creek, Alice Springs, and Charlotte Waters. Figure 4 reveals the proportion of wet periods of varying duration at each of these centres. A "wet period"

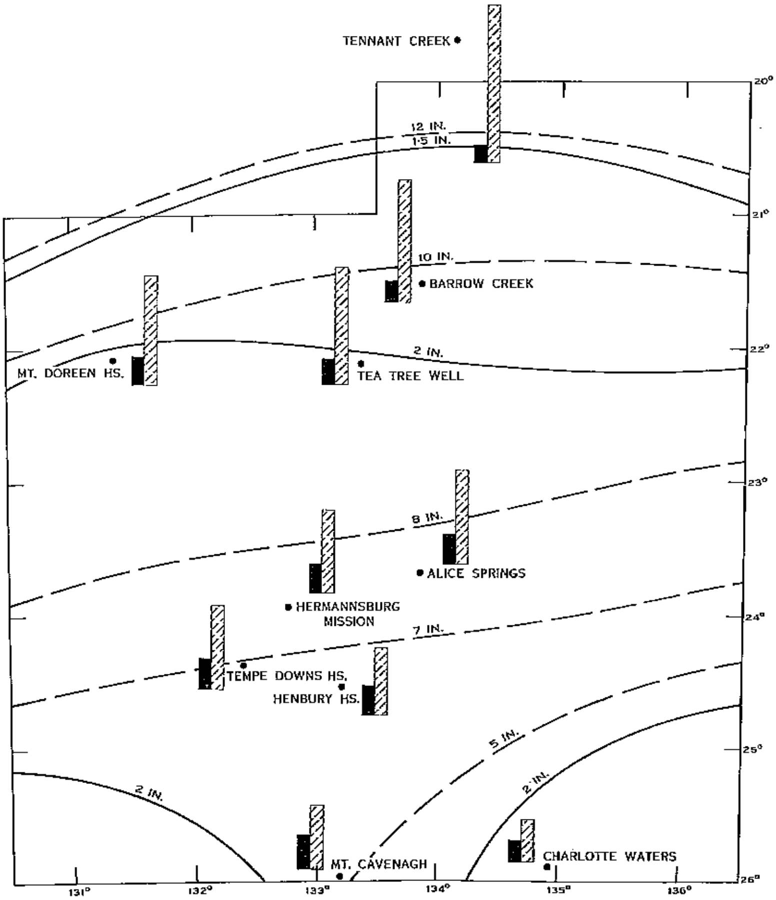

Fig. 3.—Average seasonal rainfall of the Alice Springs area. Solid lines and solid histograms refer to April–September rainfall. Broken lines and shaded histograms refer to October–March rainfall.

is defined as a period of rainy weather which is terminated by more than two consecutive dry days.

The expected number of wet periods at Tennant Creek varies from about 2·5 per month in mid summer to less than 0·5 per month in late winter. In summer slightly less than half of these periods extend for more than 2 days but in winter less than one-quarter are of this duration. At Charlotte Waters the expected number of wet periods approximates 1 per month, and the proportion of the periods of more than 2 days' duration is less than one-quarter in all months. The situation at Alice

Springs is somewhat intermediate. There is a decrease in the frequency and duration of summer falls relative to Tennant Creek but more winter-rainfall periods occur than at the other stations.

The amount of rain received per wet period shows a parallel relationship which is summarized in Table 3 and Figure 5. At Tennant Creek 5·2 wet periods, in which 0·5 in. or more were received, occurred during the summer period and 0·9 during the winter. The comparable figures for Alice Springs and Charlotte Waters were 3·9, 1·6, and 1·7, 0·7 respectively, the more pronounced winter rainfall at Alice Springs being immediately apparent. The chances of receiving wet periods in which more than 2·0 in. of rain occurred are much less, in summer the values are 1·6 for Tennant Creek, 1·3 for Alice Springs, and 0·3 for Charlotte Waters, while in winter only at Alice Springs is there a significant chance of receiving falls of this magnitude.

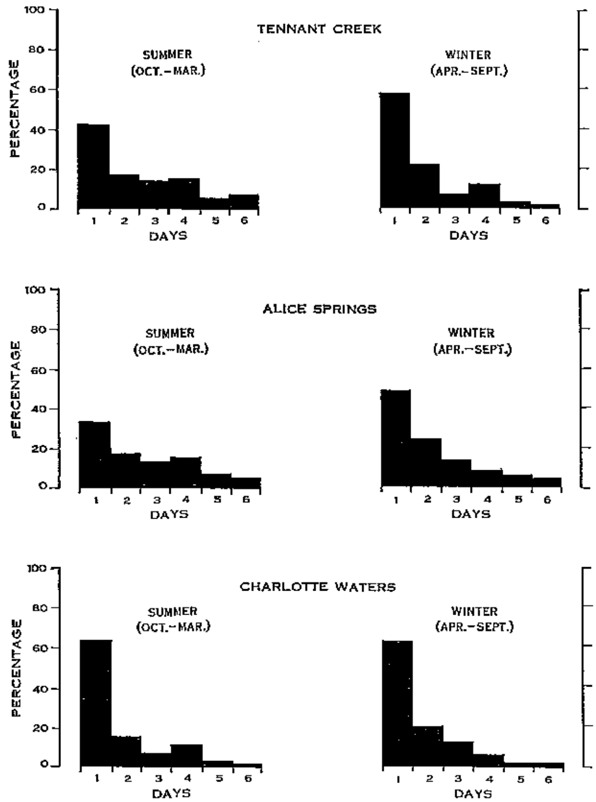

Fig. 4.—Proportion of wet periods of different duration, expressed on a seasonal basis, for Tennant Creek, Alice Springs, and Charlotte Waters.

In general the rainfall pattern throughout the area conforms to the limits represented by these three stations, although stations of higher altitude usually have significantly higher rainfall than those of low altitude in otherwise equivalent situations.

TABLE 3

EXPECTED NUMBER OF WET PERIODS IN WHICH RAINFALL OCCURRED IN AMOUNTS EXCEEDING THOSE INDICATED*

Amount (in.)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Oct.–Mar.	Apr.–Sept.
								Tennant Creek						
0·5	1·26	1·14	0·50	0·22	0·18	0·16	0·20	0·08	0·10	0·35	0·82	1·12	5·19	0·94
1·0	0·92	0·80	0·34	0·12	0·08	0·14	0·06	—	0·06	0·10	0·35	0·64	3·15	0·46
2·0	0·58	0·56	0·16	—	—	—	—	—	—	—	0·06	0·21	1·57	—
								Alice Springs						
0·5	0·62	0·70	0·57	0·31	0·28	0·37	0·26	0·24	0·15	0·57	0·81	0·59	3·86	1·61
1·0	0·40	0·56	0·39	0·22	0·17	0·15	0·07	0·11	0·09	0·28	0·41	0·42	2·46	0·81
2·0	0·19	0·41	0·20	0·08	—	0·09	—	—	—	0·09	0·20	0·17	1·26	0·17
								Charlotte Waters						
0·5	0·23	0·30	0·27	0·07	0·07	0·27	0·13	0·07	0·13	0·27	0·30	0·33	1·70	0·74
1·0	0·17	0·20	0·17	0·07	0·06	0·07	—	—	—	0·12	0·13	0·20	0·99	0·20
2·0	0·08	0·07	0·10	—	—	—	—	—	—	—	—	0·07	0·32	—

*Source of data: daily rainfall records.

(b) Dew

Although dews are of considerable significance in some arid regions as an additional source of water for plants, they are of very minor significance in this area as they rarely occur except during or for a few days following falls of rain. In the absence of humid onshore winds which are instrumental in causing dews in some coastal deserts, atmospheric humidity in this area is normally so low that even with the marked drop in temperature at night, dew-point temperature is seldom approached.

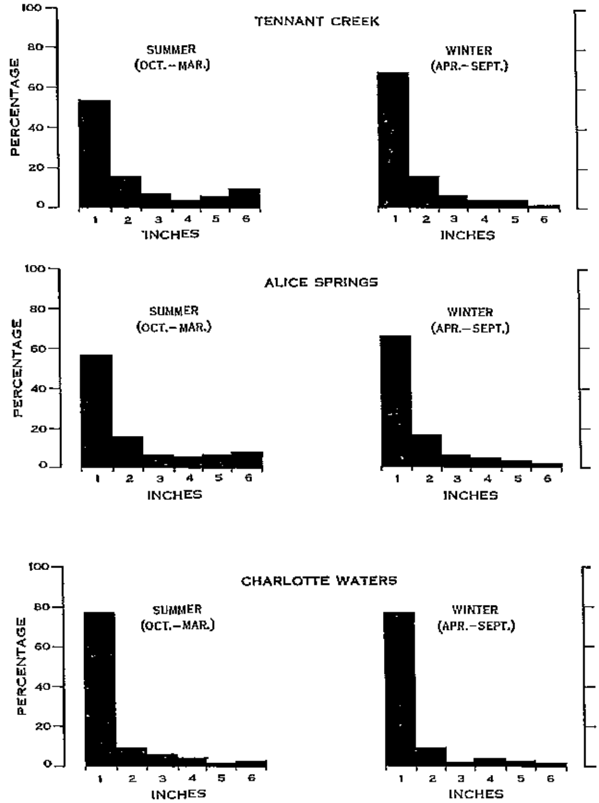

Fig. 5.—Proportion of wet periods of different total rainfall, expressed on a seasonal basis, for Tennant Creek, Alice Springs, and Charlotte Waters.

(c) Temperature

The annual temperature regime is characteristic of an area in the arid centre of a continent and is characterized by marked seasonal and diurnal fluctuations. These features are illustrated in Figure 6.

It is also apparent from Figure 6 that the higher altitude of Alice Springs suppresses night temperatures to a level slightly below those at Charlotte Waters, and in summer reduces day temperatures several degrees below those at Charlotte Waters. At Tennant Creek the peak in the temperature curve is in December, as temperatures in January, February, and March are suppressed several degrees by rain. At each centre, however, summer daily temperatures in excess of 100 °F occur almost con-

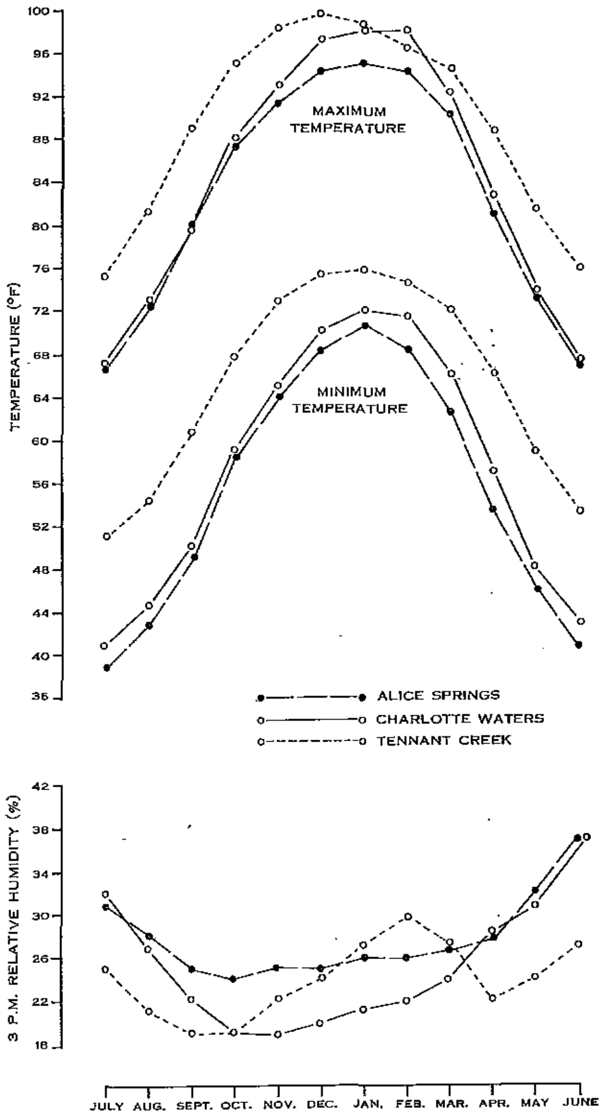

Fig. 6.—Mean monthly maximum and minimum temperatures and 3 p.m. relative humidity for Alice Springs, Charlotte Waters, and Tennant Creek.

tinuously except during (or for a few days following) falls of rain or during periods in which an inflow of southern air penetrates the area.

The marked diurnal fluctuations in temperature are a direct result of the extreme radiation conditions which normally prevail, with low humidity and little cloudiness to interfere with either incoming or outgoing radiation. The reduced diurnal variation at Tennant Creek during the summer may be attributed to the increased cloudiness and higher humidity at that time.

Foley (1945) reports that frosts are a rare occurrence at Tennant Creek, but that a definite frost season exists at Alice Springs and Charlotte Waters. At Barrow Creek occasional frosts occur in July, but in general very few frosts are recorded in the area north of the MacDonnell Ranges, particularly in areas below 1700 ft altitude.

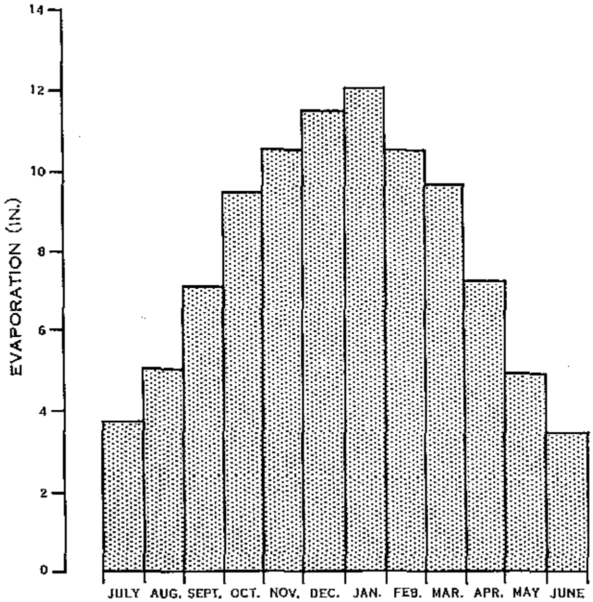

Fig. 7.—Mean monthly evaporation from standard 3 ft diameter tank evaporimeter at Alice Springs.

Using a criterion of 36°F screen temperature as representing frost conditions on the ground surface, Foley reports that at Alice Springs the average date of the first frost is May 21 with a mean deviation of 13 days and the average date of the last frost is August 30 ± 14 days. At Charlotte Waters the comparable figures are June 2 ± 12 days and August 4 ± 9 days. Thus the average frost season at Alice Springs is 102 days and at Charlotte Waters 64 days, the longer period at Alice Springs being directly attributable to the higher altitudes.

The average date of the first screen temperature of 32°F at Alice Springs is June 9 ± 10 days, and at Charlotte Waters it is June 28 ± 11 days. The average dates for the last 32°F screen temperature at each centre are August 6 ± 12 days and July 19 ± 12 days. As mentioned later, these figures sometimes provide a better guide to conditions which suppress growth of winter-active species.

(*d*) *Humidity*

Humidity is low throughout the area except during and shortly after periods of rainy weather. At Alice Springs and Charlotte Waters absolute humidity values do not fluctuate much throughout the year, but relative humidity figures show an increase in the winter months as temperature limits fall (Fig. 6). At Tennant Creek this increase during the cooler winter months is also apparent; in addition there is a real increase in humidity during late summer as a result of the wet-season rain.

The very low relative humidity values (of the order of 30% at Alice Springs) explain why dews are of rare occurrence since night temperatures must fall almost to freezing point before dew point is reached.

(*e*) *Evaporation*

Evaporation data are available only for Alice Springs but in view of the lower temperatures experienced at this locality it is to be expected that total evaporation would probably be a little higher at Tennant Creek and Charlotte Waters.

Data for Alice Springs from a standard 3-ft diameter tank evaporimeter are presented in Figure 7. The marked increase in evaporation from winter to summer is evident, as are the extremely high values recorded during the summer months. Total evaporation averages 95 in. per year.

III. Climate–Vegetation Relationships

Although rainfall is by far the most important climatic factor affecting the distribution and growth of plants in this area, most of the permanent components of the natural vegetation are quite sensitive to low temperature and remain virtually dormant during the winter even when significant falls of rain are received. Such species make rapid growth soon after the cessation of frosts in the spring which continues until any accumulated soil-water storage is exhausted. They then make intermittent growth following the sporadic summer rains. As distinct from this behaviour a number of ephemerals, particularly those of the family Compositae, are winter-active and make rapid growth on the winter rains. However, these species only root to a depth of about 6 in. and so do not seriously deplete the soil-water reservoir if previous falls have penetrated to a reasonable depth.

The following notes are set out to evaluate the water factor of the climate, and the temperature factor, in turn. Attention is paid only to pastures since the rainfall is too low to support any regular cropping system.

(*a*) *Rainfall Effectiveness*

A number of studies have been made on this subject dealing with arid regions in South Australia (Trumble 1939, 1945), Queensland (Farmer, Everist, and Moule 1947), and New South Wales (Andrews and Maze 1933; Lawrence 1941; White 1955). For the purpose of this study none of the techniques used by these investigators is strictly applicable but that of White (1955) has been used to modify a technique employed by Slatyer (1960) to assess the significance of sporadic falls of rain in the Yass Valley of southern New South Wales.

Since the Alice Springs area is essentially one in which grazing of natural pastures is the primary form of land use, it is important to gauge the frequency of occurrence of those falls of rain which are significant in promoting vegetative growth. Because the plant communities are normally grazed at moderate levels the vegetation is usually at subclimax stage, although some of the less palatable communities exist virtually in climax form. Because of this feature it is difficult to interpret climatic data in any manner which yields quantitative data on plant growth, instead it is only possible to assess vegetative responses in such subjective terms as "general renewal of growth".

However, the low grazing pressure makes such a subjective interpretation of value, since the appearance of young shoots in an inert pasture indicates the presence of palatable and nutritious plant material. It must be realized, however, that the estimates made bear little relation to the water requirements of plants for continued active growth.

(i) *Technique*.—Recognizing that the sporadic nature of the rainfall in this region results in intermittent growth by the vegetation, it is important to assess firstly the frequency of falls of rain which merely serve to enable germination of annuals and regrowth of perennials to commence, and secondly the frequency of subsequent falls which make possible continued growth by the vegetation.

For the first purpose it was assumed that if sufficient rain fell to result in positive soil-water storage for one week, this would enable the requirements to be satisfied. It was assumed that if the rainfall over a period of 1 wk exceeded $0 \cdot 4E_w$* for that week this provision would be satisfied. A value of $0 \cdot 4E_w$ was selected because transpiration would be low over the period and although evaporation would be at a rate approximating $1 \cdot 0E_w$ while the soil surface remained wet, this would only be maintained for 1–2 days following each fall and would then drop rapidly.

A comparison with recorded observations of species response indicates that this procedure provides good agreement with field conditions.

For the second purpose, it was assumed that if initial rains (such as those fulfilling the conditions outlined above) were followed by further significant falls of rain so that some growth would persist for a period of 4 wk, a significant amount of production could be expected to occur.

The evapotranspiration requirements for this 4-wk period were estimated as amounting to $0 \cdot 2E_w$ for the period. It was assumed that evapotranspiration for the first 1–2 wk of the period (except for the first 1–2 days while the soil surface remained wet) would increase from a value close to zero to a value of approximately $0 \cdot 4E_w$. As soil-water levels fell towards the end of such a period evapotranspiration would decline to a value approaching zero.

Adoption of $0 \cdot 2E_w$ to represent total water requirement over the 4-wk period may tend to provide an estimate on the low side if a considerable amount of rain is received and evapotranspiration approximates $0 \cdot 4E_w$ for the whole period. Under these conditions, however, it is very probable that the increased rainfall would satisfy the requirement at $0 \cdot 4E_w$ so that the use of the lower value ($0 \cdot 2E_w$) would not introduce errors.

In practice it has been found that in any 4-wk period in which the rainfall has exceeded $0 \cdot 2E_w$, substantial pasture growth has occurred.

* E_w = evaporation from the free water surface of a standard tank evaporimeter.

TABLE 4

EFFECTIVE RAINFALL REQUIREMENTS (IN.) FOR TENNANT CREEK, ALICE SPRINGS, AND CHARLOTTE WATERS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
						Tennant Creek						
Initial effective rain	1·09	0·88	1·01	0·94	0·70	0·56	0·55	0·68	0·90	1·11	1·22	1·16
Effective carryover rain	2·19	1·76	2·02	1·88	1·39	1·13	1·10	1·35	1·79	2·22	2·43	2·31
						Alice Springs						
Initial effective rain	1·16	1·07	0·86	0·64	0·39	0·29	0·29	0·44	0·64	0·86	1·07	1·14
Effective carryover rain	2·31	2·14	1·71	1·27	0·78	0·58	0·58	0·87	1·27	1·73	2·14	2·28
						Charlotte Waters						
Initial effective rain	1·28	1·22	0·96	0·65	0·44	0·29	0·31	0·42	0·64	0·90	1·09	1·24
Effective carryover rain	2·55	2·43	1·93	1·30	0·87	0·58	0·61	0·84	1·27	1·79	2·17	2·48

These criteria, which are based mainly on observed responses of species to various amounts of rainfall, are nevertheless very similar to those indicated by the critical water balance studies of J. L. Frith on spinifex and R. O. Slatyer on mulga (unpublished data) conducted in this area. They also seem to be in order when it is realized that evapotranspiration from an actively growing crop, adequately supplied with soil water and covering most of the ground surface, approximates $0 \cdot 6$–$0 \cdot 8E_w$ (Penman 1949, 1956).

In the present study the two critical rainfall amounts are termed "initial effective rainfall" and "effective carryover rainfall" respectively, using the terminology of White (1955).

In assessing the critical values, recourse had to be made to saturation deficit data to compute evaporation, since Alice Springs was the only station for which evaporation data were available directly. As found by Farmer, Everist, and Moule (1947) the ratio of monthly saturation deficit to monthly evaporation closely approximated a value of 16 and this factor was used in obtaining estimates of E_w for Tennant Creek and Charlotte Waters.

In Table 4 values for initial effective rainfall and effective carryover rainfall are given for Tennant Creek, Alice Springs, and Charlotte Waters for periods commencing in the months indicated. Intermediate values apply for other stations.

From Table 4 it is apparent that the summer requirements at Alice Springs are lower than at the other centres and this feature is characteristic of all stations of higher altitude. At Tennant Creek the February and March values are depressed significantly by the summer rains with associated higher humidity and lower temperature. This feature only occurs in the extreme north of the area, in areas receiving more than 12 in. of rain annually.

Winter values throughout the southern and central parts of the area are very similar. North of Tea Tree a gradual increase occurs until the values observed at Tennant Creek are recorded.

(ii) *Initial Effective Rainfall*.—In Table 5 the frequency of occurrence of periods of initial effective rainfall is given, on a monthly basis, for the seven stations in the region for which more than 30 years of daily rainfall records are available.

Apart from minor differences between Barrow Creek and Tea Tree Well and between Alice Springs and Hermannsburg, it is apparent that the general rainfall pattern is strongly reflected in the occurrence of initial effective rainfall. In the summer six months at Tennant Creek, Barrow Creek, and Tea Tree Well more than two occurrences can be expected; this value decreases to about two occurrences at Alice Springs, $1 \cdot 4$ at Henbury, and $0 \cdot 6$ at Charlotte Waters. The chances of receiving initial effective rainfall in the winter six months are highest in the central higher section of the area, where about $1 \cdot 6$ occurrences can be expected, decreasing northwards and southwards and reaching a value of $0 \cdot 5$ at Tennant Creek. As with the general rainfall regime January and February are the summer months in which initial effective rainfall is most likely to occur and May and June are the winter months with greatest probability.

TABLE 5

EXPECTED NUMBER OF PERIODS OF INITIAL EFFECTIVE RAINFALL AT SELECTED STATIONS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Oct.–Mar.	Aug.–Sept.
Tennant Creek	0·57	0·69	0·29	0·10	0·10	0·14	0·12	0·02	0·04	0·06	0·18	0;48	2·27	0·52
Barrow Creek	0·35	0·54	0·31	0·12	0·23	0·23	0·19	0·38	0·12	0·23	0·27	0·42	2·12	1·27
Tea Tree Well	0·54	0·42	0·27	0·23	0·36	0·24	0·16	0·08	0·04	0·40	0·32	0·44	2·39	1·11
Hermannsburg	0·33	0·39	0·33	0·31	0·31	0·41	0·31	0·15	0·13	0·23	0·23	0·32	1·83	1·62
Alice Springs	0·38	0·40	0·41	0·26	0·28	0·40	0·28	0·22	0·13	0·24	0·24	0·37	2·04	1·57
Henbury	0·20	0·25	0·29	0·14	0·27	0·29	0·25	0·14	0·12	0·21	0·22	0·27	1·44	1·21
Charlotte Waters	0·17	0·09	0·13	0·09	0·13	0·35	0·17	0·26	0·04	0·04	0·09	0·09	0·61	1·04

*A period which extended beyond the end of a calendar month was noted against the month in which it commenced. Source of data: daily rainfall records.

TABLE 6

EXPECTED NUMBER OF PERIODS OF EFFECTIVE CARRYOVER RAINFALL AT SELECTED STATIONS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Oct.–Mar.	Apr.–Sept.
Tennant Creek	0·49	0·55	0·24	0·08	0·04	0·12	0·04	—	0·02	0·02	0·12	0·35	1·77	0·30
Barrow Creek	0·31	0·42	0·27	0·04	0·15	0·08	0·23	0·04	—	0·15	0·04	0·27	1·46	0·54
Tea Tree Well	0·31	0·27	0·23	0·12	0·24	0·12	0·12	0·04	0·04	0·20	0·24	0·32	1·57	0·68
Hermannsburg	0·21	0·22	0·18	0·13	0·22	0·28	0·22	0·09	0·04	0·14	0·13	0·19	1·07	0·98
Alice Springs	0·21	0·28	0·26	0·15	0·24	0·19	0·20	0·13	0·07	0·19	0·09	0·25	1·28	0·98
Henbury	0·07	0·14	0·14	0·11	0·14	0·21	0·18	0·07	0·09	0·09	0·11	0·14	0·69	0·80
Charlotte Waters	0·04	0·04	0·04	0·04	0·04	0·17	—	0·09	—	—	—	0·09	0·21	0·34

*A period which extended beyond the end of a calendar month was noted against the month in which it commenced. Source of data: daily rainfall records.

(iii) *Effective Carryover Rainfall*.—As is to be expected, the chances of receiving effective carryover rainfall are significantly less than those of receiving initial effective rain, particularly in areas of lowest rainfall.

From Table 6 the same general pattern is seen to be reproduced, although in this instance the chance of receiving effective carryover rainfall in the summer six months decreases from 1·8 at Tennant Creek to 1·3 at Alice Springs and 0·2 at Charlotte Waters. In the winter six months the values in the central part of the region are significantly higher than elsewhere and of the order of 1·0. The chances decrease gradually to the north and south and as before, May and June are the winter months in which effective carryover rainfall is most likely to occur.

In summarizing the data from these tables it is of interest to note that over the whole year the number of periods of effective carryover rainfall is very similar at all stations north of Alice Springs, despite the fact that the seasonal distribution is markedly different, and approximates 2·0 per year. South of Alice Springs there is a rapid drop to 1·5 periods at Henbury, decreasing with decreasing altitude to 0·5 at Charlotte Waters.

These figures reflect the intense aridity which prevails over the area for most of the year and highlights the fact that only two significant growth periods can be expected each year even in the wetter parts of the area.

(*b*) *Influence of Temperature*

The primary influence of temperature on the rainfall effectiveness data just presented is on the suppression of growth of the perennial elements of the natural flora during the frost season. Although long periods of high temperature occur during the summer months this effect is largely felt through increased evapotranspiration by the plants, which has been allowed for by a proportionate increase in the critical rainfall requirement.

The activity of most of the perennial vegetation components, and of mulga (*Acacia aneura*) and spinifex (*Triodia* spp. and *Plectrachne* spp.) in particular, is severely depressed by frosts, individual plants showing virtually no growth response to winter rains even though turgor recovery and resumption of metabolic activity occur. Since the frost season is longest in the areas of higher altitude this effect is most marked in these regions.

Because of this feature the data presented in Tables 5 and 6 must be interpreted with caution, and with special reference to Table 6 it can be stated that in those years in which any winter month has effective carryover rainfall, a significant growth response can be expected in September after the frost season has ended.

(*c*) *Water Requirements for Irrigation*

Irrigation may be practised in small areas throughout the region when supplies of surface or ground water are available. It is difficult to obtain accurate estimates of the water requirements for irrigation since losses in delivery, frequency of irrigation, size of irrigation area, and crop affect the quantity of water used.

TABLE 7

IRRIGATION REQUIREMENTS (IN.) FOR EVAPOTRANSPIRATION ESTIMATES FOR IRRIGATION AT THREE STATIONS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
							Tennant Creek						
Total evapotranspiration	12·00	9·74	11·20	10·40	7·70	6·24	6·10	7·50	9·90	12·30	13·46	12·80	119·34
Rainfall	4·04	3·54	2·08	0·35	0·21	0·35	0·25	0·06	0·11	0·40	1·07	1·39	13·85
Net evapotranspiration	7·96	6·20	9·12	10·05	7·49	5·89	5·85	7·44	9·79	11·90	12·39	11·41	105·49
							Alice Springs						
Total evapotranspiration	11·99	10·36	9·79	7·14	4·98	3·48	3·68	5·01	6·98	9·28	10·28	11·65	94·62
Rainfall	1·74	1·32	1·09	0·39	0·60	0·52	0·29	0·31	0·28	0·71	1·15	1·53	9·93
Net evapotranspiration	10·16	9·04	8·70	6·75	4·38	2·96	3·39	4·70	6·70	8·57	9·13	10·12	84·69
							Charlotte Waters						
Total evapotranspiration	14·10	13·46	10·70	7·20	4·80	3·20	3·34	4·66	7·06	9·90	12·00	13·74	104·16
Rainfall	0·75	0·60	0·61	0·44	0·35	0·40	0·20	0·21	0·18	0·32	0·47	0·59	5·12
Net evapotranspiration	13·35	12·86	10·09	6·76	4·45	2·80	3·14	4·45	6·88	9·58	11·53	13·15	99·04

In order to provide some quantitative data which can be used for this purpose estimates of evapotranspiration have been made for Tennant Creek, Alice Springs, and Charlotte Waters, on the assumption that evapotranspiration is equivalent to free-water evaporation. This value is slightly in excess of that for an extensive cover of actively growing plants adequately supplied with soil water, but makes some allowance for the fact that most irrigation areas in the region are small and are subject to significant "oasis" effects due to the aridity of the surrounding country. This assumed rate of evapotranspiration is in good agreement with that measured at the Animal Industry Research Institute by Jackson (1958). In Table 7 the mean monthly estimates of evapotranspiration are given together with mean monthly rainfall and net irrigation need. To these estimates must be added a significant amount to represent losses in delivery. This will be at a minimum if water is pumped from an underground bore through pipes to the irrigated plots and at a maximum if water is drawn through open channels from an exposed storage. The estimates could also be reduced, by a factor of the order of 30–40%, if irrigation was used to ensure only survival of plants rather than continued active growth.

IV. Climate in Relation to Animal Production

Only two aspects of climate can be considered in this context in the present report: extreme temperature conditions and frequency of rainfall of sufficient intensity to fill station dams and tanks.

In the former respect shade temperatures over 100°F can be expected at most centres between December and March for periods as long as 20 consecutive days. In the higher parts of the area temperatures seldom exceed 105°F, but to the north and, more particularly, to the south of the MacDonnell Ranges periods of 10 consecutive days over 105° are not uncommon, and several days over 110° may be experienced. Such conditions are extremely distressing to calves and to aged or sick animals, particularly of the European breeds.

Winter temperatures are by no means extreme, despite the definite frost season which occurs in most of the area. Although stock death is sometimes attributed to low temperatures, it seems probable that low temperatures alone would seldom be responsible for the death of healthy animals. This would apply particularly in pasture areas when animals could shelter under trees where on typical frosty nights temperatures can be significantly higher than in open areas. J. C. Turner (personal communication) has observed nocturnal minima under groves of mulga, up to 5°F higher than in adjacent exposed intergroves. The associated effects of frosts on suppression of vegetative growth may be of more significance.

Because very little information is available on the intensity of individual storms it is very difficult to provide good estimates of the frequency of falls adequate to replenish station dams and tanks through run-off. Some estimate may, however, be obtained from Table 3, since it can be anticipated that wet periods in which more than 1·0 in. of rain fell would provide some run-off, and that periods in which 2·0 in. or more fell would provide significant run-off.

On this basis it can be seen that at Tennant Creek, 3·1 wet periods can be expected between October and March compared to 2·5 at Alice Springs and 1·0 at

Charlotte Waters. Of these 1·6, 1·3, and 0·3 respectively can be expected to exceed 2·0 in. This suggests that over most of the area except the south-east and extreme south at least one general recharge can be expected each summer.

In the winter the chances of wet periods occurring in which at least 2·0 in. of rain is received are very low, but periods of 1 in. can be expected in most years in the ranges and every second year in most of the remainder of the area. In the extreme south-east, however, the chances are only 1 in 5.

V. Acknowledgments

It is desired to acknowledge the assistance of the Commonwealth Bureau of Meteorology, which provided notes on general synoptic conditions in the region that appear in the introduction, and Mrs. A. Komarowski, who carried out most of the computations used in this paper.

VI. References

Andrews, J., and Maze, W. H. (1933).—Some climatological aspects of aridity and their application to Australia. *Proc. Linn. Soc. N.S.W.* **58**: 105–20.

Farmer, J. N., Everist, S. L., and Moule, G. R. (1947).—Studies in the environment of Queensland. I—The climatology of semi-arid pastoral areas. Qd. Dep. Agric. Stock Bull. No. 36.

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

Jackson, E. A. (1958).—Interim report on the irrigation requirements of lucerne at Alice Springs, Northern Territory. C.S.I.R.O. Aust. Div. Soils Tech. Mem. No. 5/58.

Lawrence, Elizabeth F. (1941).—Climatic regions in tropical Australia. *Aust. Geogr.* **4**: 20–6.

Meigs, P. (1953).—World distribution of arid and semi-arid homoclimates. *In* "Reviews of Research on Arid Zone Hydrology". pp. 203–10. (Unesco: Paris.)

Penman, H. L. (1949).—The dependence of transpiration on weather and soil conditions. *J. Soil Sci.* **1**: 74–89.

Penman, H. L. (1956).—Evaporation: an introductory survey. *Neth. J. Agric. Sci.* **4**: 9–29.

Slatyer, R. O. (1960).—Agricultural climatology of the Yass valley. C.S.I.R.O. Aust. Div. Land Res. Reg. Surv. Tech. Pap. No. 6.

Trumble, H. C. (1939).—Climatic factors in relation to the agricultural regions of southern Australia. *Trans. Roy. Soc. S. Aust.* **63**: 36–43.

Trumble, H. C. (1945).—Agricultural climatology in Australia. *J. Aust. Inst. Agric. Sci.* **11**: 115–19.

White, R. C. L. (1955).—Drought and effective rainfall frequency in pastoral New South Wales west of the wheat belt. Bur. Met. Aust. Met. Stud. No. 5.

PART IV. AN OUTLINE OF THE GEOLOGY OF THE ALICE SPRINGS AREA

By T. QUINLAN*

I. INTRODUCTION

This outline of the geology of the Alice Springs area is the result of a rapid reconnaissance survey and a review of previous work.

(a) *Previous Work*

Chewings (1914, 1928), Mawson and Madigan (1930), and Madigan (1932*a*, 1932*b*) determined the stratigraphic succession in the western and eastern MacDonnell Ranges. Hossfeld (1954) reviewed their work and the work of the Aerial, Geological, and Geophysical Survey of Northern Australia undertaken between 1935 and 1940, and gave an extensive bibliography for the area. Subsequently field parties from the Bureau of Mineral Resources, Geology and Geophysics carried out detailed reconnaissance mapping of selected areas (see reliability diagram on geological map). Some of this work has been published (Sullivan and Öpik 1951; Joklik 1955; Noakes 1956; Öpik 1956; Casey and Gilbert-Tomlinson 1956), but much of it is still being compiled. This work together with that done since 1953 by the Resident Geologists (based at Alice Springs) has resulted in a better understanding of the regional geology.

Much of the information presented here is based on the results of field work by other geologists of the Bureau of Mineral Resources, to whom acknowledgment is gratefully made.

(b) *Geology in Relation to Land Systems and Land Use*

Three broad lithologic units have been used in defining the individual land systems. These are:

Metamorphic and igneous rocks of Pre-Cambrian age;

Sedimentary rocks—folded, faulted, and mainly cemented—Lower Proterozoic to Upper Palaeozoic age;

Sediments—not folded but mainly compacted—Permian to Recent age.

The three broad lithologic units and the land systems are correlated in Table 8.

The lithologies of rocks of the three units and their geological structure govern the efficient use to which land of the individual land systems may be put (Part XII). In particular:

(1) The mining industry has been mainly dependent on the occurrence of mineral deposits in the igneous and metamorphic rocks (Part V).

(2) The geological structure influences the distribution of aquifers, and thus the occurrence of ground water which can be used for stock or irrigation. The value of an aquifer (i.e. whether it is high- or low-yielding) is determined largely by its lithology (Part VI).

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TABLE 8

RELATION BETWEEN BROAD LITHOLOGIC UNITS AND LAND SYSTEMS

Broad Lithologic Unit	Age		Structural Unit	Named Stratigraphic Unit	Lithology	Land Systems
Sediments — not folded, but mainly compacted	Quaternary	Recent	Rocks crop out throughout the Alice Springs area		Alluvium	Outounya,* Leahy,* Ringwood,* Pulya,* McDills, Finke, McGrath, Ammaroo, Sandover, Utopia
					Wash	Ringwood,* Amulda, Kanandra, Todd, Woodduck, Adnera, Deering, Hamilton, Undippa
					Soil	Boen,* Warburton,* Karee, Bushy Park, Leahy*
		Pleistocene—Recent			Aeolian sand	Dinkum, Simpson, Ewaninga,* Singleton, Amadeus*
					Kunkar, calcrete, alluvium	Ebenezer,* Lindavale,* Titra, Woolla
					Evaporite and clay	Amadeus*
					Terrace gravel	Weldon,* Reynolds,* Berrys Pass, Stokes
	Tertiary				Chalcedony, calcareous and gypsiferous silt	Delny,* Santa Teresa, Table Hill, Lindavale
				"Deep weathering profile"	Laterite and grey billy	Boen,* Warburton,* Tietkins, Wonorah, Chisholm, Delny,* Kulgera, Alcoota, Ryan,* Tennant Creek,* Chandlers,* Rumbalara,* Wilyunpa,* Peebles, Angas,* Reynolds,* Ambalindum
	Mesozoic			Minor basins and piedmonts	Sandy siltstone, siltstone, lignite, shale, grit, gravel, sandy clay, clay	Unit does not crop out and no land systems mapped

TABLE 8 (*Continued*)

Broad Lithologic Unit	Age	Structural Unit	Named Stratigraphic Unit	Lithology	Land Systems
Sediments — not folded, but mainly compacted (continued)	Mesozoic (continued)	Great Artesian Basin		Claystone, sandstone, siltstone, arkose	Ebenezer,* Endinda,* Kalamerta
			Rumbalara shale	Shale, claystone, fine-grained sandstone	Rumbalara,* Wilyunpa,* Peebles,* Endinda*
			Finke "series" — De Souza sandstone	Sandstone	Rumbalara,* Peebles,* Lilla*
	Palaeozoic — Permian			Silty sandstone, pebble conglomerates, boulder beds	Lilla,* Rumbalara*
				Arkose, conglomerate	Cavenagh*
Sedimentary rocks —folded, faulted, and mainly cemented	Upper Palaeozoic	Amadeus trough		Conglomerate, sandstone, siltstone, arkose	Gillen*
			Pertnjara "series"	Sandstone, conglomerate, siltstone	Sonder,* Pertnjara, Gillen,* Middleton,* Kernot,* Krichauff,* Muller, Ewaninga*
			Mareenie sandstone	Sandstone	Sonder,* Gillen,* Middleton,* Krichauff*
		Georgina basin	Dulcie sandstone	Sandstone	Krichauff,* Cherry Creek*
		Ngalia trough		Sandstone, conglomerate, siltstone	Hann*
	Lower Palaeozoic	Georgina basin		Sandstone, quartz greywacke, shale, limestone, dolomite	Hogarth, Tomahawk, Cherry Creek,* Huckitta*
				Dolomite, shale, limestone, sandstone	Ooratippra, Lucy Creek, Ilgulla, Huckitta*

TABLE 8 (*Continued*)

Broad Lithologic Unit	Age		Structural Unit	Named Stratigraphic Unit	Lithology	Land Systems
Sedimentary rocks —folded, faulted, and mainly cemented (continued)	Palaeozoic	Lower Palaeozoic (continued)	Georgina basin (continued)	Sandover beds	Shale, siltstone, limestone, sandstone	Alinga, Ilbumric,* Cherry Creek,* Huckitta*
				Mopunga group (in part)	Quartz greywacke, sandstone, conglomerate, siltstone, dolomite	Sonder,* Ilbumric,* Krichauff*
			Amadeus trough	Larapintine "series"	Sandstone, quartz greywacke, shale, thin limestone	Sonder, Gillen,* Middleton, Kernot,* Chandlers*
				Pertaoorrta "series"	Shale, sandstone, quartz greywacke, limestone	Gillen,* Middleton,* Kernot,* Chandlers,* Huckitta,* Allua,* Renners, Angas,* Pulya*
	Pre-Cambrian	Upper Proterozoic	Ngalia trough		Sandstone, shale, limestone, dolomite	Hann*
			Georgina basin	Mopunga group (in part)	Siltstone, shale, sandstone, arkose, boulder beds, dolomite	Hann,* Sonder*
			Amadeus trough	Pertatataka "series"	Shale, siltstone, boulder beds, quartz greywacke, dolomitic limestone	Gillen,* Chandlers,* Allua,* Pulya,* Coghlan
				Bitter Springs limestone	Dolomitic limestone, limestone, shale	Gillen,* Huckitta,* Allua,* Pulya*
				Heavitree quartzite	Sandstone, silicified sandstone, quartzite	Sonder,* Gillen,* Krichauff*
					Siltstone	Sonder,* Gillen*

TABLE 8 (*Continued*)

Broad Lithologic Unit		Age	Structural Unit	Named Stratigraphic Unit	Lithology	Land Systems
Sedimentary rocks —folded, faulted, and mainly cemented (continued)	Pre-Cambrian	Lower Proterozoic	Warramunga geosyncline	Hatches Creek group	Sandstone, quartzite, conglomerate, siltstone, acid and basic volcanics	Hann,* Davenport, Ilbumric*
				Warramunga group	Sandstone, greywacke, siltstone, shale	Tennant Creek*
Metamorphic and igneous rocks					Granite Quartz-feldspar porphyry, gabbro, basic intrusives	Napperby,* Barrow* Kurundi
			Arunta block MacDonnell–Harts Ranges		Granite, quartz reefs	Unca,* Jinka, Barrow*
		Undifferentiated	Arunta block Mt. Doreen–Reynolds Range		Granite, gneiss, schist, basic intrusives, pegmatite, phyllite, metamorphosed sandstone, amphibolite	Harts,* Napperby,* Aileron, Pularoo, Ryan, Ennugan, Tennant Creek,* Weldon,* Reynolds*
			MacDonnell–Harts Ranges		Gneiss, schist, amphibolite, granite, granodiorite, basic intrusives, pegmatite, dolerite, gabbro	Harts,* Bond Springs, Delny,* Ryan,* Indiana, Unca,* Anderinda
			Mann–Musgrave Ranges		Granite, granodiorite, dolerite, schist, gneiss, pegmatite	Cavenagh,* Outounya*

* Land systems occurring on more than one rock unit.

(3) Soil types are dependent on the lithology of the parent rock. In general, soils developed from igneous and metamorphic rocks are more fertile than those developed from sedimentary rocks (Part VIII).

As geological mapping of the area continues, some of the present ideas on stratigraphy and general geology will undoubtedly be modified; but the land systems outlined in this report will not be affected radically because, geologically, they are based on lithology rather than age.

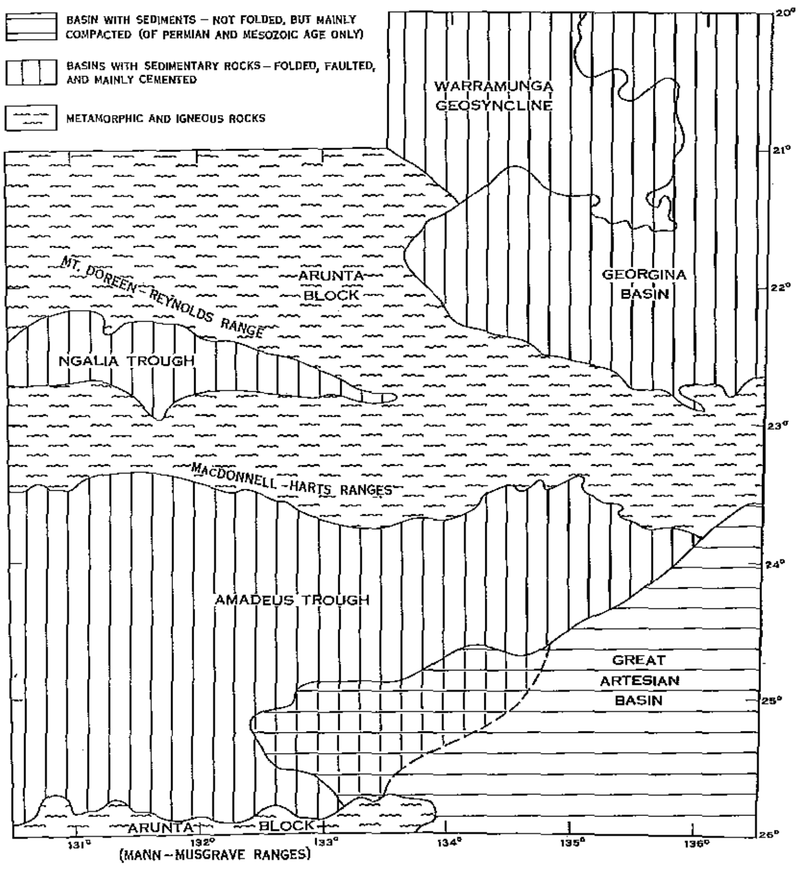

Fig. 8.—Structural units.

II. Structural Units

The Alice Springs area is underlain by portion of the Australian Pre-Cambrian Shield, which consists of folded and faulted metamorphic and igneous rocks. Marine transgressions in Upper Proterozoic, Palaeozoic, and Mesozoic time resulted in the deposition of successive layers of sedimentary rocks over much of the area. The thickness of these sediments varies from place to place and is greatest in four basins which developed in the underlying basement rocks.

Six structural units have been defined. Their boundaries are outlined in Figure 8.

(*a*) *The Arunta Block*

This name has been used (Noakes 1953) for that portion of the Australian Pre-Cambrian Shield which underlies the southern half of the Northern Territory. It has been formed by the metamorphism, folding, and faulting of sedimentary and igneous rocks at several periods during Pre-Cambrian time. Within the Alice Springs area the Arunta block crops out in three main areas: the northern portion of the Mann and Musgrave Ranges near the South Australian border, the MacDonnell and Harts Ranges in the centre of the area, and the area about Mt. Doreen and the Reynolds Range to the north-west of Alice Springs. Elsewhere it is covered by younger sediments that reach a maximum thickness of 30,000 ft in part of the Amadeus trough.

(*b*) *The Warramunga and Davenport Geosynclines*

A thick sequence of sediments and igneous rocks was deposited in the Warramunga geosyncline during the Lower Proterozoic. Following folding and intrusion of granites another thick sequence of sedimentary and igneous rocks was deposited in the Davenport geosyncline which partially overlapped the Warramunga geosyncline. The Davenport geosyncline was also folded and intruded by granites during the Lower Proterozoic.

(*c*) *The Amadeus Trough*

The Amadeus trough (David 1950; Bureau of Mineral Resources 1960) was an intracratonic structure in which sedimentary rocks ranging in age from Upper Proterozoic to Upper Palaeozoic were deposited. The maximum thickness of sediments preserved is between 20,000 and 30,000 ft.

(*d*) *The Georgina Basin*

Portion of the Georgina basin (Bureau of Mineral Resources 1960) lies within the Alice Springs area. In this report, the Cambrian limestone which crops out in the north-east corner of the area and the greywacke which crops out at Barrow Creek and Central Mt. Stuart are considered to have been deposited in this basin.

Toward the end of the Upper Proterozoic the Georgina basin was initiated and apparently linked by a marine transgression with the Amadeus trough. Cambrian and Ordovician marine sediments and Devonian terrestrial sediments are known.

(*e*) *The Ngalia Trough*

Sediments believed to be of Upper Proterozoic and Upper Palaeozoic age are preserved in a large syncline, the Ngalia trough (Tindale 1933; Bureau of Mineral Resources 1960). The total thickness of sedimentary rocks preserved is between 10,000 and 20,000 ft.

(*f*) *The Great Artesian Basin*

Part of the large Great Artesian Basin (Bureau of Mineral Resources 1960) extends into the south-east corner of the Alice Springs area. Cretaceous shales overlie sediments probably of Jurassic and Permian age. Lower Palaeozoic sediments crop out as inliers at Engoordina. The maximum thickness of sediments preserved within the area exceeds 2000 ft.

The basins of deposition may not have been discrete units throughout their development; one or more were probably connected for varying periods. The sediments of Mesozoic and younger age were not confined to any one area or basin, as isolated outcrops of these rocks are widespread throughout the Alice Springs area.

III. General Geology

The three major lithologic units have been subdivided into the 32 rock units shown on the geological map. Some of them can be correlated as approximate time equivalents and these relationships are indicated in the reference of the geological map.

(a) *Metamorphic and Igneous Rocks of Pre-Cambrian Age*

Included in this broad lithologic unit are the oldest rocks which crop out in the Alice Springs area. They are metamorphic rocks consisting of tightly folded and faulted schist and gneiss, which have been intruded by granite, pegmatite, and basic igneous rocks. Originally the metamorphics were sediments—sandstones, limestones, and shales, with some volcanic rocks.

Because of insufficient field work no attempt has been made to subdivide them or to assign relative ages to them. It is convenient, however, to describe them in terms of their geographical position.

(i) *Mann–Musgrave Ranges.*—The belt of older Pre-Cambrian rocks which extends along the South Australian border west from Umbeara forms a portion of the Mann–Musgrave Ranges. These rocks have been described as strongly metamorphosed sedimentary rocks intruded by granite, adamellite, charnockite pegmatites, dolerite dykes, and basic and ultrabasic rocks (Glaessner and Parkin 1957).

Not all these rocks are represented within the Alice Springs area, where the complex consists mainly of granite, granodiorite, schist, and gneiss with several swarms of olivine dolerite dykes. The intrusions of granite appear to be restricted to the eastern portion of the outcrop area. The granite is cut by numerous pegmatitic segregations of graphic intergrowths of microcline–perthite and quartz. The granodiorite, much ofwhich is porphyritic, occurs mainly in the central and western portions.

(ii) *MacDonnell–Harts Ranges.*—The gneissic and schistose rocks of the MacDonnell and Harts Ranges possibly originated as sedimentary rocks with some interbeds of volcanic rocks. These were strongly folded and metamorphosed and subsequently intruded by igneous rocks: acid (granite and pegmatite), intermediate (granodiorite), and basic (gabbro, dolerite, and amphibolite). The main intrusions of granite are limited to the area between the Jervois and the Harts Ranges; basic rocks occur throughout. Pegmatites which bear mica of commercial quality occur only in the Harts Range and in the Plenty River area.

Joklik (1955) has shown the Harts Range to be the "core of an anticlinorium" with the rocks of the Harts Range group "closely folded about axes which plunge parallel" to the axis of the main structure. He divided the metamorphosed sedimentary rocks into several formations. Lithologically the rocks are quartz–mica–

feldspar schist and gneiss with varying amounts of kyanite, garnet, and ferromagnesian minerals. The "facies as observed range from the low-grade greenschist facies to pyroxene hornfels facies".

The structure of the Harts Range is complex; the general structural pattern indicates that there have been two periods of folding and deformation. During the first, the rocks were strongly metamorphosed, foliated, and lineated; during the second the foliation was folded.

(iii) *Mt. Doreen and Reynolds Range.*—Metamorphic rocks and acid and basic intrusives crop out in this area. Two main groups of metamorphic rocks are represented in collections of specimens but their field relations have not been determined nor have they been mapped. The first group consists of gneissic rocks which have suffered intense thermal metamorphism and deformation; it includes garnet–sillimanite gneiss which contains a green spinel. The second group consists of rocks of sedimentary origin (phyllite and metamorphosed sandstone) and some amphibolites, which may be of volcanic origin. They have been subjected to thermal metamorphism but have not been extensively deformed. Quartz schist and quartz–mica schist were also identified in the field.

Regionally, the foliation in the Reynolds Range strikes north-west and dips north-east. West of Mt. Doreen homestead the regional strike swings to the west.

The metamorphic rocks are intruded by granite and by small bodies of basic igneous rocks. The granite is coarsely porphyritic, with aggregations of quartz and microcline phenocrysts up to 9 in. across. The rock has not been much deformed, but is cut by pegmatite and aplite dykes.

Sedimentary rocks, possibly of Upper Proterozoic age, have been faulted and infolded into the metamorphic rocks. The quartzite of the Reynolds Range appears to rest unconformably on the granite.

(*b*) *Sedimentary Rocks of Lower Proterozoic to Upper Palaeozoic Age*

(i) *Lower Proterozoic.*—The arenaceous and argillaceous sediments and the volcanic and hypabyssal rocks which crop out in the Davenport Range are considered to be of Lower Proterozoic age. They have been divided into the Warramunga group (Ivanac 1954) and the overlying Hatches Creek group (Hossfeld 1954), separated by an unconformity (Smith, personal communication).

(1) The Warramunga group consists of strongly deformed and slightly metamorphosed, interbedded sandstone, greywacke, siltstone, and shale, with subordinate grit and conglomerate. They invariably crop out in low rounded rises covered by laterite rubble, and fresh exposures are rare. The group has been intruded by a two-mica microcline granite.

Outcrops of rocks of this group have been traced from Tennant Creek to the northern and western margins of the Davenport Range, a distance of 60 miles in a south-east direction. Rocks of similar lithology crop out 12 miles south-east of Mt. Doreen homestead and 8 miles east of Coniston homestead; these and similar rocks at present mapped as undifferentiated Pre-Cambrian may well be found to correlate with part of the Warramunga group.

Hurley *et al.* (1959) assigned the group to the lower part of the Lower Proterozoic. A potassium–argon age determination on granite intruding the Warramunga group was 1630 million years.

(2) The Hatches Creek group consists of interbedded sandstone, shale, siltstone, greywacke, conglomerate, and acid and basic volcanics. It has been intruded, in the cores of anticlines, by granite, gabbro, and quartz–feldspar porphyry. Sills of basic hypabyssal rocks which intrude sediments of the group have been folded with them. The folding is complex. The axial planes of the anticlines have been deformed to give a sigmoidal trace in plan, and the synclines are long and attenuated, or are faulted out.

Sediments of the Hatches Creek group also crop out in the Crawford and the Osborne Ranges 170 miles north of Alice Springs. Isolated small outcrops have been found on the sand plain north-east of the Davenport Range.

The group has been assigned to the upper part of the Lower Proterozoic (Hurley *et al.* 1959). The potassium–argon age determinations on four granites intruding this group range from 1320 to 1460 million years.

(ii) *Upper Proterozoic.*—Sandstone, limestone, and shale were deposited in the Amadeus and Ngalia trough and in the Georgina basin during this time. As a result of detailed work in some areas, several formations and groups will be defined elsewhere (Smith, unpublished data; Prichard and Quinlan, unpublished data). However, named units do not cover the entire areal extent of these rocks and, in many places, lithological correlations cannot be made where there is no continuity of outcrop. The names, lithology, and relative ages of these units are summarized in the reference on the geological map.

The oldest Upper Proterozoic rocks crop out in the MacDonnell Ranges; they rest unconformably on metamorphic rocks. To the north, progressively younger formations rest on the basement rocks. In the Davenport Range the middle Cambrian Sandover beds unconformably overlie basement rocks of Lower Proterozoic age.

(1) *Amadeus Trough.*—The Upper Proterozoic section at Alice Springs commences with a discontinuous siltstone formation deposited on the uneven surface of the metamorphic rocks. This is followed in turn by the Heavitree quartzite (Heavitree Gap quartzite of Chewings 1928), of approximately 1500 ft of sandstone, silicified sandstone, and quartzite, and by the Bitter Springs limestone (Joklik 1955), 2000 to 3000 ft of interbedded dolomitic limestone, limestone, and shale. Disconformably overlying the Bitter Springs limestone is the Pertatataka "series" (Madigan 1932*a*). The "basal Pertatataka conglomerates" (Madigan 1932*b*) are now known to contain boulder beds with striated and faceted cobbles and pebbles of glacial origin (Mawson 1957; Prichard, personal communication).

Stromatolitic algae are the only fossils which have been found in these rocks. The total thickness of Upper Proterozoic sediments at Ellery Creek (50 miles west of Alice Springs) is about 6000 ft. The thickness and lithology of each of the four units are known to vary along the east-trending MacDonnell Ranges. The thickness of the Heavitree quartzite decreases from 1500 ft at Ellery Creek to 600 ft at Alice Springs. The ratio between the amount of pyritic shale and the amount of dolomitic limestone in the Bitter Springs limestone increases from Ellery Creek to Alice Springs. East of

Alice Springs, the Heavitree quartzite increases in thickness and the ratio of shale to dolomitic limestone in the Bitter Springs limestone decreases.

The "basal Pertatataka conglomerates" at Ellery Creek have been divided into an upper unit, which consists of 550 ft of medium-grained quartz greywacke, and a lower unit, 740 ft thick, consisting of interbedded pebble and cobble conglomerates, boulder beds, and thin lenses of dolomitic limestone (Prichard and Quinlan, unpublished data). The "basal conglomerates" are known to crop out only between the Finke River and Ellery Creek and at Areyonga native settlement, 100 miles south-west of Alice Springs.

The Pertatataka "series" at Ellery Creek, above the "basal conglomerates", is composed of thick beds of shale and siltstone. South-east of Alice Springs, at Aralka Well on the Hale River, the lithological units are not as distinct. The "series" is thinner and the sediments are coarser than at Ellery Creek. More carbonate sediments are present. The lithology of the Pertatataka "series" on Henbury station is similar to that at Aralka Well, but the unit is thicker.

(2) *Georgina Basin.*—A generalized section of the Upper Proterozoic sediments of the Jervois Range (Smith, personal communication) is (in descending order):

725 Ft shale, dolomite, and sandstone

115 Ft coarse to very coarse granite arkose with some boulders, and thin beds of dolomite. This is the Oorabra arkose of Joklik (1955)

40 Ft interbedded boulder beds and beds of thin dolomite

Unconformity

Granite of Lower Proterozoic age

This section constitutes the lower half of the Mopunga group (Noakes 1956); but Smith (personal communication) in redefining the group has detached the lowest 40 ft because of the presence of an unconformity between the boulder beds and the Oorabra arkose.

The top unit of shale, dolomite, and silty sandstone does not vary markedly in thickness or lithology, except that where it lies directly on Pre-Cambrian rocks it is thinner. The variation in the thickness and lithology of the Oorabra arkose and the basal unit is considerable; it appears to be due to the original relief in the floor of the basin of deposition.

(3) *Ngalia Trough.*—The interbedded sandstone, limestone, shale, and dolomite which crop out to the south of Yuendumu Native Settlement and Mt. Doreen homestead have been assigned to the Upper Proterozoic succession. They rest unconformably on the Pre-Cambrian metamorphic rocks, and are overlain unconformably by sediments possibly of upper Palaeozoic age.

(iii) *Lower Palaeozoic.*—In the Georgina basin the base of the Cambrian (K. G. Smith, personal communication) is placed at the base of the "ferruginous quartz greywacke . . . . . about 1300 ft thick", which is the highest unit of the Mopunga group (Noakes 1956).

In the Amadeus basin the base of the Cambrian is placed at the base of the "No. 3 quartzite" of the Pertaoorrta "series" (Madigan 1932*b*). No shelly fossils have been found in the "No. 3 quartzite", but arthropod trails have been found in the formation in the Ross River section, 40 miles east of Alice Springs (Gilbert-Tomlinson, personal communication).

(1) *Amadeus Trough.*—The Upper Proterozoic succession is followed conformably by a sequence of marine sediments of Cambrian and Ordovician age, the Pertaoorrta "series" and the Larapintine "series" (excluding the Mareenie sandstone). Madigan (1932*a*, 1932*b*) described these units at Ellery Creek in some detail. The Cambrian–Ordovician boundary has not yet been established, but it possibly occurs above the base of the Larapintine "series" (Gilbert-Tomlinson, personal communication). The two "series" consist of very thickly interbedded shale, sandstone and quartz greywacke, limestone, and shale and thin limestones. Eight formations will be defined within the two "series" by Prichard and Quinlan (personal communication). The Pertaoorrta "series" increases in thickness from Ross River (40 miles east of Alice Springs) to the west and to the south; this increase is accompanied by a decrease in the carbonate content. The carbonate to clastic ratio at the Ross River is estimated to be 1; this falls to 0·05 at Ellery Creek, to 0·02 at Stokes Pass, 110 miles west of Alice Springs, and to about 0·02 at Areyonga Native Settlement. The Larapintine "series" (excluding the Mareenie sandstone) is 4200 ft thick at Ellery Creek and 8000 ft at Stokes Pass. The limestone and shale formations thicken more than the arenaceous formations. The thickening is not accompanied by marked variations in lithology.

(2) *Georgina Basin.*—A generalized section of the lower Palaeozoic sedimentary rocks of the Georgina Basin is (in descending order):

Dulcie sandstone (Smith, unpublished data)	Devonian	Sandstone
	Unconformity	
	Upper Cambrian–Middle Ordovician	Sandstone, quartz greywacke, limestone, and shale
	Upper Cambrian	Dolomite, with some shale, limestone, and sandstone
Sandover beds (Öpik 1956)	Middle Cambrian	Siltstone, siliceous shale, with thin beds of limestone and fine-grained sandstone
Mopunga group (in part) (Noakes 1956)	Lower Cambrian	"Ferruginous quartz greywacke with some limestone and siltstone—about 1300 ft"

These rocks (excluding the Dulcie sandstone) are of Cambrian and Ordovician age and are approximately 4500 to 5000 ft thick.

The flat-lying sandstone, quartz greywacke, siltstone, and conglomerate which crop out at Central Mt. Stuart and at Barrow Creek are assigned a Cambrian age and correlated on lithological grounds with the quartz greywacke at the top of the Mopunga group.

K. G. Smith (personal communication) found archaeocyathids in lenses of dolomite in the ferruginous quartz greywacke at the top of the Mopunga group. He placed the base of the Cambrian at the base of this unit.

(iv) *Upper Palaeozoic*.—The sedimentary rocks of upper Palaeozoic age and the rocks assigned to the upper Palaeozoic which crop out in the Amadeus and Ngalia troughs and in the Georgina basin rest with regional unconformity on lower Palaeozoic and Upper Proterozoic sedimentary rocks. The thickness of the younger sediments may be great (of the order of 10,000 to 30,000 ft). However, their true stratigraphic thickness may only be in the order of 2000 to 10,000 ft, after allowance has been made for initial dips.

(1) *Amadeus Trough*.—The Mareenie sandstone (Madigan 1932*a*) of the Amadeus trough consists of medium-grained quartz sandstone and silty sandstone. Typically it is cross-bedded on a very large scale: individual sets of cross-beds are up to 100 ft thick, and they may be up to a quarter of a mile long. The sets are smaller (1 to 5 ft) in some areas where the sandstones have an appreciable silt content.

The Mareenie sandstone is correlated with the Dulcie sandstone of Upper Devonian age in the Georgina basin. This correlation is made because of the distinctive lithology common to both sandstones.

Syn-orogenic deposits of the Pertnjara "series" follow unconformably on the Mareenie sandstone. A generalized section of the "series" is (in descending order):

Calcareous sandstone

Boulder and cobble, calcareous and quartzose conglomerate

Red-brown siltstone (of variable thickness)

Red-brown sandstone with fine and coarse pebbles.

The measured thickness at Ellery Creek is 25,000 ft; the true stratigraphic thickness is estimated to be 10,000 ft, after allowing for initial dips.

On the north side of the Missionary Plain the Pertnjara "series" mainly consists of a thick sequence of conglomerate. The number and the size of the boulders and cobbles decrease to the south; on the south side of the Missionary Plain the "conglomerate" consists of calcareous sandstone with some pebbles. Within the thick sequence of conglomerate evidence can be found for at least three main and distinct phases of movement during the orogeny which probably occurred during the upper Palaeozoic.

The arkose of Ayers Rock and the boulder conglomerate of Mt. Olga are lithologically similar to the Pertnjara "series" and are tentatively correlated with it.

The sequence at Mt. Connor of red sandstone with some pebbles, thick siltstone, and current-bedded sandstone is considered to be equivalent to the lower part of the Pertnjara "series" and the Mareenie sandstone.

(2) *Georgina Basin*.—The Dulcie sandstone (after Smith, unpublished data) lies unconformably on sediments of lower Palaeozoic age. The formation consists of approximately 2000 ft of brown medium-grained quartz sandstone and silty sandstone. The basal part is very thickly cross-bedded, but towards the top the sandstone becomes silty and the bedding thinner and more regular.

Fish plates collected from the Dulcie Range fix the age of the formation as Devonian (Hills 1958). This is the youngest known Palaeozoic formation in the Georgina basin.

(3) *Ngalia Trough.*—The folded sequence of pebbly sandstone, conglomerate, and siltstone which rests unconformably on the Upper Proterozoic sedimentary rocks in the Ngalia trough is tentatively considered to be of upper Palaeozoic age. The unit is approximately 10,000 ft thick.

(*c*) *Sediments of Permian to Recent Age*

These rocks have not been folded and dips greater than 5° are uncommon. They may have been compacted and consolidated by the weight of overlying sediments, but in general they have not been cemented. However, at the surface of the ground they may have been lithified by the chemical processes involved in the development of the Tertiary "deep weathering profile".

(i) *Permian.*—The glacial deposits, conglomerate, and silty sandstone which crop out in the area about Crown Point, Yellow Cliffs, and Lilla Creek (within the Great Artesian Basin) are of uncertain age. They have been assigned to the Permian (David 1950). These sediments form the lower portion of the Finke "series" ("Finke River sandstone series" of Chewings 1914). The upper sandstone portion of the "series" is considered to be the De Souza sandstone (of Sullivan and Öpik 1951) of assumed Jurassic age. A regional unconformity separates the De Souza sandstone from the lower portion of the Finke "series". The glacial sediments (or boulder beds) consist of boulders, cobbles, and pebbles, of quartzite and metamorphic and igneous rock, set in a massive matrix of sandy clay. The cobbles and pebbles, which constitute 5 to 10% of the deposit, are striated, faceted, and characteristically of tetrahedral and "flat-iron" shape. The shape and size of the glacial beds vary from lenses 10 to 20 ft thick and 200 ft wide to large massive units of unknown dimensions. They overlie and are interbedded with thinly bedded siltstones and very fine sandstones, which are contorted and deformed. The regional dip is low: less than 5° to the south. Fourteen miles north of east from Kulgera homestead a thick bed of granite-boulder conglomerate and arkose unconformably overlies Pre-Cambrian granite. These sedimentary rocks are tentatively assigned to the basal part of the Finke "series".

(ii) *Mesozoic.*—Erosion between Upper Palaeozoic movements and the start of Mesozoic sedimentation produced relief of the order of 1000 ft in the form of narrow strike valleys and both large and small erosional basins. This relief has been of prime importance in the distribution and preservation of the Mesozoic sediments.

(1) *Great Artesian Basin.*—Drillers' logs and samples from the south-eastern part of the Alice Springs area show that the sedimentary sequence is similar to that in large areas of the Great Artesian Basin. Cretaceous shale overlies the Jurassic to Lower Cretaceous sandstone (Glaessner and Parkin 1957).

Two units have been named in the Alice Springs area from surface outcrop, the Rumbalara shale and the De Souza sandstone (Sullivan and Öpik 1951). The two formations are separated by a regional unconformity. The greatest thicknesses known are, for the shale, 1127 ft in the Anacoora bore, and for the sand, 860 ft in the Charlotte

Waters bore. The sections in these bores are not complete, and the complete units must be thicker.

Lithologically the De Souza sandstone is a brown, thinly current-bedded, friable, ferruginous quartz–sandstone. No fossils have been found and a Jurassic age has been tentatively assigned to the formation.

The Rumbalara shale is a sequence of shale, claystone, and fine-grained sandstone. At Rumbalara an ochreous bed of claystone approximately 5 ft thick occurs near the base of the formation. In outcrops along Coghlin Creek there are at least two ochreous beds. The formation is of Lower Cretaceous age (Sullivan and Öpik 1951).

(2) *Minor Basins and Piedmonts.*—At some time during the Mesozoic, probably in the Lower Cretaceous, the sea moved northward and westward from the Simpson Desert embayment of the Great Artesian Basin, flooding the strike valleys and erosional basins. The northern limit of this transgression is not known. Sediments, possibly of Mesozoic age, crop out at Barrow Creek, and the northernmost areas of these sediments known from bore-hole data are on Willowra, Pine Hill, Bond Springs, and Mt. Riddoch stations.

The Mesozoic or pre-laterite sediments cannot always be distinguished in bore-hole samples from the unconformably overlying Tertiary to Quaternary alluvium; until fossils allow of their separation the basin and piedmont deposits of Mesozoic and Cainozoic age are considered as one rock unit. Lithologically the group consists of gravel, sandy clay, shale, and clay.

The lithology and the morphology of these sediments suggest that, though most are marine, some were deposited in a piedmont environment. It is thought that as the old alluvial fans grew they coalesced to form a deposit with a prismatic shape.

On the northern front of the MacDonnell Ranges Mesozoic sediments filled old river valleys. These sediments were penetrated in the "16 Mile Bore", 16 miles north of Alice Springs. Basement of schist was struck between 617 and 639 ft. In the "16 Mile Bore . . . the sediments consist predominantly of shale with some beds of grit" (Hossfeld 1954). Crespin (1950, unpublished data) found "lignite . . . glauconite . . . gypsum . . . numerous spherical bodies referred to radiolaria, fragments of molluscan shells, and an ostracod" in samples from this bore, and suggested that they were of Lower Cretaceous age.

Basin and piedmont sediments are also known to occur below the Todd River flood-plain (immediately south of Alice Springs) and at the northern margin of the Mann and Musgrave Ranges.

(3) *Undifferentiated.*—Within the MacDonnell and Harts Ranges the maximum thickness of Mesozoic sediments is between 100 and 300 ft. Lithologically the sediments are claystone, sandy siltstone, and siltstone.

At Kalamerta Creek, north of Kulgera homestead, there is a thick bed of arkose at the base of the sequence.

(iii) *Tertiary*

(1) "*Deep Weathering Profile*".—The whole area was raised above sea-level by post-Mesozoic earth movements and subjected to a long period of erosion and

weathering. During this period laterite and grey billy profiles were developed. These two types of profile are considered to be complementary: a grey billy profile developed on a parent rock with a low iron content, and a laterite profile on a parent rock with a high iron content.

The upper surface of the "deep weathering profile" as it is preserved is a broad regional dome with superimposed local relief of approximately 100 ft or so. It rises about 20 miles north of Alice Springs to an elevation of 2350 ft. Approximate elevations at other points on this surface are Kulgera 1650 ft, Tennant Creek 1200 ft, near Mt. Razorback (100 miles west of Alice Springs) 2300 ft, and south-west of Arltunga 2200 ft. In addition to the local relief, residuals of older Pre-Cambrian, Proterozoic, and Palaeozoic rocks stand above this surface in the MacDonnell and Harts Ranges. They are probably remnants of older erosion surfaces which underwent further weathering during this period.

The warping which produced this regional doming is considered to be, in part, of Quaternary age. It has been partly responsible for the rejuvenation of stream erosion which has now almost exhumed the pre-Mesozoic land surface in the MacDonnell and James Ranges. This is discussed in more detail in Part VII.

(2) *Chalcedony, Calcareous and Gypsiferous Silt.*—Irregularities and erosional depressions in the surface of the "deep weathering profile" became small freshwater basins of deposition later in the Tertiary. These are now filled with thin sequences of interbedded chalcedony, calcareous silt, and gypsiferous silt.

Gastropods and lamellibranches have been obtained from these sediments at Arltunga and gastropods from outcrops near the Phillipson Pound. The calcareous sediments are restricted to the basins near the MacDonnell Ranges; to the south, in the area about Erldunda and Mt. Ebenezer, the silt interbedded with the chalcedony is gypsiferous.

(iv) *Quaternary.*—Quaternary sediments cover 104,400 sq. miles of the 144,400 sq. miles of the Alice Springs area. They have been assigned to two main groups: Pleistocene–Recent, and Recent. Their absolute ages are not yet known.

Much of the outcrop area of Quaternary deposits is underlain by Mesozoic and Tertiary basin and piedmont sediments.

The Quaternary deposits which have been mapped are:

(1) *Terrace Gravel.*—On the southern flank of the western MacDonnell Ranges a thin layer of gravel lies on the bevelled surface of calcareous sandstone of the Pertnjara "series". The boulders, cobbles, and matrix are derived and have been transported from topographically higher outcrops of the Pertnjara "series". Similar gravels exist within the strike valleys of the MacDonnell and Reynolds Ranges, where the boulders are derived from the walls of the valleys. These gravels are thought to be associated with a period of erosion during the Pleistocene.

(2) *Evaporite and Clay.*—There are two main areas of salt lakes, the Lake Amadeus and the Central Mt. Wedge systems. These are basins of internal drainage in which clay has accumulated, and salts have been concentrated by evaporation from surface waters and from ground water. The stratigraphy and economic significance of the deposits have yet to be studied.

(3) *Kunkar, Calcrete, and Alluvium.*—On the edges of the salt lakes are areas of calcareous accumulation from ground water. Calcium carbonate has been deposited as large concretionary masses of travertine within the alluvium to form kunkar, or as a calcareous cement in the alluvium to form calcrete.

Small deposits of nodular travertine and calcrete also occur in drainage channels and on the slopes of low rises, with Mesozoic shale at shallow depth, in the Mt. Ebenezer and Kingston Range area. Though superficially similar to the kunkar deposits about the salt lakes, they may have been deposited from soil moisture or from perched ground water.

(4) *Aeolian Sand.*—Both ancient and active seif-type dunes and redistributed aeolian sand cover large portions of the Alice Springs area. There are two main trends, north-north-west in the eastern portion of the area and east–west in the western portion, apparently controlled by the prevailing winds. The ancient dunes and the redistributed sand fields are fixed by vegetation.

(5) *Recent Sediments.*—The soil, the creek alluvium, and the wash forming the alluvial fans are superficial, and are discussed in Part VIII.

IV. References

Bureau of Mineral Resources (1960).—Tectonic map of Australia, Scale 40 miles to 1 in. (Bur. Min. Resour. Aust.)

Casey, J. N., and Gilbert-Tomlinson, Joyce (1956).—Cambrian geology of the Huckitta–Marqua region, Northern Territory. *In* El Sistema Cambrico, su Paleogeografia y el Problema de su Base, part 2. 20th Int. Geol. Congr., Mexico. (Also in Bur. Min. Resour. Aust. Bull. No. 49, 1957, pp. 55–74.)

Chewings, C. (1914).—Notes on the stratigraphy of central Australia. *Trans. Roy. Soc. S. Aust.* **38:** 41–52.

Chewings, C. (1928).—Further notes on the stratigraphy of central Australia. *Trans. Roy. Soc. S. Aust.* **52:** 62–81.

David, T. W. E. (1950).—"The Geology of the Commonwealth of Australia." Vol. 1. (Arnold: London.)

Glaessner, M. F., and Parkin, L. W. (Editors) (1957).—The geology of South Australia. *J. Geol. Soc. Aust.* **5:** 80–101.

Hills, E. S. (1958).—Record of *Bothriolepis* and *Phyllolepis* (Upper Devonian) from the Northern Territory of Australia. *Trans. Roy. Soc. N.S.W.* **92:** 174–5.

Hossfeld, P. S. (1954).—Stratigraphy and structure of the Northern Territory of Australia. *Trans. Roy. Soc. S. Aust.* **77:** 103.

Hurley, P. M., Fisher, N. H., Pinson, W. H., Fairbairn, H. W., Smith, K. G., and Walpole, B. P. (1959).—Geochronology of Proterozoic granites in the Northern Territory. U.S. Atomic Energy Comm. Rep. NYO–3940: 122–49.

Ivanac, J. F. (1954).—The geology and mineral deposits of the Tennant Creek gold-field, Northern Territory. Bur. Min. Resour. Aust. Bull. No. 22.

Joklik, G. F. (1955).—The geology and mica-fields of the Harts Range, central Australia. Bur. Min. Resour. Aust. Bull. No. 26.

Madigan, C. T. (1932*a*).—The geology of the western MacDonnell Ranges, central Australia. *Quart. J. Geol. Soc. Lond.* **88:** 672–710.

Madigan, C. T. (1932*b*).—The geology of the eastern MacDonnell Ranges, central Australia. *Trans. Roy. Soc. S. Aust.* **56:** 71–117.

Mawson, D. (1957).—The Sturtian glacial horizon in the MacDonnell Ranges. *Aust. J. Sci.* **19:** 162.

Mawson, D., and Madigan, C. T. (1930).—Pre-Ordovician rocks of the MacDonnell Ranges (central Australia). *Quart. J. Geol. Soc. Lond.* **86:** 415–29.

NOAKES, L. C. (1953).—The structure of the Northern Territory with relation to mineralization. 5th Emp. Min. & Metall. Congr. **1**: 284–96.

NOAKES, L. C. (1956).—Upper Proterozoic and sub-Cambrian rocks in Australia. *In* El Sistema Cambrica, su Paleogeografia y el Problema de su Base, part 2. 20th Int. Geol. Congr., Mexico. (Also in Bur. Min. Resour. Aust. Bull. No. 49, 1957, pp. 213–38.)

ÖPIK, A. A. (1956).—Cambrian geology of the Northern Territory. *In* El Sistema Cambrica, su Paleogeografia y el Problema de su Base, part 2. 20th Int. Geol. Congr., Mexico. (Also in Bur. Min. Resour. Aust. Bull. No. 49, 1957, pp. 25–54.)

SULLIVAN, C. J., and ÖPIK, A. A. (1951).—Ochre deposits, Rumbalara, Northern Territory. Bur. Min. Resour. Aust. Bull. No. 8.

TINDALE, N. B. (1933).—Geological notes on the Cockatoo Creek and Mt. Liebig country, central Australia. *Trans. Roy. Soc. S. Aust.* **57**: 206–17.

PART V. THE MINERAL DEPOSITS OF THE ALICE SPRINGS AREA

By G. R. RYAN*

The mineral deposits of the Alice Springs area occur in six distinct geographic districts (Fig. 9). The districts, their constituent localities, and the principal products are given in Table 9. The main mineral-producing localities are shown on the geology map.

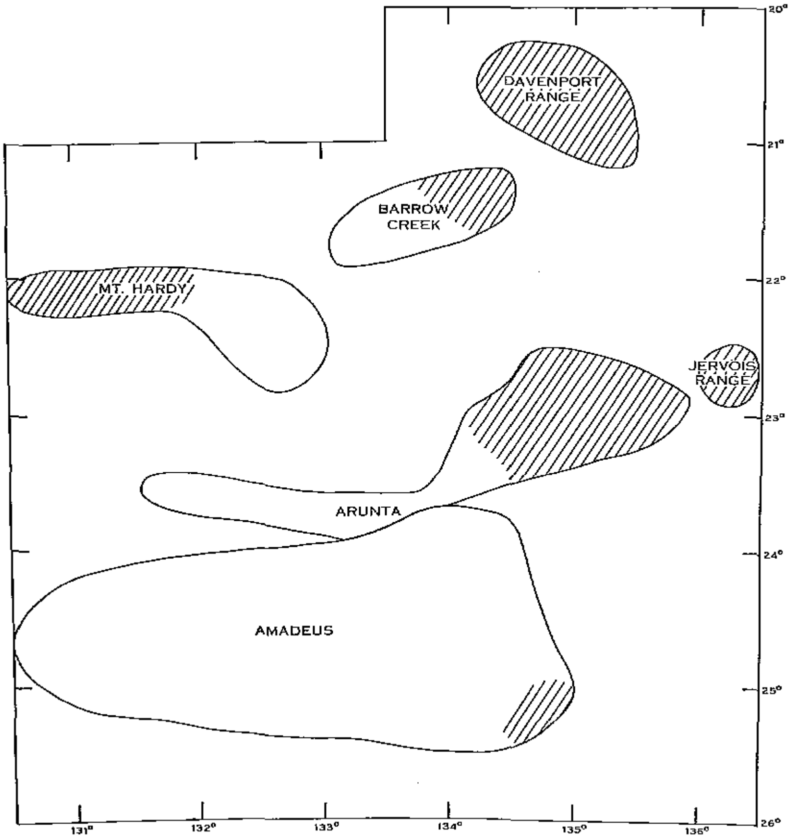

Fig. 9.—Mineral districts of the Alice Springs area. Shaded areas indicate major occurrences of minerals.

The Davenport Range, Barrow Creek, Mt. Hardy, and Jervois Range districts are mineralogically and genetically very similar; they contain tungsten and copper and small amounts of gold, bismuth, tin, tantalum, silver, lead, and zinc. All these deposits, as far as is known, are epigenetic, and derived from granite. The Arunta

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and Amadeus districts are distinct from the other four and from each other. The mineral deposits of the Arunta district are, with few exceptions, epigenetic and

TABLE 9
MINERAL DISTRICTS AND THEIR PRODUCTS

District	Major Occurrence		Minor Occurrence	
	Locality	Product	Locality	Product
Davenport Range	Hatches Creek Wauchope Mosquito Creek	Tungsten,* bismuth, copper (gold)† Tungsten (tin) Tungsten (uranium)	Woodenjerrie Kurundi Silver Valley Bonny Well Elkedra Skinner Pound	Tungsten Gold Lead Copper (Copper, tungsten) (Copper)
Barrow Creek	Home of Bullion	Copper,* lead, zinc	Anningie Ivy	Tin, tantalum Tantalum, tin, tungsten
Mt. Hardy	Mt. Hardy Mt. Doreen Mt. Singleton	Copper Tungsten Tungsten,* copper	Lander Brooks Soak Coniston Vaughan Springs Yuendumu Tilmouth Well	Copper Tungsten Tin Lead,* copper, silver Copper, tungsten (Iron)
Jervois Range	Jervois Range	Copper,* lead, zinc, silver (bismuth)	Bonya	Copper,* bismuth
Arunta	Harts Range Plenty River Arltunga Undippa	Mica,* (uranium, beryl) Mica Gold Mica	Strangways Range Pinnacles Delny Haasts Bluff Goyder Pass	Mica,* copper (phosphate, uranium) Copper, limestone Tungsten,* tin, tantalum (Copper) (Nitrate)
Amadeus	Rumbalara	Ochre	Areyonga Owen Springs Ooraminna Alice Springs Lake Amadeus Erldunda Jay Creek	Copper Copper Building stone Aggregate, lime, building stone (Salt) (Gypsum) (Ochre)

*Principal product.
†Brackets denote non-producer.

derived from granite, but they include pegmatitic products such as mica and beryl, as well as metallic ores. The deposits of the Amadeus district are primarily of sedimentary origin.

Geologically the six mineral districts are more diverse. The Hatches Creek group, which is probably of Lower Proterozoic age, is host to most of the mineral deposits in the Davenport Range district, except at Mosquito Creek, where the host rock is the Lower Proterozoic Warramunga group. The age of the rocks in the Barrow Creek district and the Mt. Hardy district has not been established, as very little work has been done in these areas. The rocks have been subjected to varying degrees of metamorphism, and they are considered to be older Pre-Cambrian. Farther south, the metamorphic rocks of the Arunta district are also older Pre-Cambrian, and the host rocks of the Jervois district are a north-eastern extension of the Arunta district.

Metalliferous deposits are almost unknown in the Amadeus district, with the exception of some unimportant copper lodes in the Lower Palaeozoic sandstone at Areyonga and Owen Springs. Lower Palaeozoic and Upper Proterozoic sandstone and limestone are used as building stone in Alice Springs. The Rumbalara ochre deposits lie at the base of Lower Cretaceous rocks. Lime is won from travertine near Alice Springs, and evaporite in the more arid areas south of Alice Springs has been tested as a possible source of salt and gypsum.

Mica and tungsten are the principal mineral products from central Australia. The Arunta district is Australia's most important source of mica; the value of mica production since 1892 is slightly more than £1,000,000. Wolfram and scheelite concentrates from Hatches Creek have realized £1,300,000 since 1915. This mineral field has also produced some bismuth. Tungsten at Wauchope and Mt. Doreen, copper at the Jervois Range and the Home of Bullion mine, ochre at Rumbalara, and gold at Arltunga are the next most important deposits. None of the mineral deposits, except the mica at Harts Range and Plenty River, is large by Australian standards.

The distance from markets and the aridity of the country have discouraged exploration and will continue to do so. On present evidence the mineral potential does not appear large but intensive prospecting has so far been restricted to small areas.

The oil possibilities of the portions of the Amadeus trough and Great Artesian Basin within the area are under investigation. In the Georgina basin a trace of oil was found in Cambrian limestone at Ammaroo but oil prospects are probably better east of the Alice Springs area.

PART VI. AN OUTLINE OF THE WATER RESOURCES OF THE ALICE SPRINGS AREA

By N. O. JONES* and T. QUINLAN*

I. INTRODUCTION

Parts of two large simple ground-water basins, the Great Artesian Basin and the Barkly basin, are included in the area. Elsewhere individual aquifers are of limited areal extent, because of stratigraphic and structural complexity.

Before 1939, shallow wells and a few bores had been used to supplement the natural waters. Since 1945, there has been a rapid and continuing growth in the number of bores. New pastoral properties are being developed which are dependent on bores for permanent waters. Few bores have been drilled deeper than 600 ft except in the area of the Great Artesian Basin, where several bores have been drilled to 1000 ft. Approximately 1000 pastoral watering points are used in the area. Assuming that the feeding radius for stock is 5 miles, the area which can be grazed from the existing surface waters and bores, allowing for overlap, is about 53,000 sq. miles.

Surface water is quite common in certain parts of the area, and is particularly useful in areas where it is difficult to obtain supplies of ground water. It can also be used to supplement bores.

Ground-water conditions in the area are varied, and in many cases complex. Drilling has shown a wide distribution of ground water useful for stock purposes although probably only about a third of the bores have been successful. Much information has been collected on the occurrence and quality of ground water, but quantitative data on resources are still lacking.

Areas of outcrop of the main types of aquifers in the area are indicated on the geological map and the existing bores and surface waters are shown on the pasture lands map. Form-lines on the piezometric surface,† the boundaries of the ground-water provinces, and areas possibly suitable for irrigation are shown on the ground-water provinces map.

II. SURFACE WATERS

(a) *Natural*

Many of the natural water-holes are used to water stock. They are of three types:

(i) *Permanent Water-holes.*—Permanent water-holes are situated at the foot of high sandstone ridges within the MacDonnell, James, Dulcie, and Davenport Ranges. The grazing areas around them are limited but have a good carrying capacity. These

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† Piezometric surface is used to describe the level of standing water in wells and bores under both free and confined conditions.

water-holes are continuous with the main body of ground water, which is held at or near the surface of the ground by regional aquicludes. The quality of water is good, except in a few localities where it is salty, e.g. the Glen Helen water-hole, where salts have been dissolved from the limestone to the north. Tempe Downs station depends almost entirely on natural waters of this type for stock water.

(ii) *Seasonal Water-holes.*—Seasonal water-holes occur along the main water-courses for varying periods after rain. Soakage waters in the shallow alluvium provide the supply. When this fails, evaporation and consumption dry up the holes, some becoming salty during the process. Important water-holes of this type occur in the beds of the Hugh and Finke Rivers.

(iii) *Water-holes and Clay Pans.*—Small depressions, water-holes, and clay pans occur on almost all the pastoral leases and hold water for short periods after falls of rain from which there has been run-off. They may be useful temporary watering points for stock. In some places the storage capacity has been increased by excavation.

(*b*) *Artificial*

In addition to these natural waters, artificial storages have been constructed on many properties, generally in areas where drilling for water has been unsuccessful. The duration of these waters depends on their storage capacity, the amount of rainfall and evaporation, the stocking rate, and the quantity of water lost by seepage. Slatyer (Part III) estimates the annual expectation of falls of rain adequate to replenish surface catchments.

III. Ground Water

(*a*) *Occurrence*

Three main groups of aquifer, corresponding to the broad lithologic units (Part IV), are recognized. The surface distribution of these lithologic units is known in general, but it is their distribution below the piezometric surface which is significant, because although a rock may be porous and permeable it must lie below the piezometric surface before it is an aquifer.

(i) *Metamorphic and Igneous Rocks.*—In this group the only aquifers are fractured, jointed, and weathered zones. In many areas the rocks have not been substantially weathered, and few joints remain open within the zone of saturation. Where the deep weathering profile is preserved, ground-water prospects may be considerably improved. Drilling in areas of granite has failed to disclose important aquifers in decomposed zones, although they are known near Tennant Creek.

Aquifers in these rocks are generally small, irregular, and difficult to predict. The quantity of ground water stored is relatively small, and drilling may be slow and expensive.

(ii) *Sedimentary Rocks, Mainly Folded, Faulted, and Cemented.*—The aquifers are sandstones and limestones which, except for those of the Barkly Tableland, have been moderately folded and faulted. Few of the sands have not been cemented, but many of the sandstones have a significant intergranular porosity and permeability. The harder sandstones ("quartzites" in local usage) commonly possess a well-developed joint system which may be open within the zone of saturation. Some horizons in the limestones have well-developed joint systems or solution cavities. Shales, silty sandstones, and silty limestones (e.g. the Pertnjara "series" and the Sandover beds) rarely yield useful quantities of ground water because of their low permeability, even where they are reasonably porous.

Aquifers within the sediments of Upper Proterozoic to Middle Palaeozoic age (e.g. the Larapintine "series" and the Pertaoorrta "series") are extensive, and they store large quantities of readily available ground water. Where adequate information is available, individual aquifers can be traced or predicted through large areas. The necessary drilling depth to such aquifers (or the depth at which water will be struck) may also be predicted from the geological structure. In some areas, e.g. the Missionary Plain, the required depth of drilling may be too great to be economic.

(iii) *Sediments Not Folded but Mainly Compacted.*—The aquifers are flat-lying and, with the exception of the limestones, are not cemented.

In the south-east of the area they form part of the Great Artesian Basin, in which the presence of interconnected aquifers overlain by a regional aquiclude results in extensive subartesian and artesian conditions.

Elsewhere the marine and terrestrial sediments occur either as valley fills or as piedmont deposits. The aquifers are sands and gravels which occur as irregular lenses with variable degrees of interconnexion.

In some areas, e.g. Erldunda and Curtin Springs, the weathered Tertiary chalcedony and calcareous siltstone have not been satisfactorily distinguished from the Quaternary kunkar. Both are useful aquifers, but salinity and recharge conditions may be different.

Where the flat-lying sediments do not extend into the zone of saturation, ground water can be obtained only from the older underlying rocks. Thus aquifers in flat-lying sediments are not as extensive as implied by the area of outcrop of these sediments; the actual reduction in area is difficult to predict in areas of poor outcrop and where the zone of saturation is 200 to 500 ft below the surface of the ground.

Drilling and development problems are not uncommon in "drift sand" in the alluvium. Improvement in techniques would increase the yield from many bores and would enable some aquifers, at present not used, to be developed.

(*b*) *Hydrology*

(i) *Piezometric Surface.*—The piezometric surface ranges in depth from 0 to 500 ft below the land surface. The piezometric form-lines indicate that the major topographic relief of the area is reflected in the relief of the piezometric surface which shows a general fall from the highest points, in the MacDonnell, Reynolds, and Musgrave Ranges, to the Simpson Desert in the south-east and to the Barkly Tableland in the north-east. In hilly areas the relief of the piezometric surface is less than that of the land surface and is also less than would be expected in humid areas under similar geological conditions.

The average depth to the piezometric surface is also related to the type of aquifer. It is shallowest in and near the salt lakes and within most of the outcrop areas of the Quaternary kunkar, usually less than 30 ft. In the metamorphic rocks it is relatively shallow and depths greater than 100 ft are uncommon except where the metamorphics have a thick alluvial cover. In the areas of folded sedimentary rocks the average depth to the piezometric surface is somewhat greater, but the actual depths are much more variable because of the influence of large geological structures. It is deepest in the elevated marginal areas of the large simple sedimentary basins. In the areas about the Goyder River and to the north-east of the Davenport Range, it is from 300 to 500 ft below the land surface.

Both free and confined ground waters are widespread and their areas of distribution commonly overlap. In many cases, particularly in the alluvial aquifers, the presence of confined waters cannot be predicted. The only extensive artesian area is in the extreme south-east, although local artesian conditions occur in other places, e.g. Tuit's bore at Palm Valley.

Perched ground waters are common, particularly in the alluvium along the major streams. Commonly they are not permanent, but some constantly yield large quantities of good-quality water to shallow wells. When the main ground water is saline, the perched waters may be the only useful supplies available.

(ii) *Recharge.*—The recharge of ground water comes entirely from the rain falling on the area or the adjacent ranges. Most of the rain does not infiltrate below the zone of soil moisture and is thus lost by evaporation and transpiration without adding to the ground-water resources.

Entry of water to an aquifer is, in general, dependent on concentration of water by run-off. The most effective recharge conditions are those where, as at Alice Springs, run-off from a large hilly catchment area is channelled over a permeable bed with direct connexion to an aquifer. As all streams are influent throughout their course a study of the surface drainage system considered in relation to the distribution of aquifers should indicate the major ground-water recharge zones.

In many areas lacking a surface drainage system the occurrence of ground water with low salinity suggests that significant recharge must also occur from local run-off concentrations, e.g. from dune crests to swales. Recharge will occur only where the floor of the run-on area is sufficiently permeable.

The only quantitative recharge data available are those for the Alice Springs basin. They indicate that in favourable areas run-off may be 5 to 10% of the total rainfall, although much of this run-off will not be added to the ground water. In unfavourable areas, therefore, recharge must be a very small part of the rainfall. An average recharge rate equal to 1% of rainfall would add 2×10^5 million gallons per year to the ground water stored in the Alice Springs area; actual recharge is certainly greatly in excess of current pumping (some 10^3 million gallons per year) as there is no sign of regional depletion.

Recharge is very irregular, as it is dependent not only on the amount and intensity of rainfall but also on the frequency of exceptionally wet periods.

(iii) *Loss of Ground Water.*—Ground water is lost by subsurface flow from the area, by evaporation and transpiration, and by pumping. In the eastern half of the area, the main loss is by subsurface flow towards the Barkly Tableland and the Great

Artesian Basin. The piezometric form-lines on the ground-water map indicate the direction of flow and the extent of the area draining in these directions.

Ground-water loss by evaporation is largely confined to the salt lakes and adjoining areas. Piezometric and salinity information show that the near-surface moisture in these lakes is supplied from ground water except for short periods after rain. Loss by transpiration is more widespread but is confined to areas where the zone of saturation is close to ground surface. No estimate of the relative importance of evaporation and transpiration is possible, but together they account for the greater part of the ground-water loss from the western half of the Alice Springs area.

Under natural conditions the piezometric surface was essentially stable, that is, recharge approximately balanced loss. Pumping of water causes a lowering of the piezometric surface but if safe yield is not exceeded the amount will eventually be balanced either by induced recharge or by a decrease in natural loss. Thus available recharge is the limiting factor in ground-water development, if excessive withdrawal from storage is to be avoided.

(iv) *Quality.*—The ground-water salinity pattern in the Alice Springs area is complex. Contributing factors are the variety of aquifer types and their degree of interconnexion, the proportions and solubilities of salts in the rocks, and the relationship of areas of ground-water recharge and loss.

None of the aquifers tapped by bores is believed to retain a major proportion of connate water. In areas with simple stratigraphy, structure, and recharge pattern, such as the Cambrian sediments north-east of the Davenport Range, ground-water salinity is relatively uniform. The presence of regional aquifers and good recharge permits the existence of good to moderate-quality waters throughout this area.

Where aquifers are small and disconnected, with an uneven pattern of recharge and with local areas of evaporation, extreme local variations of salinity occur. In the Alice Springs town basin, with an area of only 3 sq. miles, the content of total dissolved solids ranges from 70 to 23,000 p.p.m. Similar variations are known in other areas.

In addition to the range in total salinity, there is a wide range in the proportions of different salts in ground water. Certain rock types provide abundant salts; for example, the high sulphate content of the waters of many of the limestones and sandstones in the Amadeus basin is due to the oxidation of the pyrite in these beds and in the interbedded shales. The bores at Haasts Bluff settlement, drawing from the pyritic Bitter Springs limestone, were condemned for human consumption because of the high sulphate content (800 p.p.m.) of water with total dissolved solids of 1800 p.p.m. A high proportion of magnesium appears to be characteristic of water from some metamorphic aquifers.

The more saline waters generally move very slowly. The less saline waters are generally more mobile and the source of their salts is not readily traced to a particular bed, largely because of the effects of mixing with recharge waters. The recharge waters are commonly of low salinity, as all streams are influent throughout their courses and the waters are inland rain-waters which have had little opportunity to dissolve salts from the atmosphere or from the rocks which crop out in the catchment area.

During the movement of water through the aquifers the chemical character of the water may change substantially. The changes have not been studied in detail, but the enormous quantities of kunkar deposited in the area marginal to the salt lakes indicate the extent of change.

In some areas, e.g. near New Well and Tilmouth Well on the Burt Plain, the better-quality water appears to be present as a layer above the saline water. In other places such as Mt. Peebles bore, shallow saline water is separated from underlying good-quality water by an impervious bed. In the Henbury–Rodinga area there are many places where better-quality ground water occurs adjacent to, and possibly overlies, saline ground water; the saturation appears to be due to more favourable conditions of recharge in small areas. If bores in this area are over-pumped, the quality of water obtained from them deteriorates rapidly with the encroachment of the main mass of saline ground water, e.g. Mt. Gloaming bore on Henbury station.

Pollution of ground water has not been a common problem in central Australia, although some of the shallow soakage waters are polluted by cattle. In general, the depth to the piezometric surface and the low concentration of organic material limit the possibilities of pollution.

(c) *Resources*

The total ground-water resources of the area are more than adequate for likely pastoral development, although locally it may not be possible to obtain a suitable or a sufficient supply. In some of these places surface waters can be used.

In many areas ground water suitable for town supplies is available. However, such areas are commonly small and detailed investigations are necessary before heavy local development can be undertaken safely.

Areas with ground water suitable for irrigation are discussed separately.

The ground-water resources cannot be quantitatively assessed until more basic data are obtained on water levels, permeability, and recharge; but they can be qualitatively assessed on the basis of the 15 ground-water provinces shown on the ground-water map.

(i) *Ground-water Provinces*.—The provinces are defined principally by the types of aquifer present. Some generalizations of both boundaries and characteristics have been necessary and accordingly some exceptions can always be found to the characteristics attributed to any one province. The main characteristics of the provinces are summarized in Table 10.

Several qualitative terms are used to describe the characteristics of the provinces and arbitrary limits have been assigned to them. Depth is referred to as shallow if it is less than 100 ft, moderate if it is between 100 and 250 ft, and deep if it is more than 250 ft. Good-quality water contains less than 1500 p.p.m. of total dissolved solids, and generally is suitable for human consumption. Moderate-quality water contains between 1500 and 7000 p.p.m. of total dissolved solids and generally is suitable for all stock. Above 7000 p.p.m. the water is considered to be saline and may not be suitable for stock.

TABLE 10

GROUND-WATER PROVINCES

Province	Aquifers	Depth to Piezometric Surface*	Drilling Depth*	Quality†	Availability
Davenport	Fractured quartzites and volcanics of Lower Proterozoic age in complex structures	Shallow to moderate depth below local base level of erosion	Depends in part on geological structure, generally moderate	Generally good to moderate, but may be saline in areas of sediments of the Warramunga group	Moderate, commonly confined to topographically inconvenient locations
Barkly	Fractures and solution cavities in limestone and dolomite and some porous sandstone, all of Cambrian age	Deep	Deep	Moderate to good	Good except near margin where bedrock is above piezometric surface
Wycliffe	Unconsolidated sands in alluvium; and Quaternary kunkar	Shallow to moderate	Shallow to moderate	Mostly good to moderate; may be saline to the north-west	Good except near southern margin
Sandover	Fractured and porous Upper Proterozoic and Palaeozoic sandstones, limestones, and dolomites	Generally moderate, may be deep in the north-east	Moderate to deep	Moderate to good	Good except for small areas underlain by thick shales or very hard dolomite
Stirling	Porous and fractured Palaeozoic sandstones	Moderate to deep	Moderate to deep	Good to saline	Good where sandstones extend below the piezometric surface
	Quaternary sands and kunkar	Shallow	Shallow	Good to moderate	Good in kunkar areas, variable in shallow alluvium
	Fractured and weathered zones in metamorphic rocks	Shallow	Shallow to moderate	Moderate or saline	Poor

TABLE 10 (*Continued*)

Province	Aquifers	Depth to Piezometric Surface*	Drilling Depth*	Quality†	Availability
Lander	Quaternary kunkar	Shallow	Shallow	Good to moderate	Good
	Minor basins and piedmonts	Shallow to moderate	Shallow to moderate	Good to moderate	Generally good
	Weathered and fractured metamorphic rocks	Shallow to moderate	Shallow to moderate	Moderate to saline	Poor
Plenty	Minor basins and piedmonts	Variable	Variable	Good to moderate	Variable
	Weathered zones in metamorphic rocks	Shallow to moderate	Shallow to moderate	Variable	Generally poor
Coniston	Fractured and weathered zones in metamorphic rocks; sands in small pockets of creek alluvium	Commonly shallow	Shallow to moderate	Very variable, depending on local conditions of recharge	Poor; some areas of granite with almost no prospects
Hann	Sandstones and limestones of Upper Proterozoic and Palaeozoic age	Moderate	Moderate to deep	Moderate	Variable
	Sands in minor basins and piedmonts	Shallow to moderate	Shallow to moderate	Good to moderate	Generally good
	Quaternary kunkar	Shallow	Shallow	Moderate to saline	Good
	Weathered zones in metamorphic rocks	Moderate	Moderate to deep	Moderate	Poor
Hermannsburg	Sandstone and limestones of Upper Proterozoic and Palaeozoic age, with pockets of Mesozoic and Quaternary sands	Variable	Dependent on geological structure	Very variable; some areas with mainly saline water	Variable; dependent on geological structure

TABLE 10 (*Continued*)

Province	Aquifers	Depth to Piezometric Surface*	Drilling Depth*	Quality†	Availability
MacDonnell	Fractured and weathered zones in metamorphic rocks; sands in pockets of alluvium	Shallow	Generally shallow	Variable depending on local recharge	Generally poor, except in larger alluvial pockets
Karinga	Mesozoic sands and Cainozoic limestones	Generally shallow, deeper towards southern margin	Shallow to moderate	Good to moderate in areas of good recharge, elsewhere saline	Good but many areas with saline water
Kulgera	Fractured and weathered zones in metamorphic and igneous rocks	Generally shallow	Shallow to moderate	Variable depending on local recharge conditions	Poor
Simpson	Mesozoic sand	Deep near western margin, shallower eastwards, artesian conditions in south-east corner	Deep to very deep	Good to moderate except in marginal areas of poor recharge	Good, except near northern and western margins

*Shallow = <100 ft; moderate = 100–250 ft; deep = >250 ft.
†Good = <1500 p.p.m. total dissolved solids; moderate = 1500–7000 p.p.m. t.d.s.; saline = >7000 p.p.m. t.d.s.

IV. Irrigation Water

Because surface water is unlikely to be used for irrigation (Part XII) the following discussion is confined to ground water. The ground-water provinces provide a satisfactory basis for the consideration of stock waters, as stock require a relatively wide distribution of watering points each with a relatively low yield, and only moderate quality is necessary. However, when considering waters for irrigation, much more stringent conditions must be applied.

A preliminary assessment of the ground water suitable for irrigation in the area, and its agricultural significance, has been made by Perry, Quinlan, and Jones (personal communication), using the following arbitrary limits:

Pumping lift	Shallow	0–50 ft
	Moderate	50–100 ft
	Deep	>100 ft
Quality (U.S. Department of Agriculture 1954; Durand 1959)	C3	0–1500 p.p.m. T.D.S.
	C4	1500–3200 p.p.m. T.D.S.
	C5	>3200 p.p.m. T.D.S.
Annual recharge	Small	$<10^3$ ac. ft.
	Moderate	10^3–10^4 ac. ft.
	Large	$>10^4$ ac. ft.
Storage	Small	$<10^4$ ac. ft.
	Moderate	10^4–10^5 ac. ft.
	Large	$>10^5$ ac. ft.

Insufficient data were available to discuss rate of yield.

On overseas experience these criteria are restrictive but their use will define areas where irrigation is most likely to be economic and which are suitable for the irrigation of a wide range of crops. The soils over the withdrawal points are all coarse-textured and permeable and therefore have a low salinization hazard.

Table 11

Estimations of mean annual recharge and storage in the six most probable areas

Catchment	Mean Annual Recharge ('000 ac.ft.)	Storage (million ac.ft.)
Narwietooma	17·6	1·6
Hamilton	19·5	0·8
Woolla–Harpers	10·8	1·6
Tea Tree	10·2	
Ingallana	4·9	Insufficient data
Stirling (moderate quality only)	7·0	

Throughout the area quantities of suitable ground water adequate to irrigate a few acres can be found on most station properties. However, using these criteria 19 areas (Fig. 10) were selected as possibly having adequate supplies of suitable quality water to support irrigated agriculture. As the catchments of these include the majority of the larger rocky areas which provide the bulk of the ground-water recharge, few others are likely to be found in the future.

From the 19 areas the 6 best known were selected for more detailed consideration, including estimates of annual recharge and storage. Calculations of recharge were based on the assumption that fixed proportions of the rain falling on the various

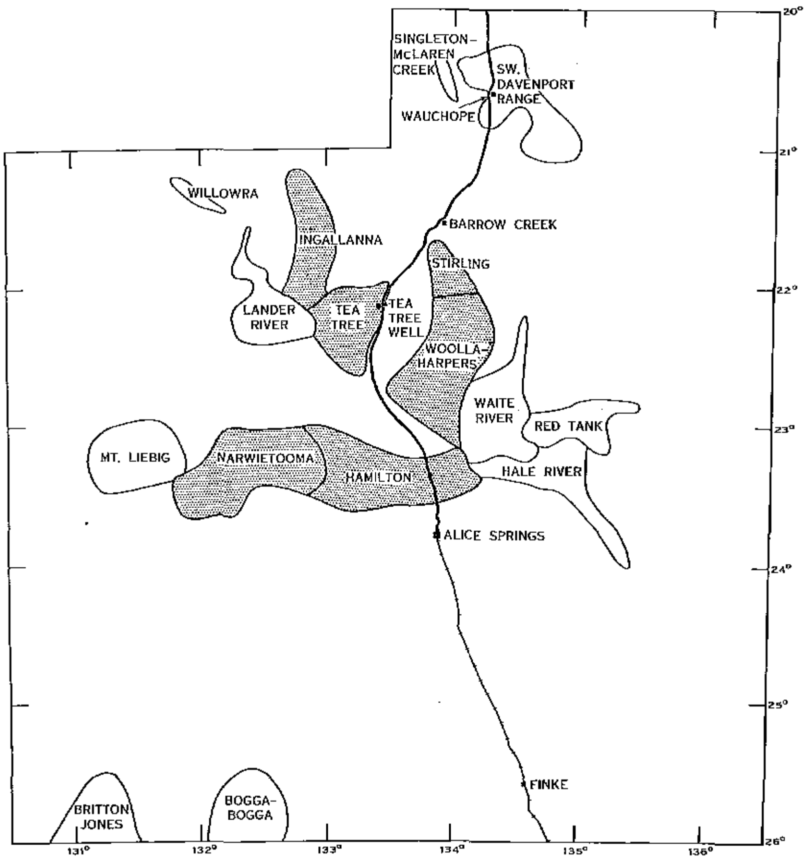

Fig. 10.—Locations of catchments. Those shaded are the most promising and are considered in more detail in the text.

physiographic units are added to ground water. The assumed ratios were 3% for mountains and hills, 1% for undulating plains, alluvial fans and flood-plains, and limestone plains, and nil for sand plains and salt lakes. Storage was obtained by estimating the volume of saturated aquifer commanding depths of 50 ft and 100 ft at withdrawal points and multiplying by an assumed coefficient of storage (0·05). A summary of the estimation on the six most probable areas and of the available information on the other 13 catchments is given in Tables 11 and 12 respectively.

TABLE 12

CHARACTERISTICS OF OTHER CATCHMENTS

Catchment	Area of Mountains and Hills in Catchment (sq. miles)	Mean Annual Rainfall (in.)	Aquifer	Recharge*	Storage†	Depth‡ at Withdrawal Point	Quality §	Remarks
Lander River	950	11	Sands in piedmonts and possibly basins	Large	Large	Moderate	C3	Infiltration may be poor
SW. Davenport Range	1040	12	Basin sands and kunkar	Large	Large	Moderate to shallow	Variable	In several small areas
Mt. Liebig	310	10	Basin sands and kunkar	Moderate	Large	Shallow to moderate	Mainly C4 some C3	—
Willowra	?	12	Basin sands and kunkar	Unknown	Large	?Shallow	?C5	—
Bogga Bogga	Not estimated	8	Mesozoic sands, Tertiary limestone and kunkar	Moderate	?Large	?Moderate	Unknown	Withdrawal point indefinite
Britton Jones	Not estimated	8	Mesozoic sands, Tertiary limestone and kunkar	Moderate	?Large	?Moderate	Unknown	Withdrawal point indefinite
Waite River	900	10	Tertiary limestone and alluvium	Large	?Small	Shallow and moderate	?C3	Areal extent of aquifer unknown
Red Tank	590	10	Basin sands	Large	Large	Shallow	?C3	Withdrawal point indefinite
Hale River	1640	10	Sediments in small basins, and possibly marginal sands of Great Artesian Basin	Large	Unknown	Shallow	C3	Withdrawal point indefinite
Tempe Downs	30	8	Palaeozoic sandstones, broadly folded	Moderate	Moderate	Moderate	Unknown	Aquifer characteristics uncertain
Lalgra	?	8	Palaeozoic sandstones, broadly folded	Moderate	Moderate	Shallow	?C3	Aquifer characteristics uncertain
McDills	?	—	Great Artesian Basin sands	Large	Large	Shallow	C4	Possible serious decline in pressure head

*Large = $>10^4$ ac. ft.; moderate = 10^3–10^4 ac. ft.; small = $<10^3$ ac. ft.
†Large = $>10^5$ ac. ft.; moderate = 10^4–10^5 ac. ft.; small = $<10^4$ ac. ft.
‡Shallow = <50 ft; moderate = 50–100 ft; deep = >100 ft.
§C3 = <1500 p.p.m. total dissolved solids; C4 = 1500–3200 p.p.m. t.d.s.; C5 = >3200 p.p.m. t.d.s.

The figures quoted for recharge and storage are estimations based on limited data. However, they are large enough to justify investigations to prove them. If proven they are adequate to justify the establishment of a limited irrigated agriculture. This is discussed more fully in Part XII.

V. References

Durand, J. H. (1959).—The quality of irrigation water. *Afr. Soils* 4: 52–88.
United States Department of Agriculture (1954).—Diagnosis and improvement of saline and alkali soils. U.S.D.A. Agric. Handb. No. 60: 1–160.

PART VII. GEOMORPHOLOGY OF THE ALICE SPRINGS AREA

By J. A. Mabbutt*

I. Introduction

This Part begins with a description of the physical regions of the area, establishing a regional vocabulary for the later sections. This is followed by a history of the physical landscape, which explains the genetic classification of the land systems. The physical features are described in this genetic grouping, emphasis first being given to common features of each group, followed by a short account of the distinguishing features of each land system.

II. Physical Regions

The Alice Springs area lies at the heart of the continent. It includes three relief provinces of very different character—the southern desert basins tributary to Lake Eyre basin, the central ranges which form the main east–west drainage divide, and the northern uplands and plains that slope regionally north-westwards to the Sturt Plain and north-eastwards to the Georgina River and Barkly Tableland (Fig. 11).

(*a*) *Southern Desert Basins* (*55,000 Sq. Miles*)

More than three-quarters of this province is dune-covered and without organized surface drainage.

(i) *The Amadeus Depression.*—This forms the western part, consisting of Lake Amadeus, a large salt pan at 1550 ft above sea-level, its tributary slopes with dune fields, rising to 2000 ft near the central ranges and towards the Musgrave Ranges in the south, and the limestone plains and smaller pans which occupy the axis of the depression in the east.

(ii) *The Simpson Desert.*—This extends into the eastern half and is divided into an inner dune field with low stony tablelands, occupying the south-east corner and lowest portion of the Alice Springs area, and a dissected marginal tract where the dunes are limited by stony plains, plateaux, and isolated sandstone ranges. A third subregion of the Simpson Desert is the Plenty River plains in the north-west, a tributary lowland with sand plain, flanked by erosional plains. The Simpson Desert is separated from the Amadeus depression by the Finke River, which has been responsible for dissection of the desert margin and which has formed a barrier against dune extension.

(iii) *The Southern Granite Hills and Plains.*—These limit the Amadeus depression on the south, and constitute the piedmont of the Musgrave Ranges. The plains descend eastwards from 2100 to 1750 ft above sea-level, with scattered hills up to 500 ft high.

(*b*) *Central Ranges* (*15,000 Sq. Miles*)

These form an almost unbroken belt more than 250 miles long and, at its maximum, 100 miles from north to south.

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(i) *The Folded Central Ranges.*—These have a distinctive pattern of east–west ridges and narrow vales (Plate 12, Fig. 1; Plate 15, Fig. 1) and form the larger southern portion. There are two belts; the broader southern and eastern fold ranges comprise the Krichauff, James, and eastern MacDonnell Ranges and the narrower northern arm consists of the western MacDonnell Ranges. The two belts enclose a sandy intermont lowland, the Missionary–Todd Plain. In the southern and eastern ranges

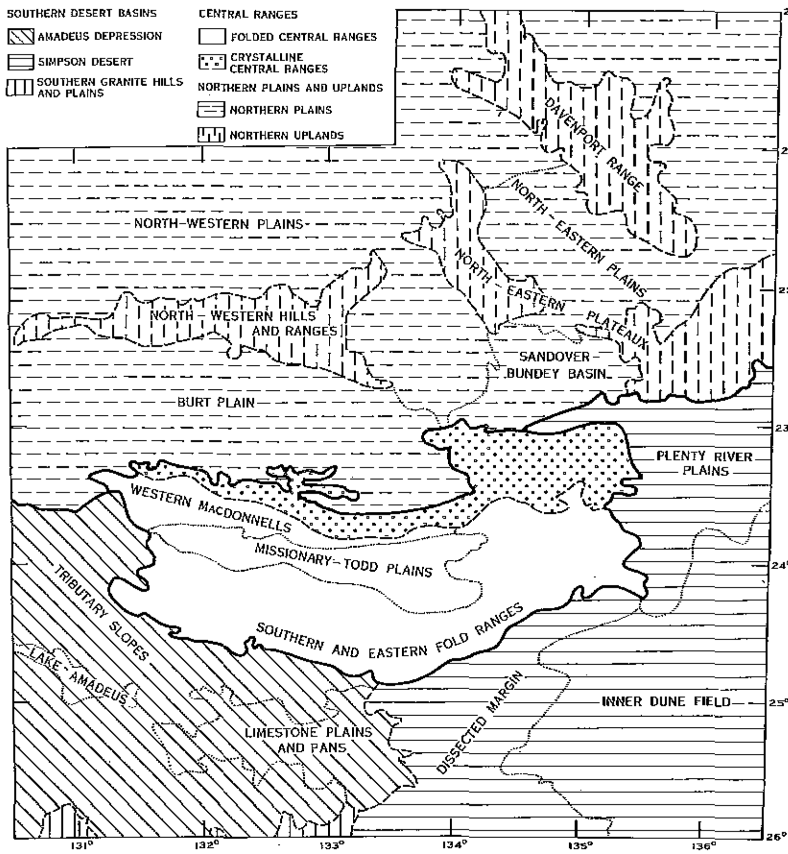

Fig. 11.—Physical regions.

the summits rarely surpass 2400 ft, with less than 500 ft relief, whereas the crests of the western MacDonnells are mostly between 2750 and 3000 ft, with up to 1000 ft relief and with higher peaks which attain 4470 ft above sea-level in Mt. Sonder.

(ii) *The Crystalline Central Ranges.*— These are a belt of gneiss and schist which forms the northern part of the MacDonnell Ranges. Relief locally exceeds 2000 ft, and the highest mountain is Mt. Zeil (4955 ft).

The drainage divide is mostly in the crystalline central ranges, and the upper drainage of the Finke, Todd, and Hale Rivers escapes southwards through impressive gaps in the folded central ranges.

(c) *Northern Plains and Uplands* (*75,000 Sq. Miles*)

North of the central ranges there is a complex of uplands and extensive plains which form parts of separate internal drainage units.

(i) *The Northern Plains*.—Each comprises a perimeter peneplain and an inner depositional tract, characteristically with sand plain and locally with salt lakes. There is an over-all fall in altitude northwards.

The Burt Plain, north of the central ranges, lies between 2000 and 2300 ft above sea-level at its eastern end and has a very gentle fall westwards; its drainage axis is marked by a belt of salt pans flanked by calcrete plains.

The Sandover–Bundey basin lies between 1800 and 1450 ft above sea-level further east. This is an area in which a rejuvenated drainage has formed erosional plains with low hills and plateaux; the flood-plains of the upper Sandover River and its tributaries occupy the lower parts.

The north-western plains descend north-westwards from 1800 to 1200 ft above sea-level, and are drained by several large channels, including the Hanson and Lander Rivers, which die out in the sand plain.

The north-eastern plains descend to 800 ft in the north-east corner of the area. The most important drainage element is the disrupted Sandover River system.

(ii) *The Northern Uplands*.—These comprise plateaux and bevelled ranges which lack the bold outlines and strong relief of the central ranges.

The north-western hills and ranges bound the Burt Plain on the north and form an unbroken upland 200 miles long, broadening eastwards where it forks and encloses the plains of the upper Hanson River. The uplands are mainly of granite, with quartzite ranges prominent in the east — the Reynolds Range — and in the extreme west; relief is generally below 500 ft.

The Davenport Range consists mainly of folded sandstones with a north-westerly trend; the bevelled crests only locally exceed 1500 ft above sea-level and relief is typically less than 500 ft.

The north-eastern plateaux form an arcuate belt south and east of the Davenport Range; in the west they are formed of sandstone, as in the Barrow Creek uplands and the Dulcie plateau, whilst the lower Lucy Creek plateau in the extreme east is formed of limestone. The plateaux are bounded on the south by prominent escarpments and by the dissected Huckitta–Jervois Range. The plateau summits descend gently north-eastwards towards the lower Sandover drainage.

III. The Formation of the Physical Landscape

(a) *Active Land-forming Processes*

Under the dry climate which prevails in the Alice Springs area, the initial breakdown of rocks and the comminution of rock debris are slow. Hill slopes remain steep, rocky, and boulder-mantled, and geological structure is clearly expressed in relief. Occasional heavy rains cause "flash" run-off, leading to short episodes of flood flow with heavy load. The minor channels deposit their load as alluvial plains at the hill foot: major drainage persists as sand-filled channels in sandy alluvial flood-plains and ends in alluvial basins and lowlands, except for the Finke and Sandover Rivers which drain beyond the area. Thus the lowlands are essentially zones of accumulation under which the lower erosional surfaces have been buried, emphasizing the simple contrast of hill and plain typical of arid landscapes.

However, the land forms of the Alice Springs area have evolved over a long period during which changes in climate and erosive energy have occurred, and they cannot be understood apart from the geomorphological history.

(*b*) *Tertiary Planation and Deep Weathering*

In Mesozoic time the area now forming the central ranges was high ground with sea on the north-west and south-east. The transgressive Cretaceous seas must have invaded a region of strong relief, for marine siltstones of this age have been recorded from bore sections in the Burt Plain, nearly 3000 ft below the summits of the crystalline ranges only a few miles to the south (Crespin, unpublished data). Marine Mesozoic sedimentation in the south-east was approximately co-extensive with the Lake Eyre basin, the southern granite hills and plains forming a land area on the west. The outline of the present physical landscape — a central area of highland forming a watershed for drainage feeding into depositional lowlands to the north and south-east — thus has its origin in the geography of the Mesozoic era.

Following marine withdrawal in the Upper Cretaceous, drainage was extended, and a long period of erosion formed a land surface of little relief. The plain was best developed on the soft, flat-lying Cretaceous sediments in the south-east of the area, where it survives in the summits of dissected plateaux and on the lower gibber tablelands which extend into South Australia. The monotonous northern plains are also the result of this planation acting over uniform crystalline rocks. The folded sediments in the Davenport Range were bevelled, as shown by the flat crests now surviving in these ranges (Plate 14, Fig. 1). Subdued relief persisted in the folded central ranges, the harder quartzite ridges were only partially bevelled and there was some infilling of strike vales. Planation was more advanced on the gently folded softer sandstones to the south of these ranges, although relief was still conditioned by structures in the underlying rocks. The crystalline central ranges underwent little summit bevelling and remained a watershed zone, south of which the transverse drainage (Plate 15, Fig. 1) of the folded central ranges had been established.

The perfection of the old land surface indicates an integrated drainage and a humid climate, and this is corroborated by the deep weathering associated with it. In the crystalline rocks, weathering was selective and best developed in the lower areas, with the formation of pisolitic ironstone gravels above mottled and pallid zones in kaolinized rock. Subsequent dissection has revealed even greater depths of weathering of the Cretaceous Rumbalara shales in the south-east and also of the argillaceous Palaeozoic sediments south of the folded central ranges, where structure is commonly obliterated to depths exceeding 50 ft. It is generally the mottled and pallid zones which now survive, the uppermost lateritic horizon having been stripped off. The range-building quartzites and sandstones were naturally more resistant to weathering.

Associated with the weathered land surface, more particularly on the deeply weathered argillaceous rocks, are silcrete duricrusts up to 30 ft thick. Related secondary quartzites occur as superficial horizons on quartzites and sandstones. The resistant silcretes give rise to the flat-topped mesa and escarpment "breakaways" (Plate 12, Fig. 2; Plate 14, Fig. 2) which typify the south-east of the Alice Springs area. They form extensive gibber tablelands mantled with derived silcrete fragments (Plate 11, Figs. 1 and 2).

(c) Dissection of the Weathered Land Surface in the South of the Area

To this stage it has been possible to consider the area as a unit, but with later events it is necessary to distinguish between that part tributary to the Lake Eyre basin, which has undergone crustal warping, and the northern and western areas, which have been relatively stable and in which the weathered land surface has been less modified.

The duricrust cappings in the south-east have a regional fall to the south and east due to late Tertiary subsidence of the Lake Eyre basin. This subsidence caused dissection of the weathered land surface along the margins of the basin and incision of its tributary drainage in the central ranges.

With renewed stability, a lower planation surface was formed. It is particularly well developed on softer rocks in catchments tributary to the Finke River in the south-east, where it passes into a high terrace along the main channel. These lower plains rise westwards, and meet the undissected older land surface in the Amadeus depression west of the Finke drainage catchment and in the southern granite hills and plains, which were also unaffected by the younger cycle.

(d) Modification of the Weathered Land Surface in the North of the Area

At the time that subsidence of the Lake Eyre basin took place, relative uptilting also occurred about the margin of the Barkly Tableland, north-east of the Alice Springs area. It affected the folded Davenport Range as well as the flat-lying sandstones and limestones to the south-east. These, together with the old planation surface, were downwarped in a north-easterly direction. A renewal of stream incision followed, etching out the softer strike belts in the Davenport Range and forming the north-eastern plateaux on the tilted rocks to the south-east. The effects of this erosive phase were confined to a narrow peripheral zone; elsewhere, only the slightest renewal of erosive activity occurred, resulting in stripping and moderate dissection of the weathered peneplain in piedmont zones.

(e) Establishment of Internal Drainage

During the cycle of erosion below the weathered land surface, the climate became semi-arid, the outgoing drainage was truncated and partly disorganized, and the present internal drainage pattern was formed.

Deposition was widespread on lower ground south of the central ranges, piedmont gravel aprons formed south of the western MacDonnells, and great thicknesses of alluvium accumulated on the Missionary–Todd plains. Sandy plains formed on the flanks of the Amadeus depression, the lower parts of which were occupied by seasonal lakes, of which the present Lake Amadeus is a vestige. These eventually retracted and left extensive limestone plains. More widespread depositional plains were formed by the larger channels entering the Simpson Desert basin. With the cessation of drainage, parts of these deposits became cemented with surface limestone, as in the gravel terraces of the Finke River. The erosional plains formed below the old land surface in this area also received a widespread mantle of secondary limestones.

Internal drainage was also established north of the central ranges. The Burt Plain drained to lakes along its axis, and the tributary plains formed zones of sandy alluviation which encroached on the weathered peneplain up slope. Limestone plains were formed on the drying out of these lakes, and alluvial trains in valleys on the old land surface further north were also calcreted. Further east, extensive lacustrine limestones formed in the Sandover–Bundey basin, in the area of the Plenty River plains, and in basins in the crystalline central ranges. Limestones were also laid down unconformably on weathered surfaces in Phillipsons Pound and at the east end of the Missionary–Todd plains. The Sandover and Elkedra Rivers, now cut off from the Georgina River, deposited their alluvia in the north-eastern plains. The Frew River, in the far north-east, was tributary to a lake system on the Barkly Tableland.

(*f*) *Aeolian Sand Distribution and Later Drainage History*

Increasing aridity led to wind re-sorting of the sandy alluvium and the formation of sand dunes and sand plain on lower ground. The largest area of sand dunes is the Simpson Desert, where parallel dune ridges are continuous over tens of miles on the calcified plains eroded below the weathered land surface. From the homogeneity of the dune systems and from their geomorphological setting, it would seem that only one major phase of aeolian sand movement has occurred in the Alice Springs area. In the south-east, dunes and sand plain are confined to the plain eroded below the weathered land surface, and do not normally encroach on the youngest valley plains; in the less dissected north and west, sand has encroached on the limestone plains which overlie the weathered land surface. This fixes the sand movement at a fairly late stage in the evolution of the area.

Subsequent amelioration of climate is indicated by the resumption of limited drainage incision, probably in part induced by further subsidence of the Lake Eyre basin. There has been strong dissection of freshwater limestones by the upper Sandover and Plenty River systems, and also in the upper Hale and other intermont basins. The gravel aprons south of the western MacDonnells have been dissected up to 50 ft. The Finke River has locally cut down 90 ft into its calcreted gravels and its tributary drainage in the south-east is similarly incised below the dune plains. In the lowest parts, much of the newer drainage is merely of the flood-out type, controlled by dune trends, or following regional slopes into the sand plain.

There is evidence that the effectiveness of drainage has decreased since this phase of downcutting, and that the zone of deposition has moved up-valley. The limestone terraces of the Finke River disappear beneath its flood-plain near New Crown homestead, and alluviation has extended up its entrenched tributaries. The narrowness of the active piedmont fans reflects the limited power of minor drainage in the upland belts.

IV. The Land Systems

The history of the physical landscape, as given above, forms a basis for the grouping of the land systems which follows. Four main classes, each with several groups, are described together with the characteristic geomorphological features of the 88 land systems. The land forms of each land system are described in greater detail in Part II.

(a) *Erosional Weathered Land Surface*

In this class of land systems the erosional cycle which formed the weathered land surface is still operative. The land systems comprise the oldest landscape elements in the area and are accordingly found in its most stable parts. They occur mainly north of the folded central ranges, with smaller extent in the southern granite hills and plains. They are underlain mainly by granite, gneiss, and schist, but in the far north occur over large areas of sedimentary rocks.

They have a wide relief range, from mountainous watersheds in the crystalline central ranges to the erosional lowlands which occupy much of the northern plains. There is widespread evidence of deep weathering on these plains.

(i) *Mountains of Gneiss and Granite.*—There is only one land system in this group.

(1) *Harts land system* is formed mostly by the crystalline central ranges, which consist mainly of gneiss, closely dissected and with about 1000 ft relief. Steep rectilinear hill slopes with much boulder cover are characteristic, and the valleys are normally very narrow, with small alluvial tracts where rock barriers have caused deposition. The land system lacks the regular structural patterns of the folded ranges and forms some of the most inaccessible terrain in the area.

(ii) *Hills and Plains of Granite, Gneiss, or Schist.*—Erosion of the Harts land system has caused lateral retreat of hill slopes, giving rise to isolated hills and ridges and fringing erosional plains which are continuous with the selectively weathered peneplain. The uplands are similar to those of the Harts land system, although generally lower; the plains range from short pediments to extensive gently undulating surfaces. These land systems also include belts of schist, which give rise to closer dissection with strong structural control, and which form rugged terrain of moderate relief.

(2) *Bond Springs land system* consists mainly of massive gneiss ridges as in the Harts land system, but with minor lowlands, including short pediments and discontinuous alluvial plains along the drainage channels. It is developed in the heads of several catchments in the crystalline central ranges.

(3) *Napperby land system* is formed mainly on granite and consists of domes and tors, with minor gneiss ridges, and fairly extensive erosional plains.

(4) *Cavenagh land system* also consists of granite hills and plains, but is situated in the southernmost part of the area. The plains show increasing drainage energy eastwards. In the west they are masked by sand; in the central part they are fairly stable stony plains with low dyke ridges; in the east the weathered surface has been replaced largely by gently undulating younger plains, and is represented only by the flat crests and lateritic cappings of scattered low hills.

(5) *Aileron land system* consists of granite hills and mainly depositional plains.

(iii) *Peneplains on Weathered Granite, Gneiss, or Schist.*—These erosional surfaces now survive mainly at the foot of ranges of crystalline rocks, up slope from the alluvium and sand plain which occupy the lower tracts. Because of their situation, they are rarely flat, although relief generally does not exceed 20 ft. Broad convex divides, with occasional outcrop and a general cover of quartz stone, alternate with wide, flat-floored valleys; areas of less relief and drainage energy are generally sandier.

These plains underwent selective rather than general weathering, and lateritic crusts typically occur on the lower margins of the interfluves. They are commonly lightly dissected, indicating a small subsequent renewal of drainage incision.

(6) *Boen land system* consists of erosional plains developed on weathered schist and gneiss.

(7) *Warburton land system* is a plain eroded on weathered granite, schist, and gneiss. It differs from the Boen land system in the more general weathering of its underlying rocks and in its more active trunk drainage, which has led to shallow dissection of the weathering zone along the margins of the interfluves.

(8) *Tietkins land system* consists of granite plains south of the Amadeus depression. The southern part is a stable surface of selectively weathered granite but the plain becomes increasingly covered by sand and calcrete northwards.

(9) *Outounya land system* comprises granite and schist plains east of the Tietkins land system, where the drainage is generally more competent and where there are fewer surface deposits. In the north-west, it is a flat plain with little surface drainage, but it is increasingly dissected eastwards. This dissected belt marks the edge of the old weathered plains, and the surfaces to the east are eroded in fresh granite, with some alluvial cover in the south.

(iv) *Sandstone and Quartzite Ranges.*—There is only one land system in this group.

(10) *Hann land system* consists of sandstone and quartzite uplands, strike ranges, and their tributary slopes, above the old land surface north of the central ranges. Relief is generally smaller than in the central ranges and single ridges are more characteristic than multiple ranges. Because of regional stability, the depositional lowland units in this land system have undergone little erosion.

(v) *Peneplains or Undulating Terrain on Weathered Sedimentary Rocks.*—In the far north of the area, beyond the flood-outs of the larger drainage channels, there are extensive tracts in which the weathered land surface has not been buried. It is developed on flat-lying shale, sandstone, and limestone, with minor areas of closely folded older rocks. These rocks are less uniform than the crystalline rocks, and land forms are consequently more varied.

These land systems are particularly extensive in the north-east of the area; in the north-west they form broad tongues marking higher portions of the old peneplain, the intervening depressions being occupied by sand plain. Wind re-sorting of a residual sandy cover has obliterated or disorganized surface drainage.

(11) *Wonorah land system* is a gently undulating stony plain on which more resistant sandstone forms minor ridges and hills.

(12) *Alinga land system* consists of undulating terrain on folded Palaeozoic sandstone, shale, and thin limestone, with lines of low hills formed by more massive sandstone. The weathered surface has undergone slight dissection and forms stony rises with lateritic gravel.

(13) *Ooratippra land system* is a flat plain with little surface drainage, formed on flat-lying interbedded dolomite, limestone, and shale, and is situated where the old peneplain slopes down northwards from the Lucy Creek plateau.

(*b*) *Partially Dissected Erosional Weathered Land Surface*

Differences in lithology and structure have produced a variety of forms on the weathered land surface. The land systems in this group have resulted from the partial destruction of that land surface, and they combine an inherited relief with the effect of later erosion cycles. The older surface generally has survived as upland units, commonly with weathered rock.

Dissection has been controlled largely by the geological setting. Where unfolded resistant strata have been dissected, the former land surface has survived as plateau summits, and silcrete duricrusts have played a similar role on the softer sediments in the south-east. In other areas, notably where the former peneplain was developed on crystalline rocks, there has been only slight stripping and dissection.

(i) *Dissected Planed Surfaces on Weathered Granite, Gneiss, or Schist, with Minor Limestone Cover*.—The land systems in this group have been formed by moderate to strong dissection of peneplains on weathered crystalline rocks, notably in areas with drainage tributary to the Lake Eyre basin. They generally occur in headwater areas. The land forms comprise relict watershed areas of weathered peneplain—locally with cappings of limestone—benches formed in the weathering profile, pediments and alluvial plains in or derived from the weathering zones, and younger erosional surfaces (Plate 8, Fig. 2) formed in fresh rock. Maximum relief ranges from 75 to 150 ft.

(14) *Chisholm land system* has been formed by narrow drainage entrenchment below a peneplain formed on weathered schist and gneiss, giving rise to flat-crested interfluves and steep-sided flat-floored valleys.

(15) *Delny land system* is characterized by strong dissection of a weathered peneplain on schist and gneiss, by moderately extensive plains formed at a lower level, and also by the calcareous environment due to remnants of a former limestone cover.

(16) *Kulgera land system* consists of moderately dissected plains of weathered schist on the eastern margin of the southern granite hills and plains. Dissection has followed weathered valley tracts in the former plains. These are separated by broader interfluves of relatively fresh rock.

(17) *Pularoo land system* is a former granite and gneiss plain into which a close network of alluvial valley floors is entrenched.

(ii) *Stripped, Lightly Dissected Planed Surfaces on Weathered Granite, Gneiss, or Schist*.—This group of land systems has been formed mainly by stripping and slight dissection of the Boen land system and it shows a similar distribution, replacing the latter in upper piedmont zones and in the catchments of more active drainage. Erosion has proceeded by shallow stripping rather than by linear drainage incision; the old land surface survives extensively, and relief is normally less than 20 ft. Because of the selective nature of earlier weathering, lateritic cappings form only a minor unit, although derived alluvial plains may attain moderate proportions.

(18) *Alcoota land system* consists of plains on schist and gneiss in which there has been selective erosion of zones of deeper weathering, giving rise to slightly broken terrain.

(19) *Ryan land system* consists of an eroded peneplain on weathered granite and gneiss. Land forms vary with increasing dissection eastwards towards the Sandover River. The more stable areas are undulating plains with small hills of fresh granite, and locally stripped and lightly dissected weathered surfaces. In the more dissected parts further east, the old land surface is reduced to a few higher interfluves, or to laterite-capped crests of low granite hills in plains eroded in or below the weathering profile.

(20) *Ennugan land system* differs little in land form from Alcoota land system, but the gneiss is traversed by schist belts which have undergone more general weathering and more advanced subsequent dissection, and in these zones the older land surface survives only in low laterite-capped platforms and ridges.

(iii) *Dissected Ranges of Folded Sedimentary Rocks with Summit Planation.*— These land systems occur mainly in the folded central ranges, in the Davenport Range, and in the smaller Huckitta–Jervois Range. They form mountain complexes, owing their magnitude to the repetition of the sandstone by folding, as in the Davenport Range, or to the great thickness of rock undergoing differential erosion, as in the western MacDonnells. They range from mountainous areas without significant valley plains to ridge-and-vale terrain (Plate 12, Fig. 1), in which strike lowlands have been eroded on interbedded softer strata. They also include single outlying ranges with their tributary slopes, as in the north-western hills and ranges.

Most of the strike ridges underwent summit bevelling (Plate 14, Fig. 1) or rounding to some degree during the earliest cycle. Some weathering of hard rock surfaces took place, and there was deeper alteration of the alluvial fill in the broader strike vales. Subsequent rejuvenation has followed structure, with deep gorge incision in the harder strike ridges, and erosion and terracing of the vale fills and tributary alluvial slopes. A feature of the rejuvenation has been the superposition of transverse drainage patterns established during the earlier cycle. The narrow river gaps in the strike ranges are particularly important in terrain which forms a barrier more by its linear continuity than by its absolute relief.

The amount of rejuvenation varies widely. In the western part of the folded central ranges, beyond the catchments of drainage to the Simpson Desert basin, the older surfaces are little modified, and relief due to rejuvenation is generally less than that inherited from the earlier cycle. In the Davenport Range and in the southern part of the folded central ranges, both of which were more completely bevelled during the earlier cycle, the greater part of the relief is due to the later incision. In the eastern MacDonnell Ranges, subsequent rejuvenation has advanced so far that summit bevels have survived only locally, and the original vale floors have been buried beneath younger deposits.

Common features are the structural control of relief patterns, enhanced by the semi-arid regime of weathering and erosion, and the structural control of land forms, with well-adjusted dip slopes, steep escarpments, and an absence of weathering mantles or of slope rounding by mass movement.

(21) *Sonder land system* consists of mountain ranges formed by resistant quartzite and sandstone. Although structure and land forms vary, the land system is typified by extremely strong relief, steep and rocky hill slopes, narrow, deeply incised valleys, and insignificant level areas.

(22) *Pertnjara land system* consists of steeply rounded, gravel-capped hills, formed on conglomerate.

(23) *Davenport land system* consists of mountain ranges formed mainly on folded quartzite sandstone in the north of the area, principally the Davenport Range. The rocks are softer than in the Sonder land system, relief is therefore smaller and less rugged, and the more complete earlier planation is seen in the striking accordance of summits.

(24) *Gillen land system* consists of mountain ridges of sandstone and quartzite, and strike vales underlain by shale and limestone, although mainly floored by gravels and alluvium.

(25) *Middleton land system* consists of sandstone strike ridges and plateaux isolated in sandy lowlands.

(iv) *Hilly to Undulating Terrain on Folded Sedimentary and Igneous Rocks with Some Weathering.*—With the exception of the Kurundi land system, all the land systems in this group are underlain by weathered sedimentary rocks, mainly sandstone, with interbedded limestone and shale. They occur on the margins of the fold ranges, where the old land surface has undergone only moderate dissection, and where former through-going drainage has failed to maintain itself with decreasing rainfall. Relief is less clearly expressive of structure than in the adjoining mountain land systems. Laterite-capped or weathered low strike ridges and broad, bevelled stony rises form the main upland units, with relief only locally exceeding 100 ft. The lowlands are alluvial plains with sandy areas, and are locally badly drained.

(26) *Kurundi land system* is underlain by hypabyssal and volcanic rocks and forms more open country in the Davenport Range.

(27) *Ilbumric land system* consists of bevelled ridges and undulating terrain with broad stony rises, formed on strike belts of folded sandstone, greywacke, and siltstone. These flank the Davenport Range and have shared its uplift in part.

(28) *Tennant Creek land system* is formed of shale and other rocks which have been strongly folded and which have undergone weathering, and as a result it lacks the strike pattern of other land systems in the group.

(29) *Kernot land system* is formed on narrow strike belts of folded Palaeozoic sandstone and conglomerate in the south of the area.

(30) *Hogarth land system* comprises cuestas and rounded uplands on the Lucy Creek plateau, formed by thin sandstone and shale overlying the dolomite and limestone of which the plateau is built. The underlying dolomite and limestone form piedmont zones of appreciable extent, which may be featureless limestone plains or may form structural benches.

(v) *Plateaux Formed Mainly of Flat-lying Sandstone.*—These land systems have a dual origin: they owe their form to flat-bedded resistant rocks, but the flattish summits are partly due to a slight bevelling of structure by the weathered land surface. The highest plateaux of the folded central ranges can be traced laterally into undissected plains in the west of the area. The steep escarpments and dissected margins are due to subsequent rejuvenation, which limits these land systems to those parts of the folded central ranges tributary to the Lake Eyre basin and to the dissected southern edge of the north-eastern plains.

(31) *Krichauff land system* consists of high plateaux formed of resistant sandstone. These have formed in synclinal tracts in the south-western folded central ranges. They also comprise "one-sided" plateaux with sloping summits, formed on tilted strata as in the Barrow Creek uplands.

(32) *Tomahawk land system* consists of small plateaux, lower than those of the Krichauff land system, and formed of sandstone. These have low dips to the north-east, and the plateau summits descend gradually in that direction.

(33) *Cherry Creek land system* comprises low plateaux formed of shale and limestone. In the north-west, the plateau summits pass directly into the sand-covered weathered land surface; elsewhere, they are bounded by slopes of moderate steepness.

(vi) *Plateaux Formed of Flat-lying Limestone.*—Two land systems form the Lucy Creek plateau, in which a south- and east-going drainage has dissected the southern margin of limestone which dips gently beneath the north-eastern plains. Limestone is resistant to weathering and erosion in this dry area, and these land systems are characterized by strong structural control of relief, with rocky, sparsely drained plateau surfaces, steep, benched escarpments with much joint dissection, and narrowly entrenched trunk valleys.

(34) *Lucy land system* comprises the less dissected western part of the Lucy Creek plateau.

(35) *Ilgulla land system* is the more dissected eastern part of the Lucy Creek plateau, which has been reduced to flat-crested interfluves between the narrow entrenched main valleys. The drainage is more closely spaced, owing to the presence of less permeable sandstones and shales with the limestones.

(vii) *Plateaux, Ranges, and Lowlands on Deeply Weathered Sedimentary Rocks.*—These land systems have been formed by dissection of the duricrusted land surface of little relief formed on softish rocks of Palaeozoic and Mesozoic age in the south and east of the area. The weathered land surface consisted of plains with an overall descent and centripetal drainage south-eastwards, reflecting the structure of the Lake Eyre basin. Broad rises occurred along arcuate strike belts within the plains.

The land systems occur along the upwarped margin of the Lake Eyre basin. The amount of dissection, and hence of present relief, varies firstly with the amount of upwarping, which has been greatest in the north-west of the basin, secondly with the initial relief of the old land surface, and thirdly with the competence of the drainage, which has been greatest in the Finke catchment. Relief attains a maximum of 350 ft in the north-west, whence it decreases south-eastwards towards the centre of the basin and westwards to the limits of the Finke drainage, beyond which the weathered surface remains largely undissected and sand-covered. The deeply weathered shales form plateaux with strong silcrete duricrusts (Plate 12, Fig. 2); the sandstones, normally silicified, cap cuestas with gentle summit slopes.

The upland units in these land systems are bounded by breakaways formed by silcrete duricrusts and by steep, gullied escarpments on the underlying kaolinized rock. The silcrete cappings have partially broken down to form the gibber-strewn surfaces (Plate 11, Fig. 1), with numerous gilgais and disorganized drainage, which typify the upland summits. The dissected pallid zones give rise to steeply rounded, stony spurs, and a close pattern of narrowly incised drainage channels. Much of the lower ground consists of alluvial plains derived from the weathered rock; these, being normally somewhat alkaline, are very subject to shallow surface erosion. In the south and east, dune sands have encroached on the lowlands and have obliterated much surface drainage.

(36) *Chandlers land system* consists of cuestas and duricrusted mesas in alluvial plains and broadly undulating stony lowlands. It is developed mainly on strongly deformed Palaeozoic shale and sandstone on the southern margin of the folded central ranges.

(37) *Rumbalara land system* consists of strongly dissected, duricrusted plateaux formed on weathered shale in the dissected margin of the Simpson Desert. The plateaux have spectacular escarpments and prominent structural benches and are flanked by relatively extensive stony lowlands.

(38) *Wilyunpa land system* consists of low gibber tablelands with north-west-facing escarpments and silcrete breakaways. The summits descend gently south-eastwards and pass without a break beneath the dunes.

(c) *Erosional Surfaces formed below the Weathered Land Surface*

In this class the weathered land surface has been destroyed and younger surfaces have been eroded at lower levels. In the north, this has occurred only in the Sandover–Bundey basin and adjacent to the Barrow Creek uplands, and the younger surfaces are plains. In the south, erosion has been stronger and more widespread in drainage catchments tributary to the Lake Eyre basin, extending north of the central ranges in the Plenty River plains, and the younger surfaces range from plains to mountains.

(i) *Lightly Dissected Planed Surfaces in Granite, Gneiss, or Schist*.—These land systems comprise younger erosion surfaces once covered with aeolian sands, which have since been stripped and dissected, and they occur where the Plenty River plains open south-eastwards into the Simpson Desert. The amount of secondary stripping and drainage incision varies with setting and rock type, but erosional activity is now confined to the upper drainage sectors, and the lower valleys have become partly filled with younger alluvium.

(39) *Indiana land system* consists of closely dissected plains formed on relatively unresistant schist and gneiss.

(40) *Unca land system* comprises fairly flat plains on granite, gneiss, or schist. Drainage has been less vigorous than in the Indiana land system, and there has been only partial stripping of a former sand cover, and limited valley entrenchment.

(ii) *Erosional Plains on Granite, Gneiss, or Schist.*—In the north of the area and on the outer fringes of the Plenty River plains are actively forming surfaces newly stripped of a lateritic crust which may be seen on bounding escarpments or on included low hills. The underlying rocks were only shallowly and selectively weathered, and the plains are cut mainly in fresh rock. Drainage may be relatively vigorous in the higher parts, but flat sandy plains are common in the lowest sectors.

(41) *Jinka land system* consists of undulating, stony granite plains traversed by prominent quartz reef ridges.

(42) *Barrow land system* consists of gently undulating granite plains which pass down slope into flat sandy plains with little surface drainage.

(43) *Anderinda land system* comprises gently undulating plains on granite, schist, and gneiss, with less vigorous drainage and smaller relief than the Jinka land system, and with wider valley plains in the lowest parts.

(iii) *Moderately or Little Dissected Surfaces, Mainly on Deeply Weathered, Flat-lying or Gently Folded Sedimentary Rocks.*—These are areas of low relief, extending from the eastern end of the Amadeus depression into the dissected margin of the Simpson Desert, where they occupy the catchments of active west bank tributaries of the Finke River, with minor outliers along the Finke itself. In the Amadeus depression the underlying rocks are gently folded Palaeozoic shale and sandstone; these give place south-eastwards to flat-lying Mesozoic sandstone and shale, with some granite in the extreme south-west.

The Finke and its tributaries formed an extensive younger plain, which lies 200 ft below the duricrusted residuals in the east, but which converges on the older surface westwards, towards the limit of marginal warping and of the resulting drainage rejuvenation. Extensively, the younger plain lies within the weathering zone of the older surface. It is depositional in its lowest part, where sands and gravels occur in the main valleys. It has undergone extensive surface calcification, and has also been buried beneath lacustrine limestones along the axis of the Amadeus depression. It remains largely sand-covered, particularly in the east.

The Finke is incised up to 90 ft below its calcified gravel terraces, and its main tributaries have accordantly entrenched themselves into the younger plain. Incision has resulted in the stripping of the sand cover in zones bordering the trunk drainage. In the westernmost parts, there has been shallow valley entrenchment in the surface limestone. Elsewhere there has been more widespread stripping, which has transformed the original plain into a broadly undulating surface.

The latest phase of alluviation has affected all the main valleys, forming flat, locally ill-drained flood-plains, and giving rise to small pans and saline flats where drainage has disintegrated.

(44) *Peebles land system* consists of shale and sandstone on which the younger planation was incomplete, and it contains many steep-sided hills with long stony spurs which merge into narrow erosional terraces flanking the entrenched main valleys.

(45) *Lilla land system* underwent more complete planation of the younger surface than did Peebles land system. The headwater region consists of granite plains with some alluvial cover. Down-valley these pass into stripped erosional terraces along Lilla Creek and then into the calcreted gravel terraces of the Finke River. Because of narrower entrenchment of its lower valleys, alluvial flood-plains are less extensive than in the Peebles land system.

(46) *Ebenezer land system* consists of undulating stony plains mainly eroded on Palaeozoic and Mesozoic claystone and sandstone, with an extensive calcrete mantle in its lower parts.

(iv) *Limestone Ranges.*—These are mainly confined to the eastern MacDonnell Ranges, with lesser development in the western part of the Huckitta–Jervois Range. They are areas of strong uplift and erosion in which few traces of the old land surface survive, although it is unlikely that the limestones were responsive to bevelling and deep weathering.

The limestone and dolomite are thinly interbedded with shale and sandstone, giving rise to intricate intra-formational folding. Thus, in place of the continuous parallel strike ridges characteristic of the quartzite ranges, there are complex patterns of shorter strike ridges. Relief is also less strong, and the ridges are rarely more than 500 ft high. In the absence of massive beds the hill slopes have a deceptive overall smoothness, although they are very rocky and consist of many small structural terraces (Plate 15, Fig. 2). Thin bedding is unfavourable to the development of articulated tributary systems, and the hill slopes are characteristically embayed by parallel gullies with amphitheatral valley heads. Thinner limestone beds commonly form foothill strike ridges or long smooth-crested spurs.

(47) *Huckitta land system* consists of limestone mountains, and is developed in the area of closest folding and most massive limestone. Thin beds of softer rocks have facilitated dissection of narrow strike valleys.

(48) *Allua land system* consists of limestone ridges, alluvial vales, and flanking lowlands in areas of more open folding.

(v) *Undulating Terrain on Mainly Unweathered Folded Sedimentary Rocks.*—These land systems consist of undulating country formed by moderate erosion of gently dipping rocks of moderate but varying resistance. They occur in and south of the folded central ranges, in areas of slight folding and uplift, and on rocks which, although not sufficiently massive to form strong relief, were not prone to deep weathering. These rocks comprise conglomerate, interbedded limestone and shale, and thin-bedded sandstone. Relief does not generally exceed 50 ft. Drainage is still active in the higher parts, but the lower valleys are commonly alluvial plains.

(49) *Coghlan land system* is a closely dissected low upland of gently dipping thin-bedded shale, limestone, and sandstone.

(50) *Renners land system* is broadly undulating banded outcrop terrain with low rises formed by thin limestone bands, and long slopes on the interbedded shale. A few higher ridges are formed by more massive limestone.

(51) *Muller land system* consists of low rounded hills and ridges formed on conglomerate.

(vi) *Plains on Unweathered, Flat-lying, Sedimentary Rocks.*—These plains are more closely tributary to the Lake Eyre basin and have had a more complex history than those further north. Dissection of the weathered land surface was rapid and was followed by renewed and extensive planation. The lower parts were covered with alluvium, which subsequently formed sand plain and dunes. Finally, they underwent stripping and renewed dissection in a second phase of drainage rejuvenation.

(52) *Endinda land system* consists of stony, gently undulating plains formed on thin bedded shale and sandstone and gilgaied alluvial flats.

(vii) *Plains and Undulating Terrain Partially Stripped of Aeolian Sand Cover.*—These land systems occur in a broad arc on the periphery of the Simpson Desert. They formed lower parts of the plains eroded below the weathered land surface, and were subject to general burial beneath sand plain or dunes. They were only slightly affected by the latest recrudescence of drainage incision and stripping, and the sand cover remains extensive. Stone mantles, weathered rock outcrops, and duricrusted residuals are typical of the stripped areas, showing that the exhumed plain generally lies within the older weathering profile.

(53) *Dinkum land system* consists of extensive sand plain and dunes, in which occur stony plains of schist and gneiss with low schist or quartz reef ridges.

(54) *Angas land system* is underlain by sandstone and shale. It commonly adjoins the hillier Chandlers land system in its higher parts. The lower parts are mainly covered with sand plain and dunes.

(55) *Kalamerta land system* consists of a sandy plain with a dissected fringe of weathered Mesozoic arkose and claystone.

(*d*) *Depositional Surfaces*

The land systems in this class owe at least part of their form to surface deposits. They cover more than half the Alice Springs area and have accumulated in four phases: in the earliest landscape cycle, in the drier period following the erosion of the younger plains, as wind-borne sands at the height of aridity, and in a latest phase of drainage activity.

The most extensive deposits accumulated in the two middle phases, and the history of the accumulation is shown in the zonation of depositional land systems in the more stable lowlands; a lowest zone of salt pans and limestone plains is followed up slope by sand plain or dunes, with alluvial plains on the upper margin.

The older depositional land systems lie mainly beyond the present drainage, which is associated with a group of active alluvial land systems. This alluviation has taken two forms: alluvial fans formed by minor channels at the mountain foot, and flood-plains adjacent to large drainage channels.

(i) *Partly Dissected Piedmont Fans or Vale Fills.*—These land systems are formed largely of gravels and are developed best on the flanks of the folded central ranges, where the gravel sources have been sandstone and the Pertnjara conglomerate. Further north, gravels are restricted to slopes bordering isolated quartzite ranges and form only parts of land systems.

The deposits include weathered older "fill", calcreted younger gravels, and alluvium of the current cycle. The degree to which the older deposits have survived varies with the stability of the landscape. In the extreme west they form undissected gravel fans which pass down slope beneath younger deposits. In areas of moderate drainage rejuvenation they form a higher terrace which decreases in extent eastwards. In much of the upper catchment of the Finke only the younger gravels of the second depositional phase survive, forming a lower terrace broken by the alluvial plains of the present drainage.

(56) *Weldon land system* occurs in piedmont zones or strike vales, and consists of low terraces of unconsolidated gravels and undulating plains of selectively weathered schist and gneiss. Both the terraces and the undulating plains have been stripped and dissected close to the main drainage channels.

(57) *Reynolds land system* occupies an intermont lowland and consists mainly of piedmont terraces with a gravel cover on weathered schist and gneiss.

(58) *Berrys Pass land system* consists of fans of boulder gravels with steep stony surfaces.

(59) *Stokes land system* consists mainly of terraces of calcreted younger gravels derived from the nearby Pertnjara conglomerate. Dissection has been more active than in Berrys Pass land system, and the weathered higher terrace is very restricted.

(ii) *Plateaux and Terraces of Chalcedony Overlying the Weathered Land Surface.*—The land systems in this group are formed of chalcedony and calcareous siltstone laid down unconformably on the weathered land surface in the Sandover–Bundey basins and in lowlands within the central ranges. They have been strongly or moderately dissected and the old land surface has been exposed locally.

(60) *Santa Teresa land system* consists of high plateaux in intermont basins in the eastern MacDonnell Ranges. The underlying weathered rock surface is locally exposed as fringing benches or mesas.

(61) *Table Hill land system* consists of low plateaux. The calcareous siltstone has given rise to fine-textured alluvium on and fringing the plateaux.

(62) *Ambalindum land system* occurs in intermont basins and consists mainly of low terraces and surfaces formed by their partial dissection. An earlier, weathered basin-fill forms a duricrusted higher terrace.

(iii) *Plains of Kunkar or Chalcedony Overlying the Weathered Land Surface.*—The land systems of this group have been formed on kunkar or chalcedony laid down unconformably on the weathered land surface. They occur in the stable north and west of the area and have been only slightly dissected.

(63) *Lindavale land system* consists of plains in the south of the area. They are mostly sand-covered, with a stripped and lightly-dissected lower marginal zone.

(64) *Titra land system* consists of plains in the north of the area. It is more sand-free than the Lindavale land system and there is greater development of disconnected drainage typical of such surfaces.

(65) *Woolla land system* consists of lightly dissected linear limestone plains in broad valleys on the weathered land surface.

(iv) *Stable Alluvial Plains and Vale Fills.*—This group comprises two types of stable alluvial plains.

The most extensive are those formed on the lower margins of the erosional weathered land surface on crystalline rocks. They occur chiefly about the Burt Plain and the north-western plains, and less extensively on the border of the southern granite hills and plains. Locally, they abut directly against uplands of crystalline rocks. The low gradients on the old land surface favoured widespread alluviation in these areas. The alluvia range from red earths to clayey sands, and are notably sandier in the down-slope sectors, where they commonly pass into sand plain. The land systems are rather featureless plains, generally with less than 5 ft local relief and with alluvial gradients of 5 to 10 ft per mile. They may receive some run-on from adjoining land systems; internal drainage is by shallow, ill-defined floors, and large areas are liable to flooding after heavy rains. Old alluvial trains in the lower parts of the land systems have locally been wind-formed into low sandy rises.

The second type consists of intermont plains derived from limestone in the eastern MacDonnell Ranges and consisting of sandy calcareous alluvium, commonly above calcreted gravels. They result from the strong alluviation in the middle catchments of the Todd and Hale Rivers following the dissection of the weathered land surface.

(66) *Karee land system* consists of sandy plains in the south of the area. The lower sectors are sand plain with low dune ridges.

(67) *Bushy Park land system* consists of red earth plains and is the most extensive of the alluvial land systems. It commonly adjoins the Boen land system and the demarcation of these two land systems is often arbitrary. Dissection has locally revealed the weathered peneplain beneath the alluvial cover.

(68) *Leahy land system* consists of very sandy plains with disorganized surface drainage, and is transitional between the alluvial land systems and sand plain.

(69) *Ringwood land system* consists of calcareous alluvial plains, mainly developed between open limestone ranges.

(70) *Pulya land system* consists of fans of calcareous alluvium and calcreted gravels in narrow strike vales tributary to the Ringwood land system.

(v) *Dune Fields and Sand Plain.*—Aeolian sand covers 76,000 sq. miles in the lowest parts of the area, beyond the limits of surface drainage. It occurs as dunes or sand plain.

The central ranges separate a southern region with dune fields and restricted sand plain from a northern region with smaller dune tracts. A possible reason for this segregation lies in the source of the sands. The southern sands are derived mainly from sedimentary rocks, and are well sorted, whereas the northern sands are formed mainly from crystalline rocks, which yielded a coarse sand fraction and a higher clay content in derived soils. The coarse sand fraction may have stabilized the sand surfaces and prevented dune formation.

Another regionally differing factor may have been the thickness of the sands. Because of the greater dissection of the weathered land surface south of the central ranges, sand supply was abundant, whereas in the north the sand was more thinly spread over the little-modified old land surface. Differences in climate also may have been important. It is likely that during the drier period of wind movement the central ranges formed, as now, a climatic divide, north of which surface and subsurface drainage, clay weathering, and vegetation cover were such as to restrict sand movement, whereas to the south, greater surface mobility of a thicker sand cover allowed dune formation. Within this climatic framework, areas in the south receiving some drainage or derived from crystalline rocks would remain as sand plain, as on the intermont plains of the central ranges or on the tributary plains in the north-west of the Simpson Desert, whilst in the north, dunes would form only under special circumstances.

The dunes are mainly linear, continuous, and parallel over great distances, and orientated with the prevailing winds—north-north-westerly in the south-east and westerly in the north and west. They have gentle slopes on the west and south, and shorter, steeper flanks on the east and north. The swales are flat or broadly concave, with firmer surfaces and minor areas of "hard" ground. Reticulate or irregular short dunes occur mainly on the margins of the parallel dunes, where sand movement has been affected by relief or drainage. They are normally lower and more closely spaced than the parallel dunes.

The sand plain south of the central ranges is transitional between alluvial plains and dune fields and it occurs mainly in piedmont tracts or near large drainage flood-outs, as in the north-west corner of the Simpson Desert. It consists of flat, moderately soft sand surfaces, receiving some run-on although generally lacking organized surface drainage. In the north, sand plain of this type only occurs towards the up-slope margin of the sand cover; elsewhere the surface is broadly undulating with elongate, parallel rises which follow the regional dune trends.

Dunes and sand plain are largely fossil features, now mainly stabilized by vegetation. Sand movement is restricted to areas of sand disturbance or fresh supply, as near river channels and pan floors, and to minor areas of loose sand and dune crests.

(71) *Simpson land system* comprises most of the dune fields and is developed mainly in the Simpson Desert and Amadeus depression.

(72) *Ewaninga land system* has been formed by dune invasion of terrain similar to the lower part of the Muller land system. An extensive cover of irregular low dunes is broken by gravelly conglomerate crests and slopes typical of the Muller land system.

(73) *Singleton land system* consists of sand plain.

(vi) *Active Flood-plains.*—The alluvial flood-plains occur adjacent to the larger drainage channels and extend for long distances from the upland source of sediment. They may persist some distance into sand plain before petering out or feeding terminal alluvial basins, but they penetrate dune fields only where the dune trend is favourable. Partly for this reason, but mainly because of heavier rainfall and the survival of mature valleys on the old land surface, flood-plains are more extensive in the north of the area than in the south.

Generally, deposition is more active and of coarser materials in the piedmont zones, where the flood-plains are widest, with numerous braiding channels and lateral alluvial basins. Down-valley, the flood-plains become narrower and may be discontinuous, forming only narrow scrolls on the inside of the meanders. They are normally slightly lower than the adjacent sand plain or are locally incised below dune-covered river terraces. An inner, more active flood-plain commonly occurs below a sandier outer plain. In the lower sectors the main channels are smaller and split into distributaries which feed the broader alluvial basins of the terminal flood-outs. Areas of finer alluvium only occur where channel drainage ends within pre-existing valleys. In contrast, the flood-plains of the newer drainage elements peter out in sand plain, as in the north and west, or in interdune corridors, as in the Simpson Desert. In the younger valleys there is sufficient lateral admixture of coarse aeolian sand to counteract the down-valley tendency to finer alluvium, and the valleys are choked without forming large terminal basins.

The flood-plain land systems fall into three regional groups. The southern group is derived from the folded central ranges with significant limestone uplands, has formed under a drier climate, and is hence characterized by alluvium which may be calcareous. Its main occurrence is within the ranges or in the piedmont zone and its limited development in the plains beyond is a function of the integration achieved by the Finke drainage system and of the extent of the dune fields. A northern group is typified by well-developed convergent tributary flood-plains in valleys on the old land surface and by long courses through sand plain. These are characteristically sandy flood-plains of non-calcareous alluvium. The third group comprises the flood-plains at the east end of the Burt Plain. These head against the stripped weathered peneplain which occupies the piedmont zone and end in the upper part of the stable alluvial red earth plains of the Bushy Park land system. They are distinguished by medium- to fine-textured alluvium and by a lack of large drainage channels.

(74) *McDills land system* consists of terminal swamp basins and flood-plains of fine alluvium in the lower Finke valley near the southern border of the area.

(75) *Finke land system* comprises flood-plains of coarse-textured alluvium south of the central ranges.

(76) *McGrath land system* consists of flood-plains of medium- to fine-textured alluvium in the upper parts of former valleys on the weathered land surface. They are fairly short alluvial lobes derived from weathered crystalline rocks and have little linear drainage.

(77) *Ammaroo land system* consists of flood-plains and terminal basins of fine-textured alluvium in the north of the area.

(78) *Sandover land system* comprises flood-plains of coarse-textured non-calcareous alluvium north of the central ranges.

(vii) *Active Alluvial Fans.*—These land systems have formed about minor drainage outlets where there is a marked boundary between mountain and plain and a sharp change in drainage gradient. They occur as single or coalescent fans in piedmont zones rarely more than 5 miles wide. They are best developed at the foot of ranges formed of crystalline rocks and on the margins of isolated plateaux. They occur mainly in the north of the area, where the low piedmont gradients on the little-dissected old land surface are favourable for their formation. The corresponding alluvial plains of the folded central ranges are in the strike vales rather than in the outer piedmont zones, the upland margins being more closely approached by aeolian sand surfaces than in the north of the area.

The features of these land systems vary with the lithology of the catchments, the vigour of the feeder drainage, and the slope and drainage of the piedmonts. They generally consist of tributary valley embayments with braiding drainage channels, active alluvial lobes fed by distributaries of the main channels, flanking more stable alluvial surfaces, and varied lower sectors with terminal basins, pans, and sand plain. The more stable lower sectors may be due to a recent decline in drainage activity.

(79) *Amulda land system* consists of sandy plains derived from sandstone uplands, and occupies strike vales in the central ranges. Sand plain is extensive in the lowest parts, and active alluvial lobes form only a minor element.

(80) *Kanandra land system* consists of plains of coarse-textured alluvium derived mainly from metamorphic and igneous rocks. It occurs mainly at the outlets of the larger drainage channels on the north side of the central ranges.

(81) *Todd land system* consists of plains of coarse- to medium-textured alluvium derived mainly from igneous and metamorphic rocks. It is a multiple flood-plain rather than an alluvial fan, and it contains many features of flood-plains, but with the steeper gradients and the tendency for drainage to flood out which are characteristic of the alluvial fans.

(82) *Woodduck land system* is similar in origin to Amulda land system, but occurs north of the central ranges and forms piedmont rather than intermont plains.

(83) *Adnera land system* consists of plains of medium-textured alluvium derived from sedimentary rocks, at the foot of sandstone plateaux in the north of the area.

(84) *Deering land system* consists of plains formed from dissection of Stokes land system. Alkaline soil conditions inherited from the terraces have resulted in alluvial surfaces with much scalding and shallow gullying. It has a more integrated channel drainage than other land systems of the group.

(85) *Hamilton land system* is characterized by plains with texture-contrast soils, and occurs below the smaller drainage outlets on the north side of the central ranges. The alluvium is derived from weathered land surface and crystalline rocks.

(86) *Utopia land system* consists of short fans of fine-textured alluvium with prominent freshwater swamps. They have formed by the obstruction of drainage in embayments in sandstone plateaux of the Tomahawk land system.

(87) *Undippa land system* consists of lobes of fine-textured alluvium derived from igneous and metamorphic rocks and from chalcedony of the Table Hill land system. Organized drainage is generally absent.

(viii) *Salt Pans.*—The larger salt pans are situated along the axes of the Burt Plain and the Amadeus depression. These are structural lowlands on the old land surface, with longitudinal gradients of less than 2 ft per mile. Although the pans commonly occur down slope from the flood-outs of large drainage channels, they rarely connect directly with surface drainage. However, replenishment by subsurface drainage maintains the water-table near the surface despite evaporation losses.

The pans are relics of larger lakes, which formed the adjacent limestone plains. They undergo alternate wetting and drying, and are very susceptible to wind action, which has formed the massive fronting dunes and sandy islands of the larger pans.

The limited extent of salt crusts is remarkable in an area of long-established interior drainage. It indicates that the salt pans are not termini of closed subsurface drainage systems but that they occupy depressions in which the water-table is near the surface. Underground drainage probably continues beyond them.

(88) *Amadeus land system* comprises the larger salt pans and their marginal features.

PART VIII. SOILS OF THE ALICE SPRINGS AREA

By W. H. LITCHFIELD*

I. INTRODUCTION

An outstanding characteristic of this arid region is the extent of leached sandy and red earth soils and the relatively minor extent of calcareous, gypseous, saline, and alkaline soils that are normally expected in arid zones.

The extent of the leached soils is influenced by soil materials weathered and leached during an earlier, more humid erosion cycle, or more recent wind and water re-sorting of those weathered materials. However, leached soils also occur on younger surfaces weathered from granite, gneiss, some sedimentary rocks, and associated alluvia, and in some places on these it appears that the trend in profile formation under the present climate is towards the leached sandy or red earth profile.

Calcareous, gypseous, saline, and alkaline soils are restricted to saline and calcareous alluvia, more basic and sodic crystalline rocks, calcareous and shaly sediments, and exposed lower layers of the deeply weathered profiles that have collected soluble constituents since their formation. Gypsum, which is normally in crystalline form, is much less common than carbonates, which may occur as amorphous lime, dispersed or in nodules.

Although evidence of deeply weathered materials associated with an ancient land surface is widespread, the original surface soil has been stripped from all except some areas of peneplain. Ferruginous nodules in the old surface soil are more common in the northern part of the area than in the southern part.

The decrease in effectiveness of rainfall from north to south is not reflected in the general soil pattern. Two soil features that may be climatically controlled are the restriction of yellow earth soils to the wetter northern parts and the greater prevalence of siliceous hard pans in the subsoil in the driest southern part.

Most of the soils have massive structure with many fine vesicles but a thin sealed crust, less than $\frac{1}{4}$ in. thick, on the surface is common. Prismatic and rarely columnar subsoil structures occur only in the finer-textured types of texture-contrast soils. The coarse-structured grumusolic soils show typical blocky structure and crack patterns but gilgai microrelief is not always an associated feature.

The widespread stony surface pavements (Plate 10, Figs. 1 and 2) consist largely of siliceous material—quartz, quartzite, chert, and secondary silcrete including chalcedony. These "desert pavements" are most common on texture-contrast soils and are normally associated with a coarse vesicular "honeycomb" structure immediately beneath the surface crust.

The red sands and red clayey sands have a very low phosphorus content ($P < 0 \cdot 001\%$). Surface samples from the remainder of the soil groups have a higher

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phosphorus content (mean 0·028% P). This figure is a little above Wild's (1958) average for Australian soils. However, their nitrogen content (0·042% N) is decidedly below the average given by Taylor (1950).

The analytical results used in this report are drawn from 22 profiles and other samples taken during the course of the survey.

II. The Soil Groups

(a) *Terms and Arrangement*

The soils are arranged in eight groups, based on general profile form irrespective of the nature of the substratum. However, the alluvial soils include profiles with sedimentary layering, in some cases well organized in their lower layers, and other soils which have weak but definite profile differentiation (intergrades to other soil groups) in their uppermost layer.

Descriptive terms, such as "texture-contrast soil", have been used for groups of soils with a common general form in preference to existing names for soil groups which lack morphological independence. It is not intended that such groupings should have categorical standing in particular soil classifications. Subgroups are based on a variety of criteria, including differences of texture and colour, the presence of a stone pavement or a nodule horizon, and the nature of underlying horizons or parent material.

Table 13

GROUPING OF SOILS AND THEIR CORRELATION WITH AUSTRALIAN CLASSIFICATIONS OF ARID ZONE SOILS

	Alice Springs Area	Names used by Other Authors
1	Alluvial soils (Regosolic forms; intergrade latosolic and grumusolic forms; layered soils with a regosolic surface layer)	Alluvial soils (Stephens 1956) (The intergrade types are not committed to Stephens's classification)
1*a*	Brown alluvial sands (regosolic)	
1*b*	Brown alluvial sandy loams (intergrade latosolic layer) over various lower layers	
1*c*	Brown alluvial loams (regosolic)	
1*d*	Brown alluvial loams over red earths (regosolic layer over latosolic layer)	
1*e*	Brown alluvial calcareous loamy or clayey soils	
1*f*	Brown alluvial coarse-structured calcareous clays (intergrade grumusolic)	
1*g*	Brown alluvial loamy layers over reddish sands (regosolic layer over intergrade latosolic layer)	
1*h*	Reddish alluvial sands (intergrade latosolic)	
1*i*	Red-brown sandy alluvial red earths (intergrade latosolic)	Leached brown levee soils (Stewart 1953)

TABLE 13 (*Continued*)

	Alice Springs Area	Names used by Other Authors
2	Shallow, stony, undifferentiated soils (Lithosolic forms)	Undifferentiated skeletal soils (Stewart); arid ranges (Jessup 1951); desert tablelands and ranges (Prescott 1944); skeletal soils (Stephens)
3	Red sands and clayey sands (Latosolic forms)	
3*a*	Shallow gritty red clayey sands on crystalline rocks	
3*b*	Red clayey sands on calcareous substrata: shallow to moderate depth	
3*c*	Shallow red clayey sands on sandstone	
3*d*	Deep red clayey sands: free from carbonate or ferruginous nodule horizons	Sands of interdune corridors (Crocker 1946)
3*e*	Red clayey sands with ferruginous nodules: moderate depth or deep	Tertiary lateritic red sands (Stewart); desert sand plains (Prescott); desert sand plain soils (Stephens)
3*f*	Red dune sands	Sands of dunes (Crocker; Stephens)
4	Red earths (Latosolic forms)	
4*a*	Gritty sandy red earths: shallow to moderate depth—on crystalline rock	
4*b*	Red earths on calcareous substrata: shallow to moderate depth	Tertiary non-lateritic soils (Stewart); calcareous red earths (Stephens)
4*c*	Red earths on sandstone: shallow to moderate depth	
4*d*	Deep sandy red earths: free from carbonate or ferruginous nodule horizons	Brown soils of light texture (Stephens)
4*e*	Deep red earths: medium-textured surface; free from carbonate or ferruginous nodule horizons	Included with desert loams (Prescott)
4*f*	Sandy red earths with ferruginous nodules: over ferricrete, calcrete, mottled zone, or little-altered rock	Tertiary lateritic red earths (Stewart); included in both stony deserts and desert sand plains (Prescott); desert sand plain soils (Stephens)
4*g*	Red earths with ferruginous nodules: medium-textured surface, substrata as in 4*f*	Tertiary lateritic red earths (Stewart); included in lateritic red earths and calcareous lateritic soils (Stephens)
4*h*	Stony fine-textured red earths: various substrata	
5	Yellow earths and yellow clayey sands (Latosolic forms)	
5*a*	Deep yellow earths: with manganiferous nodule horizon	Deep yellow podzolic soils* (Stewart)
5*b*	Deep yellow clayey sands	Deep sandy yellow podzolic soils* (Stewart)
6	Calcareous earths (Other than calcareous alluvial soils)	
6*a*	Brown sandy calcareous earths; shallow, various calcareous substrata	

TABLE 13 (*Continued*)

	Alice Springs Area	Names used by Other Authors
6*b*	Brown loamy calcareous earths: shallow	Limestone calcareous desert soils (Stewart); included with desert loams (Prescott); and grey-brown and red calcareous desert soils (Stephens)
6*c*	Red sandy calcareous earths: shallow to moderate depth	Calcareous arid soils, cf. Bon Bon soils (Jessup); included with desert loams (Prescott) and red calcareous desert soils (Stephens)
6*d*	Reddish brown sandy calcareous earths: deep	Calcareous arid soils, cf. Wirraminna soils (Jessup)
6*e*	Brown loamy calcareous earths with pavement: shallow	
7	Texture-contrast and allied soils (Mainly solonetzic forms)	
7*a*	Texture-contrast soils on crystalline rocks: shallow to moderate depth	Included with stony deserts (Prescott); and included desert loams (Stephens; Hallsworth and Costin 1950)
7*b*	Texture-contrast soils on sedimentary rocks: shallow to moderate depth	Brown soils associated with surface gibbers (Crocker); stony tableland soils, cf. Coober Pedy soils (Jessup); included with stony deserts (Prescott); stony desert tableland soils (Stephens); stony downs (Hallsworth and Costin)
7*c*	Thin-surfaced texture-contrast soils	Included with stony deserts (Prescott); and desert loams (Stephens)
7*d*	Shallow texture-contrast soils with siliceous hard pan	Affinities with red and brown hardpan soils (Stephens)
7*e*	Sandy texture-contrast soils	Arid red earths, cf. Coondambo soils (Jessup)
7*f*	Sandy texture-contrast soils with pavement	Included solonetz (Prescott; Stephens; Hallsworth and Costin)
7*g*	Loamy texture-contrast soils	Included desert loams and red-brown earths (Stephens; Hallsworth and Costin)
7*h*	Texture-contrast soils with mottled yellowish subsoil	Solod (Stephens; Hallsworth and Costin)
7*i*	Sandy texture-contrast soils with variable siliceous hard pan	Affinities with red and brown hardpan soils (Stephens)
8	Coarse-structured clay soils (Grumusolic forms; other than alluvial soils)	
8*a*	Red coarse-structured clays	Affinities with grey and brown soils of heavy texture (Prescott), brown soils of heavy texture (Stephens), brown sierozem (Hallsworth and Costin)
8*b*	Greyish coarse-structured clays	Heavy grey pedocals (Stewart); grey and brown soils of heavy texture (Prescott); included grey soils of heavy texture (Stephens); and grey sierozem (Hallsworth and Costin)

*Subsequently recognized as yellow earths by Stewart.

Specialized soil conditions, including scalds (Plate 17, Fig. 2) and saline soils from the floors of salt pans (Plate 13, Fig. 2) and their environs, are not included in these groups.

The red earths, and apparently the yellow earths, can be regarded as latosolic soils if the wider use of this term is accepted. Similarly the red clayey sands are coarse-textured analogues of the red earths into which they grade with increasing clay content. The subsoil texture of the latter is rated as at least a sandy clay loam or finer. The various coarse-structured clay soils all show some of the attributes of grumusolic soils. The texture-contrast soils are mostly solonetzic in so far as their chemistry is known and would include many "desert loams" (Stephens 1956), "stony (desert) tableland soils" (Stephens 1956; Jessup 1951), and "arid red earths" (Jessup 1951).

In Table 13 the groups are listed and the names used are correlated with those used by Prescott (1944), Hallsworth and Costin (1950), Jessup (1951), Stewart (1953), and Stephens (1956).

(*b*) *Geography*

A relation between soils and regional geomorphology is shown by correspondence of boundaries on the small-scale maps of physical regions and soils, inset on the pasture lands map.

The general geographic distribution of the main soil groups is shown in Figure 12, and is described in more detail below. More detailed information on distribution of the soils can be obtained by reference to Table 14 in conjunction with either the land system or pasture lands map.

(i) *Alluvial Soils*.—These are associated with flood-plains which are dominantly coarser-textured in their upper and mid tracts and finer-textured in their terminal tracts, except where the latter have received a considerable input of wind-blown sand as well as alluvial material, e.g. along the lower Hale River. Finer-textured soils are a feature of the relatively short flood-plains of watercourses draining the eastern flank of the Burt Plain. Mainly coarse-textured alluvial soils also occur on the inner slopes of alluvial fans—most extensive on the north side of the Harts Range and in the upper valley of the Todd River eastwards from Heavitree Gap.

(ii) *Shallow, Stony, Undifferentiated Soils*.—The mountains and hills of the central ranges and the northern uplands have much rock outcrop and little skeletal soil. This contrasts with the more even-surfaced tablelands of the south-eastern quarter which have texture-contrast soils protected by silcrete pavements.

(iii) *Red Sands and Clayey Sands*.—These are the dominant soil cover of the sand plains and dune fields which are the main features of the plains throughout the area. Red clayey sands also occur over undissected parts of the calcrete plain centred along the Amadeus depression and in less extent on calcrete or limestone within the central ranges and the Lucy Creek plateau. Shallow red clayey sands over crystalline rock and deep soils on alluvial plains occur in various parts of the area. In the sand plains, sandy soils on lateritic substrata are increasingly prevalent northwards but their extent could not be defined clearly because of the reconnaissance nature of the survey.

(iv) *Red Earths.*—The main areas of red earths lie north of the central ranges. They cover both gentle slopes on low erosional plains and alluvial plains lying off upland fronts and within wider valleys. They are the commonest soils under mulga. The residual soils overlie lateritic strata, crystalline rocks near the central ranges and north-western hills and ranges, and dolomites on the plain east of Ooratippra. Small occurrences in the south of the area, e.g. near Goyder Creek, likewise cover a range of

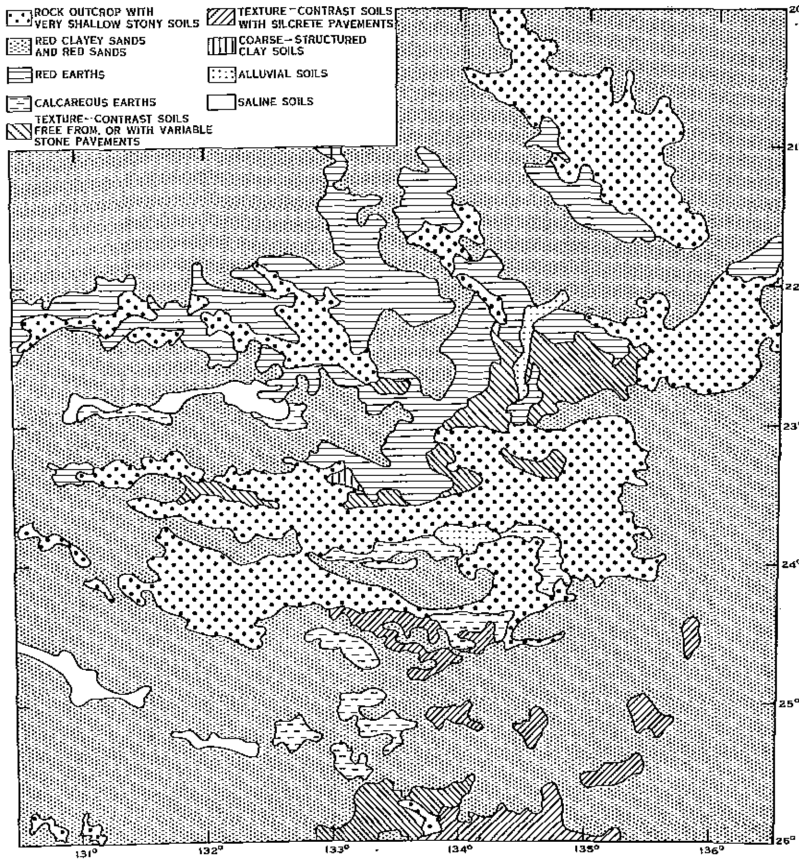

Fig. 12.—Distribution of the main soil groups.

lateritic, crystalline, and sedimentary strata, and small depressions in some of the calcrete plains. The stony surfaces of terraces flanking some of the ranges like those near Hermannsburg have protected old red earth soils from further erosion.

(v) *Yellow Earths and Yellow Clayey Sands.*—These occur only in small terminal flood-outs of the small outwash plains flanking some of the northern uplands and occasionally in the flood-plain tracts of this part of the area.

(vi) *Calcareous Earths.*—These are developed most extensively over weakly dissected calcrete plains bordering zones of saline pans along the Amadeus depression. In other places they overlie low limestone hills south-east and west of Alice Springs, the more basic crystalline rocks in the central ranges and the southern granite hills

TABLE 14

RELATION BETWEEN SOILS AND LAND SYSTEMS

	Soil	Land Systems in Which Soil is Dominant or Co-dominant	Land Systems in Which Soil is Sub-dominant	Land Systems in Which Soil is Minor
1*a*	Brown alluvial sands: (regosolic)	Kanandra, Todd		Harts, Bond Springs, Napperby, Cavenagh, Aileron, Ryan, Gillen, Lilla, Allua, Dinkum, Stokes, Ambalindum, Finke, Sandover, Deering
1*b*	Brown alluvial sandy loams: (intergrade latosolic layer) over various lower layers		Todd	
1*c*	Brown alluvial loams: (regosolic)			Bond Springs, Sandover, Todd
1*d*	Brown alluvial loams over red earth: (regosolic layer over latosolic layer)		Todd	Chandlers, Lilla, McGrath, Ammaroo
1*e*	Brown alluvial calcareous loamy or clayey soils			Finke
1*f*	Brown alluvial coarse-structured calcareous clays: (intergrade grumusolic)			Wilyunpa, Leahy, Ringwood, McDills, Finke, Ammaroo
1*g*	Brown alluvial loamy layers over reddish sands: (regosolic layer over intergrade latosolic layer)	McDills		
1*h*	Reddish alluvial sands: (intergrade latosolic)	Sandover, Todd	Finke, Woodduck, Kanandra	Harts, Bond Springs, Cavenagh, Outounya, Hann, Davenport, Gillen, Middleton, Ilbumric, Rumbalara, Stokes, Amulda, Deering

TABLE 14 (*Continued*)

	Soil	Land Systems in Which Soil is Dominant or Co-dominant	Land Systems in Which Soil is Sub-dominant	Land Systems in Which Soil is Minor
1*i*	Red-brown sandy alluvial red earths: (intergrade latosolic)			Hann, Davenport, Ilbumric, Chandlers, Lilla, McGrath, Ammaroo, Todd, Sandover
2	Shallow, stony, undifferentiated soils	Harts, Bond Springs, Napperby, Cavenagh, Aileron, Hann, Chisholm, Delny, Kulgera, Sonder, Pertnjara, Davenport, Gillen, Middleton, Kurundi, Ilbumric, Tennant Creek, Kernot, Hogarth, Krichauff, Tomahawk, Cherry Creek, Lucy, Ilgulla, Rumbalara, Indiana, Unca, Lilla, Huckitta, Allua, Coghlan, Berrys Pass, Santa Teresa, Table Hill, Titra, Woolla	Jinka, Chandlers, Muller, Angas, Reynolds	Boen, Warburton, Wonorah, Alinga, Ooratippra, Pularoo, Alcoota, Ryan, Ennugan, Wilyunpa, Barrow, Anderinda, Peebles, Renners, Dinkum, Kalamerta, Weldon, Stokes, Ambalindum, Lindavale, Pulya
3*a*	Shallow gritty red clayey sands on crystalline rocks	Outounya, Pularoo, Jinka, Barrow	Kulgera, Dinkum	Harts, Bond Springs, Napperby, Cavenagh, Aileron, Boen, Warburton, Delny, Ryan, Ennugan, Weldon
3*b*	Red clayey sands on calcareous substrata: shallow to moderate depth	Kalamerta, Lindavale	Lucy, Titra, Woolla	Tietkins, Hogarth, Allua, Simpson, Singleton
3*c*	Shallow red clayey sands on sandstone			Krichauff, Tomahawk, Cherry Creek
3*d*	Deep red clayey sands: free from carbonate or ferruginous nodule horizons	Tietkins, Middleton, Dinkum, Angas, Kalamerta, Karee, Leahy, Pulya, Singleton, Amulda, Kanandra, Wood-duck	Aileron, Outounya, Wonorah, Ilbumric, Kernot, Cherry Creek, Indiana, Unca, Simpson, Todd	Napperby, Cavenagh, Hann, Alinga, Davenport, Gillen, Middleton, Tennant Creek, Hogarth, Krichauff, Tomahawk, Ilgulla, Chandlers, Rumbalara, Jinka, Peebles, Lilla, Coghlan, Renners, Muller, Berrys Pass, Stokes, Santa Teresa, Bushy Park, Ringwood, Ewaninga, McGrath, Ammaroo, Deering

TABLE 14 (*Continued*)

	Soil	Land Systems in Which Soil is Dominant or Co-dominant	Land Systems in Which Soil is Sub-dominant	Land Systems in Which Soil is Minor
3*e*	Red clayey sands with ferruginous nodules: moderate depth or deep		Wonorah	Alinga, Singleton
3*f*	Red dune sands	Simpson, Ewaninga	Singleton, Amadeus	Tietkins, Middleton, Kernot, Rumbalara, Endinda, Angas, Karee, Leahy, Ringwood, Finke, Sandover, Amulda, Kanandra, Todd, Woodduck, Utopia
4*a*	Gritty sandy red earths: shallow to moderate depth, on crystalline rocks	Boen, Warburton, Ennugan, Barrow	Napperby, Pularoo, Kurundi, Indiana, Dinkum	Harts, Bond Springs, Delny, Ryan, Anderinda, Weldon
4*b*	Red earths on calcareous substrata: shallow to moderate depth	Outounya, Ooratippra	Kalamerta, Woolla, Ringwood	Cavenagh, Boen, Tietkins, Lucy, Peebles, Table Hill, Lindavale, Titra, Sandover
4*c*	Red earths on sandstone: shallow to moderate depth			Cherry Creek, Angas
4*d*	Deep sandy red earths: free from carbonate or ferruginous nodule horizons	Outounya, Karee, Leahy, Sandover, Kanandra	Tennant Creek, Lucy, Indiana, Unca, Dinkum, Kalamerta, Singleton	Bond Springs, Cavenagh, Aileron, Tietkins, Hann, Delny, Kulgera, Alcoota, Kernot, Chandlers, Jinka, Ebenezer, Renners, Muller, Angas, Berrys Pass, Stokes, Bushy Park, Pulya, Simpson, Ewaninga, McGrath
4*e*	Deep red earths: medium-textured surface, free from carbonate or ferruginous nodule horizons	Alinga, Bushy Park, McGrath, Ammaroo, Adnera	Warburton, Ooratippra, Ilbumric, Anderinda, Hamilton	Bond Springs, Cavenagh, Aileron, Boen, Hann, Delny, Kulgera, Alcoota, Ryan, Ennugan, Lucy, Chandlers, Weldon, Berrys Pass, Leahy, Pulya
4*f*	Sandy red earths with ferruginous nodules: over ferricrete, calcrete, mottled zone, or little-altered rock	Wonorah		Tietkins, Alinga, Peebles, Angas, Berrys Pass, Singleton

TABLE 14 (*Continued*)

	Soil	Land Systems in Which Soil is Dominant or Co-dominant	Land Systems in Which Soil is Sub-dominant	Land Systems in Which Soil is Minor
4g	Red earths with ferruginous nodules: medium-textured surface, substrata as in *4f*	Alcoota	Boen, Ooratippra, Chisholm, Delny	Tietkins, Ilbumric, Peebles, Weldon
4h	Stony fine-textured red earths: various substrata	Weldon, Reynolds, Stokes		Gillen, Peebles
5a	Deep yellow earths: with manganiferous nodule horizon			Hann, Alinga, Ilbumric, Ammaroo, Woodduck, Adnera
5b	Deep yellow clayey sands			Woodduck
6a	Brown sandy calcareous earths: shallow various calcareous substrata	Muller, Ringwood	Outounya, Chisholm, Kulgera Indiana, Allua	Harts, Bond Springs, Cavenagh, Alinga, Delny, Alcoota, Gillen, Chandlers, Lilla, Coghlan, Renners, Weldon, Stokes, Santa Teresa, Pulya, Ewaninga
6b	Brown loamy calcareous earths: shallow	Ebenezer	Delny, Allua, Table Hill, Ringwood	Ooratippra, Alcoota, Lucy, Santa Teresa
6c	Red sandy calcareous earths: shallow to moderate depth		Kalamerta	Lindavale, Simpson
6d	Reddish brown sandy calcareous earths: deep			Rumbalara, Stokes, Finke
6e	Brown loamy calcareous earths with pavement: shallow	Renners		Muller
7a	Texture-contrast soils on crystalline rocks: shallow to moderate depth	Alcoota, Ryan, Anderinda	Kulgera, Indiana, Jinka, Reynolds	Bond Springs, Napperby, Cavenagh, Aileron, Boen, Warburton, Outounya, Delny, Ennugan, Weldon

TABLE 14 (*Continued*)

	Soil	Land Systems in Which Soil is Dominant or Co-dominant	Land Systems in Which Soil is Sub-dominant	Land Systems in Which Soil is Minor
7b	Texture-contrast soils on sedimentary rocks: shallow to moderate depth	Chandlers, Wilyunpa, Peebles, Endinda	Tennant Creek, Kernot, Rumbalara, Ebenezer, Renners	Gillen, Lilla, Angas
7c	Thin-surfaced texture-contrast soils		Lilla	Kalamerta
7d	Shallow texture-contrast soils with siliceous hard pan	Peebles	Endinda	Alinga, Alcoota
7e	Sandy texture-contrast soils	Kalamerta, Finke, Deering	Ryan, Stokes, Sandover, Hamilton, Kulgera	Napperby, Cavenagh, Warburton, Outounya, Alcoota, Ennugan, Gillen, Middleton, Chandlers, Rumbalara, Peebles, Lilla, Ebenezer, Muller, Angas, Simpson, Kanandra, Amadeus
7f	Sandy texture-contrast soils with pavement		Kulgera, Tennant Creek	Kalamerta
7g	Loamy texture-contrast soils	Alcoota, Ambalindum, McGrath, Hamilton		Bond Springs, Chisholm, Delny, Table Hill, Ringwood, McDills
7h	Texture-contrast soils with mottled yellowish subsoil			Alinga, Adnera
7i	Sandy texture-contrast soils with variable siliceous hard pan			Cavenagh, Outounya, Lilla, Titra, Amadeus
8a	Red coarse-structured clays	Undippa	Table Hill	Cavenagh, Outounya, Alinga, Chisholm, Delny, Kulgera, Alcoota, Rumbalara, Wilyunpa, Kalamerta, Weldon, Stokes, Ambalindum, Ringwood, McDills, McGrath, Hamilton
8b	Greyish coarse-structured clays	Utopia		Alinga, Endinda, Sandover

and plains, alluvium in the valley of the lower Todd River, and Tertiary sediments in the upper Sandover–Bundey basin. Calcareous alluvial soils occur throughout the active flood-plains south of the central ranges.

(vii) *Texture-contrast and Allied Soils.*—Dissected lateritic strata, terraces, and some of the erosional plain on crystalline rock may all give rise to texture-contrast soils with variable pavement stone on residual surfaces. On alluvial surfaces texture-contrast soils may be free from pavement and be severely scalded. Both forms dominate a complex soil pattern in the upper Sandover–Bundey basin. Texture-contrast soils are also prevalent over the granites and adjacent sandstones near the southern border, over dissected valley terraces in the Ambalindum basin, and over alluvial sediments carried off lateritic strata around the south-western flank of the Strangways Range and the inter-range valley in the western MacDonnell Ranges running east–west near Haasts Bluff and Mt. Sonder. Texture-contrast soils with pavements of silcrete are found on tablelands and, more widely, on their adjoining erosional plains, as far north as the central ranges.

(viii) *Coarse-structured Clay Soils.*—Red coarse-structured clay soils are found extensively only on the alluvial plain to the north side of the central ranges between Hamilton Downs and Narwietooma. Small areas occur elsewhere north of the central ranges as on the eastern side of the Burt Plain, in the Ambalindum basin, and in the upper Sandover–Bundey basin on little-dissected lateritic surfaces, terrace or basin deposits, or on alluvia derived from them. Grey and brown clay soils are found only in small basins or embayments along certain of the flood-plains and their terminal flood-outs, and also in a row of small basins on the erosional plain flanking the south-western side of the Davenport Range.

(*c*) *Description of Soils*

(1) *Alluvial Soils.*—This category includes true alluvial regosolic soils that are brown in colour (Munsell hue 5YR), some intergrade soils with only slight profile organization, and some layered soils with a regosolic upper layer. Layering is common and the contrasting layers may be either depositional in origin or buried older soil layers. The intergrade soils show partial development of profile characteristics typical of groups described below. For example, typical red earths have a Munsell hue of 10R and intergrade soils to them, which are found on less active parts of flood-plains, have a hue of 2·5YR.

Although the textures range from sand to clay, all the alluvial soils are characterized by a relatively high silt content, which may not be obvious in the field texture compared with the maturely weathered soils such as red earth. This higher silt content results in strongly sealed thin crusts on finer-textured soils. In general the alluvial soils are massive, but some clays and silty clays develop the coarse blocky structure and crack pattern of coarse-structured clay soils.

These soils are usually either neutral or alkaline, their salt content is low (0·01 to 0·05%), and their phosphorus content is above average, a fine-textured soil having the highest recorded in the area (0·073%).

(1*a*) *Brown alluvial sands* are uniformly sand or loamy sand throughout the profile, and weatherable minerals, including micas, are typically present. They occur on alluvium derived from crystalline rocks on small alluvial floors between ridges, on levees, or near channels in wider alluvial tracts, and over the inner slopes of alluvial fans.

(1*b*) *Brown alluvial sandy loams* have sandy loam or loamy sand surfaces grading into sandy clay loam subsoil, and the profile has a massive vesicular structure. It appears to be an early stage of red earth profile organization, i.e. an intergrade to that group. The above profile may overlie a calcareous layer or layers of different texture.

(1*c*) *Brown alluvial loams* may either have a uniform texture throughout their profile or be slightly finer-textured at depth.

(1*d*) *Brown alluvial loams over red earth* have an alluvial layer 4 in. to 24 in. thick overlying a red earth profile. They are more common than the previous soil and occur in similar sites in depressions on flood-plains.

(1*e*) *Brown alluvial calcareous loamy and clayey soils* have textures ranging from fine sandy loam to silty clay.

(1*f*) *Brown alluvial coarse-structured calcareous clays* have a silty clay texture and finely dispersed carbonate, and are considered to be essentially alluvial, even though they have gilgai microrelief in some places. These finer sediments have been deposited in embayments of flood-plains or in cut-off basins, south of the central ranges.

(1*g*) *Brown alluvial loamy layers over reddish sands* have an alluvial layer 4 in. to 24 in. thick overlying or interstratified with reddish sand or clayey sand that is considered to be an intergrade to the red clayey sand soils.

(1*h*) *Reddish alluvial sands* have deep profiles of reddish brown or red-brown sands and clayey sands. The grain size of the sand fraction and its mineral assemblage vary according to the source of the alluvium, and in some profiles gravel beds occur at depth. This soil is considered to be an intergrade to the red clayey sand.

(1*i*) *Red-brown sandy alluvial red earths* have clayey sand surfaces grading into sandy clay loam subsoils. They are considered to be intergrades to typical red earths as they have similar structure and consistence but their colour is less intense (2·5YR). The size of the sand grains varies depending on the source of the alluvium, and easily weatherable minerals may be present where the alluvium is derived from crystalline rocks.

(2) *Shallow, Stony, Undifferentiated Soils*.—These lithosolic soils are the only form of soil development on slopes with gradients greater than about 2%, except on shales which weather to shallow clayey soils or to texture-contrast soils protected from erosion by packed pavements of hard siliceous stones. Pockets of shallow soil occur adjacent to, or between, rock outcrops in all land systems with residual soils and in those with exposures of calcrete. Except for those formed on shales the fine earth fraction of these soils is mainly fine or coarse sand depending on local lithology. Very shallow soil on calcrete may be either calcareous or leached of carbonate.

No subdivisions of this group are described.

(3) *Red Sands and Clayey Sands*.—Sand textures are commonly found on dunes; other red sandy soils, apart from slightly browner colours and in some instances sand texture at the surface, are uniform red clayey sands to the underlying substratum of a

different character or otherwise to a depth of at least 4 ft. From field observations of texture, the clay content of 8–12% and the silt content of 1–2% of the only profile analysed seem typical for the slightly clayey soils. Except for a weak surface crust they are massive in structure like the red earths but they do not contain sufficient clay to develop the texture profile that is typical of most red earths.

Freely drained soils are usually weakly acid or neutral. They have insignificant (less than 0·01%) salt content, very low nitrogen content (less than 0·02%), and very low phosphorus content (less than 0·01%, Crocker 1946). Alkalinity and appreciable salinity may develop in situations of restricted drainage.

(3*a*) *Shallow gritty red clayey sands* are normally less than 2 ft deep and are formed on granite and gneiss on gentle slopes below hills or on upper slopes or crests on undulating erosional plains. Over the far northern approaches to the Simpson Desert, e.g. in Dinkum land system, a layer of fine-grained wind-blown sandy soil may overlie the coarse-grained gritty soil on weathering rock.

(3*b*) *Red clayey sands on calcareous substrata* have from a few inches to more than 4 ft of carbonate-free soil over calcrete, a horizon of carbonate nodules, or limestone. Near salt lakes these soils may be both alkaline and saline.

These soils are found where the dune fields or sand plains adjoin the valley calcretes, calcrete plains, or salt lakes. They also occur on the eroding remnants of some old river terraces.

Some of these soils are associated with limestone or secondary carbonate in the hollows between low hills.

(3*c*) *Shallow red clayey sands on sandstone* occur in isolated situations on sandstones and quartzite hills where soil accumulation has been able to take place. The hills are characterized normally by only lithosolic soils.

(3*d*) *Deep red clayey sands* are more than 4 ft deep and are free from ferruginous nodules. Finer textures may be encountered at less than 8 ft in some profiles, although in others sand textures may continue beyond 10 ft in depth.

These soils with a conspicuous coarse sand fraction are typical of the extensive sand plains. Soils with a conspicuous fine sand fraction occur in some valley floors and they reflect the grain size of nearby sedimentary rock. Soils of this group also occur on alluvial fans, on local fills in erosional plains, and in swales in dune fields. In some of the plains and valleys along the south side of the MacDonnell Ranges, they may be underlain by gravel beds.

(3*e*) *Red clayey sands with ferruginous nodules* are moderately deep or deep soils with a layer of ferruginous nodules. Only isolated recordings were made of these soils as most of the lateritic sand plain has soils with finer-textured subsoil horizons as in 4*f*.

(3*f*) *Red dune sands* are deep sands in which the surface horizon is only slightly darkened by organic matter and the sand is loose or weakly coherent owing to the almost complete absence of clay. Crocker (1946) has pointed out that the sands mainly fall in the fine sand fraction and that the degree of sorting is variable. These soils occur in the crests and flanks of the desert sand dunes that are very extensive in the southern half of the area. Dunes are much less common in the northern half and their sands are coarser than in the south.

(4) *Red Earths*.—Red earths normally have a gradational texture profile in which either coarse or medium-textured surface horizons grade into finer-textured horizons between 1 and 3 ft depth. However, some soils that are finer-textured throughout but have the same major profile characteristics are included in this group. Their colour is almost uniformly red (Munsell hue 10R), with the few inches at the surface slightly browner. Except for a thin surface crust, they are massive in structure, their fabric is characteristically porous, and they are permeable.

In the majority of soils there is a prominent coarse sand fraction, but some from sedimentary parent materials have dominantly fine sand. In sampled profiles clay content increases in depth from 10 to 18% in a coarse-textured soil and from 18 to 29% in a finer-textured soil. The silt content is low, ranging from 0 to 10% in all of the samples. Silt and clay contents are lower than expected from field textures.

Most of these soils are moderately acid to neutral in reaction but in the south of the area where adjacent residual soils contain appreciable salt and in situations of restricted drainage some are alkaline. Their salt content is usually insignificant (less than 0·02%). Calcium is the dominant exchangeable metal cation, but in some of the moderately acid soils exchangeable hydrogen is the principal cation.

To the north of the MacDonnell Ranges some deep red earth profiles overlie prismatic structured clays comparable to that in the subsoil of texture-contrast soils. Further identification of such soils which could depend on features deep in the profile is not considered in the subgrouping of the red earths.

(4*a*) *Gritty sandy red earths* are of shallow to moderate depth and are formed on erosional plains and slopes of low gradients on gneisses and granites, and locally on andesites and porphyries in the north of the area. The coarse-grained surface horizons merge gradually into gritty medium- to fine-textured subsoils. The underlying weathering horizon may contain carbonate, and also sufficient salts to produce efflorescences in erosion gullies.

(4*b*) *Red earths on calcareous substrata* are shallow to moderately deep soils overlying calcrete, calcareous clay, or limestone. The carbonate-free red earth horizon ranges from a few inches to more than 3 ft in depth and is usually medium-textured at the surface. However, soils with coarse-textured surface horizons are common in Kalamerta land system and occur sporadically in others. The main grain size of the sand fraction in these soils varies from fine to coarse but limestones always produce soils with fine-grained sands. The red earths formed on limestones usually have some covering of material enriched with secondary carbonate.

The most extensive occurrences of these soils are associated with calcareous depositional materials of the calcrete plains. Elsewhere they are formed over various consolidated strata or in areas of restricted drainage. Concentrations of ferruginous nodules occur in some of the soils of the depressions on the calcrete plains in the Lindavale land system.

(4*c*) *Red earths on sandstone* are of shallow to moderate depth and generally have coarse-textured surface soils. They are not common and were observed in isolated occurrences in the Cherry Creek and Angas land systems.

(4*d*) *Deep sandy red earths* have clayey sand surface soils that grade into sandy clay loam or sandy clay subsoils by 2 to 3 ft depth. Coarse sand fractions are predominant but, as in red clayey sands, prominent fine sand fractions may occur in soils derived from fine-grained sedimentary rocks. Gravelly subsurface horizons occur sporadically, but are not characteristic of any particular land system.

These soils occur on stable alluvia in a great variety of lowland situations and consequently have been recorded in many land systems. In the northern half of the area the sand plain soils belong in this group more commonly than in red clayey sands.

(4*e*) *Deep red earths* are at least 4 ft deep and generally have a sandy clay loam surface horizon passing into sandy clay within 12 in. of the surface. The sand fraction is dominantly coarse-grained, but some soils derived from limestone are fine-grained. On the open alluvial plains the surface horizon may be moderately acid (pH 5·0–6·0) merging into a neutral subsoil; floors in erosional plains and on limestone are usually neutral throughout, but one alkaline profile was recorded.

Soils of this group occur on a variety of alluvium transported from crystalline rock and less commonly from limestones, on stable alluvial floors, plains, and on outwash slopes of sufficiently low gradient to maintain the soil profile in balance with sheet movement of "fine earth material"; this is usually less than ½% for soils unprotected by a stone pavement.

(4*f*) *Sandy red earths with ferruginous nodules* have a horizon of ferruginous nodules overlying ferricrete (laterite), calcrete, or both, weathered material of the mottled zone, and locally altered rock. The nodules occur not only in association with the old lateritic formations but apparently also with underlying calcrete and little-altered sedimentary strata. It is suspected that each situation has had a period of restricted drainage at some stage during the history of the soil.

These soils are most common on the sand plain and in swales between dunes in the northern half of the region; elsewhere, recordings have been sporadic.

(4*g*) *Red earths with ferruginous nodules* have medium-textured surface soils grading into clayey subsoils. The nodule horizon generally overlies deeply weathered horizons including mottled zones, but as in the previous group some of these soils have unweathered substrates. Most of the soils are found on undissected or little-dissected surfaces of lateritic plains derived from crystalline rock.

(4*h*) *Stony fine-textured red earths* have a clay loam, sandy clay, or clay surface soil mantled with quartzite cobbles overlying a stony clay subsoil. They occur on the ancient terraces flanking some of the central ranges. On the higher residuals a deep soil of weakly acid reaction may overlie a lateritic soil or deeply-weathered strata. Elsewhere the stony soil rests directly on sedimentary rock. On lower terraces the soils are underlain by calcareous horizons which may have appreciable salt content.

(5) *Yellow Earths and Yellow Clayey Sands*.—These soils are similar to red earths and red clayey sands respectively except that their subsoil colour is yellow (Munsell hue 7·5YR) rather than red. They occur only in the northern higher-rainfall half of the area in sites that receive run-on from higher country.

(5*a*) *Deep yellow earths* have greyish brown coarse or medium-textured surface horizons that grade into yellowish brown subsoil which becomes finer-textured with depth. Some profiles contain manganiferous concretions. The only recording of reaction showed a trend from moderately to slightly acid in the upper part of the profile. Variations in colour, intermediate between that of yellow and red earths, have been reported in a number of profiles.

(5*b*) *Deep yellow clayey sands* are analogous to deep red clayey sands except that their colour is yellow. They have been recorded only in flood-out depressions in the sand plain of Woodduck land system.

(6) *Calcareous Earths*.—Except for silty alluvial layers, this group includes all soils containing finely-dispersed carbonate. They are most common above highly calcareous material. They are of coarse to medium texture with clay contents ranging between 10 and 20% and characteristically have a sand fraction that is predominantly fine. Their colour is most commonly brown (Munsell hue 5YR) when dry, becoming darker and reddish (Munsell hue 2·5YR) when moist. Coarser soils possess little organized structure apart from a thin surface crust; finer soils may possess irregular blocky structure. The dispersed carbonate imparts a floury or powdery consistence. Soil reaction is commonly strongly alkaline although total salts (0·01–0·06%) are low.

(6*a*) *Brown sandy calcareous earths* are shallow soils with a sand to coarse sandy loam surface horizon overlying a highly calcareous layer, including calcrete over limestone and basic crystalline rock.

Coarse-grained soils over the more basic crystalline rocks occur on the flanking slopes to ridges and on interfluves of erosional plains.

Fine-grained soils derived from limestones occur in similar topographic situations or on valley fills.

(6*b*) *Brown loamy calcareous earths* are shallow soils with a fine sandy loam to clay loam surface soil overlying a highly calcareous horizon, limestone, calcrete, or calcareous siltstones. The dispersed carbonate is separated in a subsurface horizon in some profiles. They occur on lower slopes from ridges of limestone, on extensive old alluvial fills, particularly in the lower tract of the Todd River, on calcrete and siltstone in the southern plains, and on old, undissected calcareous sediments north of the Harts Range.

(6*c*) *Red sandy calcareous earths* are of moderate to shallow depth overlying calcrete or a highly calcareous horizon. They are normally sandy throughout, but some soils have a coarse clayey sand surface horizon grading into sandy clay subsoils. They occur in the southern part of the region in dune fields and sand plains where carbonate-rich materials occur near the surface.

(6*d*) *Reddish brown sandy calcareous earths* have dispersed carbonate in deep sandy soils and the sand fraction is normally fine-grained. They occur on flood-plains and on inter-ridge fills to the south of the MacDonnell Ranges.

(6*e*) *Brown loamy calcareous earths with pavement* are mainly shallow soils with a dense siliceous stone mantle on the surface. The surface is uneven through scalding and wind piling, and intergrades to texture-contrast soils are a recurring feature.

(7) *Texture-contrast and Allied Soils*.—All of the soils in this group have at some position in their profile an abrupt transition (never more than 1 in.) from a coarse- or medium-textured surface to a finer-textured subsoil. The latter, which is

referred to as the subsoil pan, shows considerable variation in texture and structure. Very compact, massive vesicular sandy clay loams may contain less than 20% clay; prismatic, blocky, and locally columnar-structured clays have up to 50% clay. The surface horizon is commonly reddish brown and the subsoil is red-brown or brownish red (Munsell hue 2·5YR). In some soils a thin bleached horizon occurs immediately above the subsoil pan. Carbonate and/or gypsum may be present in the lower pan horizon or underlying material. The surface horizon has massive or weak platy structure and is very susceptible to water erosion. It is normally protected from erosion by a dense pavement of siliceous stones. Numerous small scalds form where the subsoil pan has been exposed by erosion. Soil reaction is usually neutral in the surface horizon, changing to alkaline in lower horizons. Salt levels increase from low (<0·05%) to moderate or high (0·05–>1·0%). In the subsoil pan the proportion of magnesium together with sodium may approximately equal the amount of calcium in the exchangeable metal ions.

(*7a*) *Texture-contrast soils on crystalline rocks* have less than 6 in. of sandy surface horizon with a packed or less dense quartz pavement overlying a prismatic or blocky structured clay or sandy clay, usually with an underlying carbonate and locally a gypseous horizon. The depth to weathering rock is normally less than 3 ft.

These soils normally occur on flanking slopes to hills and on the interfluves of erosional plains. Shallow, nearly lithosolic soils may persist on slopes of up to 4%.

(*7b*) *Texture-contrast soils on sedimentary rocks* have thin fine sandy surface horizons with dense pavements overlying well-structured blocky or prismatic clay containing little stone. This may overlie a gypseous or calcareous horizon. Exposures along scarps indicate that at least near erosional sites, the underlying rock may be capped by massive silcrete.

These soils occur commonly in the "gibber country" on erosional plains and on the tops of silcrete-capped residuals mainly to the south of the central ranges.

(*7c*) *Thin-surfaced texture-contrast soils* have less than 1 in. thickness of surface horizon with mixed pavement stone of variable density overlying a prismatic structured clay which merges into a calcareous horizon.

(*7d*) *Shallow texture-contrast soils with siliceous hard pan* typically have a 2 in. surface horizon of clayey sand with silcrete pavement overlying a thin sandy clay loam pan with siliceous hard pan at 6 to 9 in. depth.

Isolated recordings of soils similar except for variations in the nature of the pavement stone were made in the Alcoota and Alinga land systems.

(*7e*) *Sandy texture-contrast soils* have a sand or clayey sand surface horizon over a sandy clay loam or sandy clay massive subsoil pan. The depth of the pan ranges from 6 to over 36 in., but a depth of 10 to 12 in. is most usual. The pan may be thin with coarse-textured alluvium below it. The sand fraction is usually dominantly coarse, but fine-grained sands have been recorded south of the MacDonnell Ranges. Carbonate was recorded only sporadically and gypsum was not recorded at all.

Severe scalding on these soils is a common feature on the outer part of the flood-plains south of the central ranges and to a less extent on those derived from the northern crystalline ranges. In particular, these soils develop on alluvia derived from granites, old terraces, and deeply weathered formations.

(7*f*) *Sandy texture-contrast soils with pavement* have coarse-textured surface horizons overlying a structured clay and variable alluvial substrata.

(7*g*) *Loamy texture-contrast soils* have medium-textured surface horizons with variable pavements overlying a structured clay pan. The surface horizons of 1 to 8 in. are generally thinner than in coarser-textured soils and the pans are either prismatic or blocky-structured, with an underlying carbonate horizon at 15 to 26 in. depth. Gilgai depressions occur among these soils.

These soils are found on weakly dissected Tertiary sediments and on alluvium derived from the erosion of deeply weathered surfaces.

(7*h*) *Texture-contrast soils with mottled yellowish subsoil* have grey-brown loamy surface soils overlying a bleached horizon with manganiferous nodules overlying a sandy clay subsoil, which is mottled yellow and grey.

These soils occur in association with yellow earths on flood-out depressions in the north-eastern part of the area.

(7*i*) *Sandy texture-contrast soils with variable siliceous hard pan* are similar to group 7*e* except that the subsoil pan is variable in the degree to which it is cemented.

(8) *Coarse-structured Clay Soils.*—The coarse-structured clay soils are comparable with the well-known "grey and brown soils of heavy texture" but are more usually red in colour (Munsell hue 10R) than grey or brown. Deep cracking into a coarse blocky structure occurs when the soil is dry and the solum appears to be subjected to slow mixing as suggested by the dispersal of flecks of carbonate up to the surface of the soil. There is little differentiation into horizons except for a thin surface crust and the presence of a lower gypseous horizon in some soils. An almost even soil surface, except for sporadic small collapsed cavities, is more common than gilgai microrelief.

The clay content is not as high as would be expected from field texture, two red soils analysed containing between 24 and 38% clay. Most of the profile has an alkaline reaction and recordings of salt content vary from moderate to high (0·08–0·28%) in gypsum-free horizons. Their phosphorus content is very low (0·010–0·016%) and this appears to be a general characteristic of these soils in northern Australia (Stewart, personal communication).

The two subgroups defined below are red and grey in colour but certain other clay soils are known from the area and have not been fully characterized. These include a yellowish grey soil over gypseous claystone in the Endinda land system where it borders the Simpson Desert, grey-brown soils in basins along the flood-plain of the Sandover River and in a closed basin of the Utopia land system, and a brown soil with prominent gilgais in a basin in the Undippa land system.

(8*a*) *Red coarse-structured clays* occur on alluvial fans below the crystalline mountains bordering the western MacDonnell Ranges in the Undippa and McGrath land systems, on plains formed on slightly dissected lateritic surfaces in the Alcoota land system, on Tertiary sediments in the Table Hill and Ambalindum land systems, and in gilgai depressions associated with texture-contrast soils.

(8*b*) *Greyish coarse-structured clays* occur widely in the neighbouring Barkly region and in the channel country of Queensland but have only been observed in a few basins in the Alinga land system in this area.

III. Regional Significance

(*a*) *Irrigation*

If irrigation of selected areas is to be expanded, waters of varying quality will be increasingly used. The prime consideration will therefore be to select permeable soils of low natural salt content. Sands and clayey sands generally possess these characteristics but they would require careful control over depth of wetting during spray irrigation to avoid an excessive use of water where the supply is limited. It is also anticipated that the red sands and clayey sands would be among the least fertile groups of the area. In view of these factors, the brown alluvial sandy loams (1*b*), red-brown sandy alluvial red earths (1*i*), red earths on calcareous substrata (4*b*), and deep sandy red earths (4*d*) probably offer the most desirable textural conditions. The first of these soils is being successfully spray-irrigated for lucerne production at the Animal Industry Research Institute near Alice Springs.

Sites favoured with both suitable soils and waters of adequate quality are most likely to be found in the Sandover, Woolla, and Titra land systems. In the Finke, Lindavale, McGrath, and Ammaroo land systems isolated sites may be suitable, but either water quality or soil characteristics are generally unfavourable.

Some of the finer-textured soils, such as deep red earths (4*e*), with slower, yet free, internal drainage, should be more desirable for water-spreading techniques, where a requirement would be to prevent salt accumulation but at the same time to keep the soil above wilting point for as long as possible after each flooding.

Texture-contrast soils should be avoided in all circumstances for both extensive and garden use. Their inherent salinity, coupled with restricted internal drainage through the subsoil pan, and their alkaline reaction, would predispose to failure the growth of most introduced plants, in particular sensitive fruit-trees such as citrus and many vegetables.

Coarse-structured clay soils would require both a low inherent salt status and high-quality waters, and would also often be unsuitable because of liability to relatively prolonged flooding in basins and for other edaphic reasons.

High temperatures, low production of plant material per unit area, and a high proportion of bared soil surface per unit area, are all factors limiting the accumulation of organic matter, and hence very low levels may be expected in hot, arid zones. Any cultural devices aimed at modifying these factors would increase microbiological activity in the soil and, in addition to supplying available nitrogen, should increase productivity. Little is known of the effect that the termite population has on the organic cycle and circulation of nutrients in arid-zone and northern Australian soils. They apparently consume a significant proportion of the available plant debris and their population is appreciable even in sand plain with spinifex.

TABLE 15

SUMMARY OF THE REGIONAL SIGNIFICANCE OF THE SOILS

Generalized Soil Grouping	For Intensive Production from Irrigation or Water-spreading	Erosion Hazard	For Water Storages	For Formed Road and Airstrip Construction
Coarse-textured alluvial soils	Suitable for spray irrigation subject to strict control to avoid excessive water use	Unstable	Unsuitable	Adequate for light traffic
Coarse- to medium-textured alluvial soils	Suitable for spray irrigation but permeability excessive for flood irrigation or water-spreading	Subject to moderate scalding	Unsuitable	Adequate for light traffic and airstrips subject to grading
Finer-textured alluvial soils	Qualified suitability for irrigation subject to high water quality; suitable for water-spreading	Subject to severe scalding	Dependent on deep subsoil conditions but probably usually subject to excessive loss	Adequate for light traffic and airstrips subject to grading
Red sands and clayey sands	Permeability suitable for spray irrigation subject to strict control to avoid excessive water use	Stable under spinifex vegetation	Unsuitable	Adequate for light traffic
Coarser-textured red earths	Suitable for spray irrigation; suitability for water-spreading would depend on local permeability of subsoil	Stable	Subject to excessive loss	Suitable for both roads and airstrips
Finer-textured red earths	Suitable for water-spreading and probably for flood irrigation (but subject to water quality)	Stable	Subject to excessive loss	Suitable for both roads and airstrips; ferruginous nodular horizons when present suitable for road surfacing material
Red earths on calcrete	Suitable for both water-spreading and irrigation	Stable	Subject to excessive loss	Suitable for both roads and airstrips; substrata suitable for road surfacing

TABLE 15 (*Continued*)

Generalized Soil Grouping	For Intensive Production from Irrigation or Water-spreading	Erosion Hazard	For Water Storages	For Formed Road and Airstrip Construction
Calcareous earths	Unsuitable	Subject to moderate to severe scalding	Unsuitable	Adequate for light traffic; substrata may be suitable for road surfacing
Texture-contrast soils with pavements	Unsuitable	Subject to scalding	Successful for deep soils	Require surfacing and present hazards for airstrips
Coarser-textured texture-contrast soils without pavements	Unsuitable	Subject to to severe scalding	Unsuitable	Require surfacing and unsuitable for airstrips
Coarse-structured clay soils	Usually unsuitable for irrigation; qualified suitability for water-spreading	Stable	Successful	Require surfacing and present hazards for airstrips

It can be assumed that phosphatic fertilizer will usually be required for intensive production. Total reserves of phosphorus are greatest in some of the alluvial soils and least in red sands and clayey sands and coarse-structured clay soils. The base saturation in the surface soil of red earths may vary appreciably and this factor could mean that strongly unsaturated, acidic soils may fix more phosphate than neutral soils (Russell 1950). This may call for devices in some soils such as placing of fertilizer close to the germinating seed.

(*b*) *Earthen Structures*

The textural combination of sand and clay and the absence of sodium clay in the red earths make for compact, even-surfaced earth roads and airstrips. This has given the pastoral country north of Alice Springs a pattern of access roads superior to those found in many other parts of inland Australia. On the other hand, these same properties make for excessive loss of stored water in earthen tanks, and sealing or puddling devices are needed to reduce this loss. However, coarse-structured clay soils and certain deep texture-contrast soils support successful water storages. Coarse-structured clay soils although providing open, low-gradient slopes, develop collapsed cavities and unless frequently graded are treacherous for light aircraft if used for airstrips. Road formation in texture-contrast soils is unstable owing to the washing out of dispersed clays in wet weather. These soils and the coarse-structured clay soils need surfacing for light traffic even after light rainfall. Calcretes and the nodular horizons of red earths (4*f*, 4*g*) represent resources of desirable surfacing material. The only attempt at water storage recorded on a calcareous earth was a failure.

(c) *Erosion Hazards*

The coarser-textured texture-contrast soils without surface pavements (*7e*, *7i*) and the finer-grained and silty alluvial soils present the major erosion hazards in the region but the sand plains and dune fields remain effectively fixed by spinifex vegetation. Movement in the former is inevitably accentuated by utilization. In the texture-contrast soils, the surface is completely lost and extremely hard scalds of varying size form on top of the subsoil pan. The alluvial soils will be difficult to manage for arable use. Their textural range is such as to form severe surface seals or shallow scalds which would have to be broken up to form a seed-bed. Once broken, however, these textural fractions are those most subject to loss from wind erosion.

The significance of the soils in the utilization of the country is summarized in Table 15.

IV. Acknowledgments

Analyses of the soil samples collected during the survey were carried out in the laboratories of the Division of Soils, at Adelaide, under the direction of J. T. Hutton.

V. References

CROCKER, R. L. (1946).—The soils and vegetation of the Simpson Desert and its borders. *Trans. Roy. Soc. S. Aust.* **70**: 235–58.

HALLSWORTH, E. G., and COSTIN, A. B. (1950).—Soil classification. *J. Aust. Inst. Agric. Sci.* **16**: 84–9.

JESSUP, R. W. (1951).—The soils, geology, and vegetation of north-western South Australia. *Trans. Roy. Soc. S. Aust.* **74**: 189–273.

PRESCOTT, J. A. (1944).—A soil map of Australia. Coun. Sci. Industr. Res. Aust. Bull. No. 177.

RUSSELL, E. J. (1950).—"Soil Conditions and Plant Growth." 8th Ed. (Longmans: London.)

STEPHENS, C. G. (1956).—"A Manual of Australian Soils." 2nd Ed. (C.S.I.R.O.: Melbourne.)

STEWART, G. A. (1953).—Soils of the Barkly region. C.S.I.R.O. Aust. Land Res. Ser. No. 3: 65–77.

TAYLOR, J. K. (1950).—Soils of Australia. *In* "The Australian Environment". 2nd Ed. (C.S.I.R.O.: Melbourne.)

WILD, A. (1958).—The phosphate content of Australian soils. *Aust. J. Agric. Res.* **9**: 193–204.

PART IX. VEGETATION OF THE ALICE SPRINGS AREA

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I. INTRODUCTION

The climate of the area is arid, with a mean annual rainfall varying from about 5 in. in the south-eastern corner to about 14 in. near Tennant Creek, on the northern edge. As well as being low in total amount, the rainfall is extremely erratic and unreliable, and more than half is in light falls which are of little or no use for plant growth. There is a summer maximum and a lower winter peak.

The harsh climate has been the main factor responsible for the selection of the individual plant species, their life forms, and the community forms. One of the striking features of the vegetation is the relative absence of *Eucalyptus* spp., which are generally regarded as ubiquitous in Australian vegetation. Within the Alice Springs area only five species can be regarded as characteristic plants of communities, and these communities are of restricted nature generally in habitats where the water supply is specially favourable. Thus the *E. microtheca* (coolibah) community occurs in temporarily flooded habitats, such as along broad, shallow stream-lines and in depressions, the *E. papuana* (ghost gum or carbeen) community occurs in small areas on levees of the major rivers in the northern half of the area, the *E. oleosa* (mallee) community occurs in small areas mainly in the southern half of the area and generally on lower slopes near the base of limestone hills, the *E. brevifolia* (snappy gum) community occurs only in the extreme north of the area, and the *E. camaldulensis* (river red gum)–*Acacia estrophiolata* (ironwood) community is restricted to a narrow fringe along stream channels. In general, *Eucalyptus* spp. are not important in that part of Australia north of the southern (winter maximum) 10-in. isohyet and south of the northern (summer maximum) 15-in. isohyet.

The area is characterized by plants of low stature forming structurally simple communities in which ground cover is low. Structurally the communities range through grasslands, grasslands with scattered trees or shrubs, shrublands, and woodlands. The last are low and fairly open.

(a) *Plant Geography*

The area is poor floristically. In the whole of central Australia, of which the surveyed area constitutes about two-thirds of the total area, the total number of species of vascular plants is less than 1200, which represents only about 1 species per 200 sq. miles. The distribution of the species throughout the plant kingdom is shown in Table 16.

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The Leguminosae and Gramineae are the largest families, being represented by 35 and 41 genera and 171 and 135 species respectively. Other floristically important families are Compositae (100 species), Chenopodiaceae (76), Malvaceae (41), Goodeniaceae (38), Myrtaceae (35), Myoporaceae (33), Amarantaceae (31), Boraginaceae (24), Solanaceae (23), Proteaceae (14), Zygophyllaceae (14), Cruciferae (13), and Portulacaceae (11). These 15 families comprise about 70% of the total flora.

In general the flora is typical of that of arid Australia, 41% of the species being endemic to that part between the 10-in. rainfall isohyet in the south and the 15-in. isohyet in the north. 27% are common to central Australia and higher-

TABLE 16

DISTRIBUTION OF THE PLANT SPECIES IN THE PLANT KINGDOM

	Families	Genera	Species
Pteridophyta	5	11	18
Gymnosperms	2	2	2
Monocotyledons	14	65	188
Dicotyledons	73	258	<1000
Total	94	336	<1200

rainfall tropical areas, 21% are common to central Australia and higher-rainfall southern Australia, and the remaining 11% are common to central Australia and both northern and southern higher-rainfall areas.

(*b*) *Plant Types*

Except for the remarkable absence of thorny and succulent plants, the species have many features in common with species from other arid areas throughout the world. They are all adapted to withstand long periods of drought and can be classified into three main groups according to their method of survival.

(i) *Perennial Drought-resisting Plants*.—This includes all the plants which remain in a vegetative, though generally dormant state throughout droughts and resume growth more or less where they left off, with the onset of favourable conditions. Most of the larger plants, i.e. shrubs and trees, fall into this category. The best examples are the *Acacia* spp. which are the main shrub and tree characteristics in the area, and which have sclerophyllous phyllodes instead of leaves. All the *Triodia* spp. and *Plectrachne* spp. known collectively as spinifex also fall into this group. These large (1–6 ft high, 1–20 ft dia.), perennial, tussock grasses are extremely xerophytic and have tough, pungent, pointed, sclerophyllous, longitudinally folded, and therefore apparently terete, leaves. Spinifex, although not generally the tallest species in the communities, are the characteristic plants of about 100,000 sq. miles of sand plains, dune fields, and rocky hills in the area. They are the hardiest of all grasses (Gardner 1942) and play the role of shrubs more than grasses (Burbidge 1946). The plants associated with spinifex are mainly shrubs or low trees, of which *Acacia* spp. are commonest but which also include representatives of many other genera. Most of them have very sclerophyllous leaves. The degree of drought which these plants can endure in a vegetative state is illustrated by the fact that *Triodia basedowii* leaves and *Acacia aneura* phyllodes can withstand a diffusion pressure deficit equivalent to about 130 atmospheres of pressure (Slatyer, personal communication).

Zygochloa paradoxa (sandhill cane grass), which occurs on relatively unstable dune crests and on very sandy banks, also belongs in this group.

Although highly sclerophyllous leaves or phyllodes are the commonest type of adaptation in the perennial drought-resisting plants, there are a limited number of species which exhibit other forms of adaptation. These forms include succulent leaves, of which the best example is the herbaceous *Calandrinia balonensis* (parakeelya). The subshrubs *Atriplex vesicaria* (saltbush) and *Kochia astrotricha* (bluebush), both of which are characteristic plants of communities in the southern half of the area, are semi-succulent and in addition are partially deciduous during long severe droughts. Some species such as *Newcastlia spodiotricha* have a dense woolly tomentum; some such as *Casuarina decaisneana* (desert oak) have very small scale-like leaves on cladodes; some such as *Dodonaea cuneata* have very viscid leaves.

(ii) *Perennial Drought-evading Plants.*—Far fewer species occur in this group than in the previous one. It includes all perennial species which endure drought periods in a dormant state and begin new growth from vegetative buds with the onset of favourable conditions. Trees and shrubs in this group are deciduous, the best and commonest examples being *Brachychiton gregorii* (kurrajong) and *Erythrina vespertilio* (coral tree).

Economically the most important in the group are the perennial tussock grasses which have a short growing season. Following rains they grow rapidly from a rootstock or rhizomes, mature, and produce seeds, and then the leafy part dies. In most cases the dead leaf and stem material remains standing until the next growth period. Their life cycle is somewhat similar to the next group (ephemerals) but they regenerate vegetatively instead of from seeds. The most important of these is *Eragrostis eriopoda* (woollybutt), which grows as an understorey in the *Acacia aneura* (mulga) community and a number of other communities. In small areas it occurs as a grassland. Other important examples are *Eragrostis xerophila* (neverfail), *Astrebla pectinata* (barley Mitchell grass), and *A. lappacea* (curly Mitchell grass), all of which most commonly occur in grasslands on fine-textured soils. Less important are *Aristida pruinosa* (three-awned spear grass), *A. browniana* (kerosene grass), *Themeda australis* (kangaroo grass), *T. avenacea* (native oat grass), *Chrysopogon fallax* (golden-beard grass), *Bothriochloa ewartiana* (desert blue grass), *Eulalia fulva* (silky browntop), and *Chloris acicularis* (curly windmill grass). Most of these are more prominent near the northern higher-rainfall margin of the area or occur in habitats favoured with extra water.

A number of shorter grasses such as *Aristida arenaria* (kerosene grass) and *Enneapogon* spp. may act as short-term perennials regenerating from small rootstocks. It is not known whether vegetative regeneration is normal in these plants or whether it occurs only during a succession of favourable seasons. However, as seeds are probably their most important method of regenerating, particularly after long droughts, they have been classified in the next group.

(iii) *Ephemeral Drought-evading Plants.*—The life cycle of this group of plants is so adjusted that although they exist in an arid area, their vegetative growth occurs only under relatively non-arid conditions following rain. Thus they are adapted not so much to withstand drought as to take advantage of the short favourable periods. Following rain their seeds quickly germinate, there is a short period of rapid growth, a large seed production, and with the onset of water stress they die. An almost ubiquitous feature is that seed production starts at a very early stage, plants only an inch or so high and several weeks old producing flowers and seeds. This ensures that, if the fall of rain was adequate for germination but for only a very short period of growth, seed reserves of each species are replenished. If the fall of rain is sufficient for a longer period of growth, the plants continue to grow and continue to produce flowers and seeds. In favourable seasons the number of seeds produced must be astronomical.

A large number of species, generally referred to in the following parts of this publication as short grasses and forbs, fall into this group. The commonest are the composites *Helipterum floribundum* (white daisy), *H. charsleyae* (yellow daisy), *Calocephalus platycephalus*, *Senecio gregorii* (yellow daisy), and *Helichrysum* spp. Grasses, including *Aristida arenaria* (kerosene grass), *Enneapogon* spp., *Neurachne* spp., and *Tripogon loliiformis*, crucifers, especially *Stenopetalum* spp. and *Lepidium* spp., chenopods, such as *Bassia* spp., *Chenopodium* spp., *Atriplex* spp., and *Salsola kali* (roly-poly), and legumes, especially *Swainsonia* spp., are also common. *Erodium* spp. are common in some seasons.

These plants constitute the ground storey of large areas of country commonly under shrub and tree communities. The characteristic plants in any one locality vary from season to season, probably because each species has an optimum germination temperature. If this is so, the species which germinate will be determined by the temperature during and immediately following each fall of rain. It is also probable that some species have germination-inhibiting mechanisms which prevent seeds from germinating unless rains have been sufficient to provide a reasonable growing season.

(*c*) *Plants and Environment*

Although climate has been the primary factor in the selection of species and life forms and is the controlling factor influencing the structure and density of the plant communities in the area, soil characteristics are of primary importance in determining the floristics and distribution of the communities within the area. However, the most important soil characteristics are those which control the amount and availability of water supply, and thus the physical properties and depth of soil exert a greater influence on plants than the chemical properties. A similar conclusion was reached by Shreve (1951) in his studies of the Sonoran Desert in America. Thus the physical properties of the soils tend to exert their influence on vegetation through their modifying or compensating effect on climate and particularly water supply. An example of such an effect is the distribution of the *Acacia kempeana* (witchetty bush) and *A. aneura* (mulga) communities, Of the two communities *A. aneura* has a higher water requirement than *A. kempeana.* This is illustrated by the fact that although both communities are geographically widespread throughout the area, *A. kempeana* is commonest on the more droughty calcareous habitats and *A. aneura* is commonest on deeper, red earth soils. That the calcareous nature of most of the *A. kempeana* habitats, as against the non-calcareous nature of the *A. aneura* habitats, is not the selective factor is shown by the fact that in the northern higher-rainfall areas *A. kempeana* community occurs on well-drained, low, non-calcareous rises within the *A. aneura* community on more favourable topography. Also near the southern margin of the area, under a low rainfall and particularly on granite soils, *A. kempeana* community occupies most of the topography and *A. aneura* community is restricted to depression areas which have deeper soils and a more favourable water supply.

Another example is the distribution of *Eucalyptus* spp. communities. The absence of these communities over most of the area is striking. Where they do occur they are restricted mostly to habitats with a favourable water supply.

Among the spinifex areas, the *Triodia pungens* community is typical of plains in the northern part of the area where the mean annual rainfall is greater than about 13 in. and *T. basedowii* community occurs on sand plains and dune fields between the 5-in. and 13-in. mean annual rainfall isohyets. However, the *T. pungens* community occurs as far south as the 8-in. isohyet but in restricted areas where, because of topographic or soil characteristics, water supply is more favourable.

The relationships of the vegetation communities with climate and other environmental factors are illustrated in Figures 13 and 14. It should be noted that the plant names in these figures refer to communities and not to the species themselves. Many of the species characteristic of communities also occur sparsely as associated plants in other communities.

(*d*) *Relation between Upper and Lower Storeys*

A feature of the vegetation of the area is the independence of ground-storey and upper-storey communities. It seems that each species in a community is determined by the environment rather than by the presence of other plants. For example *Acacia aneura* (mulga) is the characteristic upper-storey plant over about 10,000 sq. miles of the area but there are 18 distinct ground-storey communities associated with it. On the other hand the commonest of the ground-storey communities associated with the *A. aneura* upper-storey community, viz. short grasses and forbs, is also associated with 12 other upper-storey communities. For this reason 17 upper-storey and 31 ground-storey communities are described separately and their associations one with the other are shown in Table 17 and briefly discussed. A general idea of the distribution of the communities can be obtained from the land system map, in conjunction with Tables 18 and 19.

The distribution pattern of the commonest ground-storey communities can be obtained by referring to the pasture lands map.

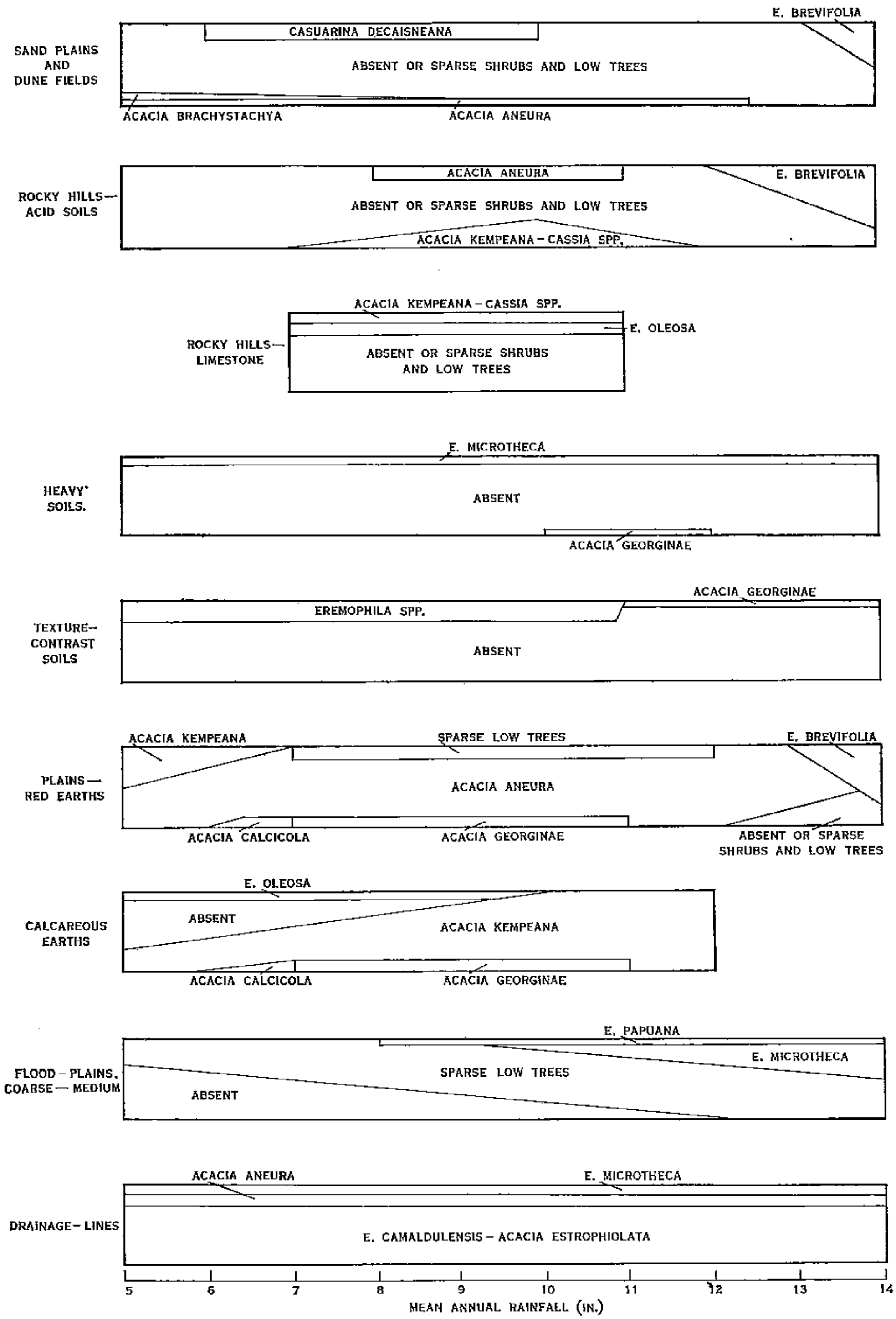

Fig. 13.—Relationship of upper-storey communities to environmental features.

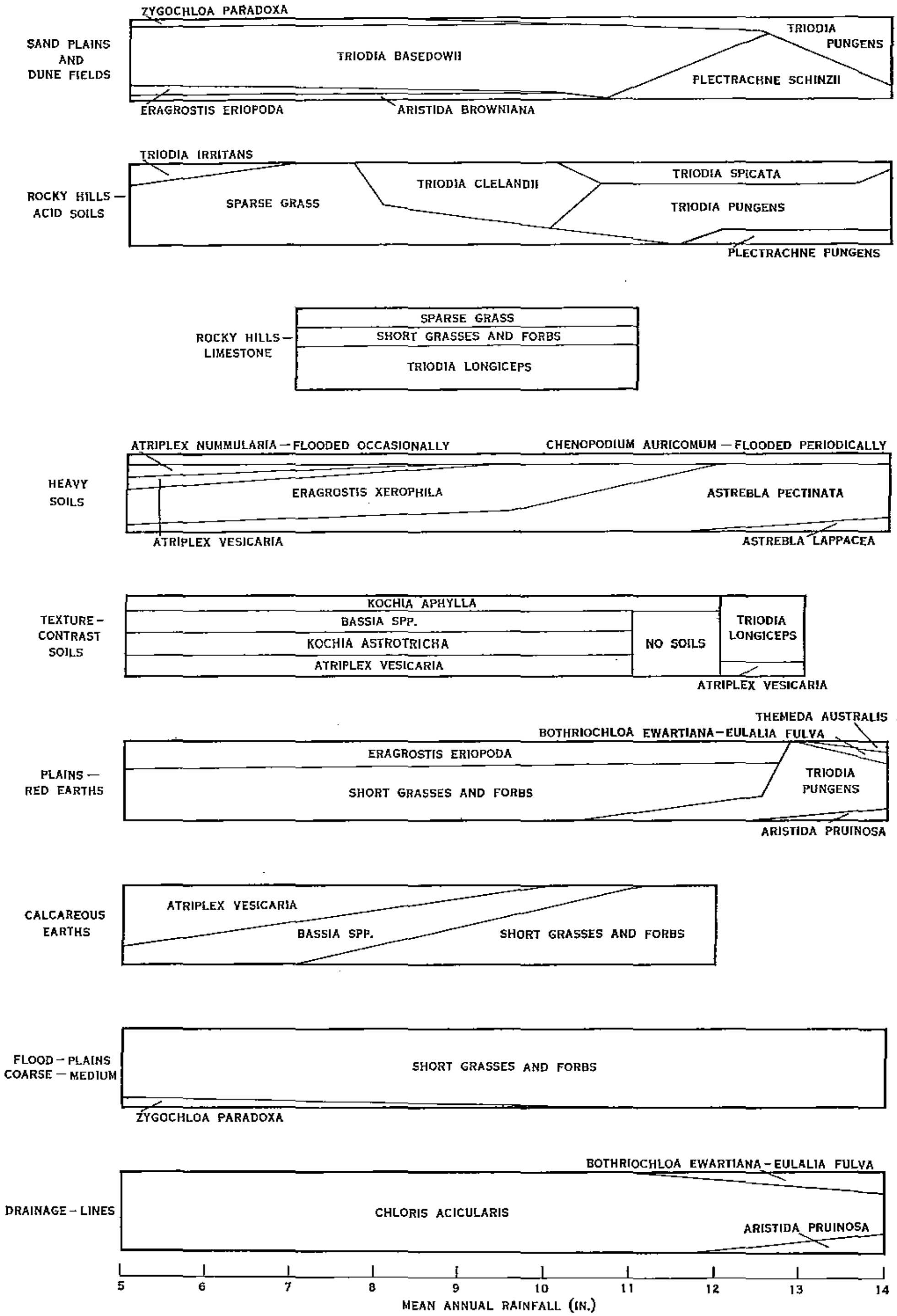

Fig. 14.—Relationship of ground-storey communities to environmental features.

TABLE 17

ASSOCIATIONS OF GROUND-STOREY AND UPPER-STOREY COMMUNITIES

Ground-storey Communities	Upper-storey Communities																	
	Acacia aneura	*Acacia kempeana*	*Acacia georginae*	*Acacia calcicola*	*Acacia brachystachya*	Sparse low trees	*Eucalyptus microtheca*	*Eucalyptus papuana*	*Eucalyptus oleosa*	*Eucalyptus brevifolia*	*Eucalyptus camaldulensis*–*Acacia estrophiolata*	*Casuarina decaisneana*	*Melaleuca glomerata*	*Acacia kempeana*–*Cassia* spp.	*Cassia eremophila*	*Eremophila* spp.–*Hakea leucoptera*	Sparse shrubs and low trees	Absent
Plectrachne schinzii	●						●			●							●	
Plectrachne pungens													●				●	●
Triodia basedowii	●				●		●					●					●	
Triodia pungens	●						●	●		●	●	●	●		●		●	●
Triodia hubbardii																	●	
Triodia clelandii																	●	
Triodia spicata	●																●	
Triodia longiceps		●	●						●	●							●	●
Triodia irritans	●																●	
Eragrostis eriopoda	●	●	●		●	●	●	●										●
Eragrostis xerophila			●				●											●
Astrebla pectinata			●															●
Astrebla lappacea																		●
Aristida pruinosa							●										●	
Aristida browniana							●				●						●	
Themeda australis	●						●											
Themeda avenacea						●	●											
Chrysopogon fallax						●	●	●										
Bothriochloa ewartiana–*Eulalia fulva*	●		●				●				●							
Chloris acicularis	●		●				●	●			●							●
Zygochloa paradoxa							●				●						●	
Short grasses and forbs	●	●	●	●		●	●		●		●			●	●	●	●	●
Sparse forbs and grasses	●													●			●	
Muehlenbeckia cunninghamii	●						●	●										●
Chenopodium auricomum							●											●
Atriplex nummularia							●											●
Atriplex vesicaria	●	●	●	●														●
Kochia astrotricha	●	●	●	●														●
Kochia aphylla	●		●															●
Arthrocnemum spp.																		●
Bassia spp.	●	●	●	●		●							●			●	●	●
Absent	●		●				●							●	●		●	●

TABLE 18

RELATION BETWEEN UPPER-STOREY COMMUNITIES AND LAND SYSTEMS

Upper-storey Community	Land Systems in which Community occurs on		
	Large Proportion of Area	Moderate Proportion of Area	Small Proportion of Area
Acacia aneura	Boen, Tietkins, Alinga, Kalamerta, Lindavale, Karee, Bushy Park, Leahy, Ewaninga, Adnera	Aileron, Warburton, Ooratippra, Chisholm, Delny, Alcoota, Gillen, Ilbumric, Kernot, Hogarth, Cherry Creek, Stokes, Kanandra, Deering, Hamilton	Harts, Bond Springs, Napperby, Cavenagh, Outounya, Hann, Wonorah, Kulgera, Pularoo, Ryan, Ennugan, Sonder, Middleton, Tennant Creek, Krichauff, Lucy, Chandlers, Rumbalara, Wilyunpa, Barrow, Anderinda, Peebles, Lilla, Ebenezer, Allua, Coghlan, Renners, Muller, Dinkum, Angas, Weldon, Berrys Pass, Table Hill, Ambalindum, Titra, Woolla, Ringwood, Pulya, Simpson, Singleton, McDills, McGrath, Ammaroo, Sandover, Amulda, Todd, Woodduck
Acacia kempeana	Cavenagh, Outounya, Muller	Lucy, Ilgulla, Ebenezer, Huckitta, Woolla, Todd	Bond Springs, Boen, Warburton, Tietkins, Hann, Alinga, Ooratippra, Delny, Kulgera, Pularoo, Alcoota, Ryan, Gillen, Chandlers, Rumbalara, Unca, Allua, Renners, Dinkum, Angas, Kalamerta, Weldon, Santa Teresa, Table Hill, Lindavale, Titra, Bushy Park, Ringwood, Pulya, Ewaninga, McGrath, Sandover, Kanandra, Hamilton, Amadeus
Acacia georginae	Ooratippra, Ringwood	Delny, Hogarth, Lucy, Pulya	Bond Springs, Boen, Hann, Alinga, Alcoota, Ryan, Gillen, Kurundi, Ilbumric, Tennant Creek, Tomahawk, Cherry Creek, Ilgulla, Peebles, Huckitta, Allua, Coghlan, Endinda, Dinkum, Santa Teresa, Table Hill, Ambalindum, Leahy, McDills, McGrath, Sandover, Todd
Acacia calcicola			Cavenagh, Outounya, Kulgera, Gillen, Chandlers, Peebles, Ebenezer, Muller, Kalamerta, Weldon, Lindavale
Acacia brachystachya			Ebenezer, Kalamerta

TABLE 18 (*Continued*)

Upper-storey Community	Land Systems in which Community occurs on		
	Large Proportion of Area	Moderate Proportion of Area	Small Proportion of Area
Sparse low trees	Warburton, Pularoo, Ennugan, Indiana, Jinka, Barrow, Anderinda, Dinkum, Finke, McGrath, Sandover, Kanandra, Todd, Woodduck	Napperby, Aileron, Delny, Weldon, Woolla, Ammaroo, Adnera	Harts, Bond Springs, Napperby, Cavenagh, Hann, Chisholm, Alcoota, Davenport, Ryan, Gillen, Middleton, Kurundi, Ilbumric, Tennant Creek, Hogarth, Lucy, Rumbalara, Barrow, Lilla, Huckitta, Allua, Muller, Stokes, Santa Teresa, Table Hill, Ambalindum, Titra, Bushy Park, Ringwood, Pulya, Simpson, Ewaninga, Amulda, Deering, Hamilton, Utopia
Eucalyptus microtheca			Hann, Alinga, Ooratippra, Chisholm, Gillen, Ilbumric, Cherry Creek, Lucy, Chandlers, Allua, Renners, Endinda, Lindavale, Woolla, Leahy, Ringwood, Pulya, Simpson, Singleton, McDills, Finke, McGrath, Ammaroo, Sandover, Todd, Woodduck, Adnera, Utopia
Eucalyptus papuana			Finke, Sandover
Eucalyptus oleosa			Huckitta, Allua, Stokes, Ambalindum, Lindavale
Eucalyptus brevifolia			Warburton, Hann, Wonorah, Davenport, Kurundi, Ilbumric, Tennant Creek
Eucalyptus camaldulensis–Acacia estrophiolata			Harts, Bond Springs, Napperby, Cavenagh, Warburton, Outounya, Hann, Chisholm, Delny, Pularoo, Alcoota, Ryan, Ennugan, Sonder, Pertnjara, Davenport, Gillen, Middleton, Kurundi, Tennant Creek, Hogarth, Krichauff, Tomahawk, Lucy, Ilgulla, Indiana, Jinka, Barrow, Anderinda, Peebles, Lilla, Huckitta, Allua, Coghlan, Muller, Weldon, Reynolds, Berrys Pass, Stokes, Santa Teresa, Table Hill, Ambalindum, Bushy Park, Ringwood, Pulya, Finke, McGrath, Ammaroo, Sandover, Amulda, Kanandra, Todd, Woodduck, Adnera, Deering, Hamilton, Utopia

TABLE 18 (*Continued*)

Upper-storey Community	Land Systems in which Community occurs on		
	Large Proportion of Area	Moderate Proportion of Area	Small Proportion of Area
Casuarina decaisneana			Middleton, Lindavale, Simpson, Singleton, Amadeus
Melaleuca glomerata			Titra, Amadeus
Acacia kempeana–Cassia spp.	Harts, Bond Springs, Tomahawk	Allua, Table Hill, Titra	Cavenagh, Boen, Alinga, Chisholm, Ryan, Sonder, Gillen, Lucy, Wilyunpa, Lilla, Huckitta, Muller, Ambalindum
Cassia eremophila			Tietkins, Kulgera, Angas, Lindavale, Titra, Amadeus
Eremophila spp.–*Hakea leucoptera*		Chandlers, Lilla	Napperby, Warburton, Alcoota, Ryan, Gillen, Rumbalara, Coghlan, Weldon, Reynolds, Stokes, Ambalindum, Deering
Sparse shrubs and low trees	Harts, Napperby, Cavenagh, Aileron, Hann, Wonorah, Sonder, Pertnjara, Davenport, Gillen, Middleton, Kurundi, Tennant Creek, Kernot, Krichauff, Rumbalara, Unca, Huckitta, Allua, Coghlan, Angas, Weldon, Reynolds, Berrys Pass, Stokes, Santa Teresa, Simpson, Singleton, Amulda	Bond Springs, Alinga, Ilbumric, Hogarth, Cherry Creek, Table Hill, Titra, Ewaninga, Woodduck, Utopia, Amadeus	Boen, Warburton, Tietkins, Ooratippra, Chisholm, Kulgera, Pularoo, Alcoota, Ryan, Ennugan, Tomahawk, Ilgulla, Chandlers, Indiana, Jinka, Barrow, Anderinda, Peebles, Lilla, Ebenezer, Renners, Muller, Endinda, Dinkum, Lindavale, Woolla, Karee, Bushy Park, Leahy, Finke, Ammaroo, Sandover, Kanandra, Todd, Adnera
Absent	Kulgera, Alcoota, Ryan, Lucy, Ilgulla, Chandlers, Wilyunpa, Peebles, Lilla, Ebenezer, Renners, Endinda, Ambalindum, Pulya, McDills, Ammaroo, Deering, Hamilton, Utopia, Undippa, Amadeus	Rumbalara, Muller, Angas, Ringwood, Finke, McGrath, Sandover	Bond Springs, Napperby, Cavenagh, Warburton, Outounya, Alinga, Delny, Ennugan, Gillen, Tennant Creek, Unca, Barrow, Anderinda, Allua, Coghlan, Kalamerta, Weldon, Stokes, Table Hill, Lindavale, Titra, Ewaninga, Amulda, Kanandra, Todd

TABLE 19

RELATION BETWEEN GROUND-STOREY COMMUNITIES AND LAND SYSTEMS

Ground-storey Community	Land Systems in which Community occurs on		
	Large Proportion of Area	Moderate Proportion of Area	Small Proportion of Area
Plectrachne schinzii		Aileron, Singleton	Davenport, Berrys Pass, Bushy Park, Simpson, Sandover, Woodduck
Plectrachne pungens			Napperby, Warburton, Hann, Alinga, Davenport, Kurundi, Ilbumric, Singleton, Amadeus
Triodia basedowii	Middleton, Angas, Simpson, Ewaninga, Singleton, Amulda	Unca, Woodduck, Adnera, Utopia, Amadeus	Bond Springs, Tietkins, Hann, Alinga, Ooratippra, Ennugan, Davenport, Gillen, Ilbumric, Tennant Creek, Kernot, Hogarth, Krichauff, Tomahawk, Cherry Creek, Ilgulla, Indiana, Endinda, Dinkum, Kalamerta, Lindavale, Woolla, Karee, Bushy Park, Leahy, Finke, Ammaroo, Sandover, Kanandra
Triodia pungens	Aileron, Hann, Wonorah, Davenport, Kurundi, Ilbumric, Tennant Creek, Krichauff	Harts, Alinga, Cherry Creek, Titra, Woolla	Warburton, Ooratippra, Ryan, Barrow, Weldon, Bushy Park, Singleton, Sandover, Amulda, Woodduck, Amadeus
Triodia hubbardii			Krichauff
Triodia clelandii	Sonder, Pertnjara, Gillen, Stokes	Middleton, Berrys Pass	Harts, Hann, Krichauff, Muller
Triodia spicata	Napperby, Weldon, Berrys Pass	Hann	Harts, Aileron, Warburton, Ryan, Ennugan, Davenport, Krichauff, Reynolds
Triodia longiceps	Huckitta, Allua, Reynolds, Santa Teresa		Tietkins, Hann, Wonorah, Alinga, Chisholm, Tennant Creek, Lucy, Ilgulla, Rumbalara, Barrow, Ambalindum
Triodia irritans			Gillen, Middleton, Kernot
Eragrostis eriopoda	Tietkins, Karee		Bond Springs, Napperby, Cavenagh, Aileron, Boen, Warburton, Outounya, Alinga, Delny, Kulgera, Alcoota, Ryan, Ennugan, Gillen, Kernot, Hogarth, Rumbalara, Unca, Peebles, Allua, Muller, Angas, Kalamerta, Weldon, Berrys Pass, Lindavale, Woolla, Bushy Park, Ringwood, Pulya, Simpson, Ewaninga, Singleton, Finke, McGrath, Sandover, Kanandra, Todd, Woodduck, Adnera, Hamilton

TABLE 19 (*Continued*)

Ground-storey Community	Land Systems in which Community occurs on		
	Large Proportion of Area	Moderate Proportion of Area	Small Proportion of Area
Eragrostis xerophila			Delny, Alcoota, Ryan, Ennugan, Renners, Weldon, Stokes, Table Hill, Ambalindum, Ringwood, McGrath, Sandover, Kanandra, Deering, Hamilton, Undippa
Astrebla pectinata	Ambalindum, Undippa		Alcoota, Lucy, Endinda, Weldon, Stokes, Table Hill, McGrath, Ammaroo, Deering
Astrebla lappacea			Alinga, Ammaroo
Aristida pruinosa			Ilbumric
Aristida browniana	Kanandra		Bond Springs, Napperby, Aileron, Hann, Cherry Creek, Peebles, Allua, Dinkum, Kalamerta, Ringwood, Pulya, Simpson, Singleton, Sandover, Todd, Woodduck
Themeda australis			Hann, Middleton, Ilbumric, Lucy, Chandlers, Huckitta, Weldon, Berrys Pass, Pulya
Themeda avenacea			Hann, Ilbumric, Lucy, Anderinda, Ammaroo, Sandover, Woodduck, Adnera
Chrysopogon fallax			Hann, Ooratippra, Ilbumric, Lucy, Jinka, Dinkum, Ammaroo, Sandover, Woodduck, Adnera
Bothriochloa ewartiana–Eulalia fulva			Hann, Ilbumric, Lucy, Jinka, Anderinda, Huckitta, Berrys Pass, Pulya, McGrath, Ammaroo, Amulda, Todd, Woodduck, Adnera, Utopia
Chloris acicularis			Harts, Bond Springs, Napperby, Cavenagh, Boen, Warburton, Outounya, Hann, Chisholm, Delny, Pularoo, Alcoota, Ryan, Ennugan, Sonder, Pertnjara, Davenport, Gillen, Middleton, Kurundi, Tennant Creek, Hogarth, Krichauff, Tomahawk, Cherry Creek, Lucy, Ilgulla, Rumbalara, Indiana, Jinka, Barrow, Anderinda, Peebles, Lilla, Huckitta, Allua, Coghlan, Renners, Muller, Weldon, Reynolds, Berrys Pass, Stokes, Santa Teresa, Table Hill, Ambalindum, Bushy Park, Ringwood, Pulya, Ewaninga, Finke, McGrath, Ammaroo, Sandover, Amulda, Kanandra, Todd, Woodduck, Adnera, Deering, Hamilton, Utopia

TABLE 19 (*Continued*)

Ground-storey Community	Land Systems in which Community occurs on		
	Large Proportion of Area	Moderate Proportion of Area	Small Proportion of Area
Zygochloa paradoxa			Lilla, Endinda, Simpson, Singleton, Finke, Sandover, Kanandra
Short grasses and forbs	Boen, Warburton, Outounya, Alinga, Ooratippra, Delny, Alcoota, Ryan, Ennugan, Lucy, Indiana, Unca, Jinka, Barrow, Anderinda, Muller, Dinkum, Lindavale, Titra, Woolla, Bushy Park, Leahy, Ringwood, Pulya, McDills, Finke, McGrath, Ammaroo, Sandover, Todd, Woodduck, Adnera, Hamilton	Napperby, Cavenagh, Aileron, Chisholm, Kulgera, Pularoo, Gillen, Kurundi, Ilbumric, Kernot, Hogarth, Ilgulla, Ebenezer, Huckitta, Allua, Kalamerta, Weldon, Stokes, Table Hill	Harts, Bond Springs, Tietkins, Hann, Middleton, Tennant Creek, Tomahawk, Cherry Creek, Chandlers, Rumbalara, Peebles, Lilla, Coghlan, Renners, Endinda, Angas, Santa Teresa, Ambalindum, Ewaninga, Singleton, Amulda, Kanandra, Deering, Utopia, Amadeus
Sparse forbs and grasses	Harts, Bond Springs, Hogarth, Tomahawk, Rumbalara, Coghlan, Table Hill	Cavenagh, Sonder, Kernot, Krichauff, Cherry Creek, Indiana, Huckitta	Napperby, Boen, Aileron, Warburton, Hann, Alinga, Chisholm, Delny, Kulgera, Pularoo, Alcoota, Ryan, Gillen, Middleton, Ilbumric, Chandlers, Wilyunpa, Unca, Jinka, Barrow, Anderinda, Peebles, Allua, Renners, Muller, Dinkum, Santa Teresa, Ambalindum, Pulya
Muehlenbeckia cunninghamii			Chandlers, Muller, Lindavale, Leahy, Pulya, Ewaninga, Sandover, Kanandra, Adnera, Utopia
Chenopodium auricomum	Utopia		Alinga, Wilyunpa, Endinda, Ringwood, McDills, Ammaroo, Sandover, Hamilton, Undippa
Atriplex nummularia			Wilyunpa, Endinda, Ambalindum, Simpson, McDills, Finke, Amadeus
Atriplex vesicaria	Wilyunpa, Peebles, Endinda, Kalamerta	Kulgera, Lilla	Outounya, Alinga, Delny, Ryan, Tennant Creek, Chandlers, Rumbalara, Allua, Stokes, Table Hill, Ambalindum, Titra, Pulya, McDills, Deering
Kochia astrotricha	Lilla, Ebenezer, Renners		Cavenagh, Outounya, Delny, Kulgera, Alcoota, Chandlers, Rumbalara, Endinda, Angas, Kalamerta, Lindavale, Amadeus

TABLE 19 (*Continued*)

Ground-storey Community	Land Systems in which Community occurs on		
	Large Proportion of Area	Moderate Proportion of Area	Small Proportion of Area
Kochia aphylla			Napperby, Cavenagh, Warburton, Outounya, Kulgera, Alcoota, Ryan, Gillen, Chandlers, Peebles, Ebenezer, Allua, Coghlan, Endinda, Angas, Kalamerta, Weldon, Stokes, Ambalindum, Pulya, McDills, Finke, McGrath, Kanandra, Todd, Deering, Hamilton
Arthrocnemum spp.		Amadeus	Outounya, Chandlers, Rumbalara, Wilyunpa, Lilla, Ebenezer, Endinda, Ambalindum, Titra, Ringwood, Simpson
Bassia spp.	Chandlers, Deering	Delny, Alcoota, Rumbalara, Wilyunpa, Anderinda, Peebles, Lilla, Ebenezer, Endinda, Angas, Ambalindum, McDills	Warburton, Outounya, Alinga, Ryan, Gillen, Indiana, Allua, Coghlan, Muller, Kalamerta, Weldon, Reynolds, Stokes, Lindavale, Titra, Karee, Ringwood, Pulya, Simpson, McDills, Finke, McGrath, Kanandra, Adnera, Hamilton, Amadeus
Absent	Amadeus		Harts, Alinga, Delny, Cherry Creek, Ebenezer, Allua, Table Hill, Titra, Finke, Sandover, Deering, Undippa

II. Description of Communities

(a) *Upper-storey Communities*

(i) Acacia aneura (*Mulga*).—Communities characterized by *A. aneura* occur throughout the whole of the area but are best developed on plains adjacent to the mountains and hills, where they occur extensively on coarse to medium-textured red earth soils. Smaller areas occur on skeletal soils and rocky hillsides on acid rocks and on red clayey sands, particularly on depressions or marginal to hills where the moisture status may be slightly better than under the surrounding spinifex communities. Mulga very rarely occurs in calcareous habitats.

A. aneura is generally a low tree 10–25 ft high (Plate 6, Fig. 1). Within the species there is a diversity of leaf shapes and sizes and of general tree shape. Some of the various forms can be correlated with particular habitats but others occur in mixed stands and under a range of environmental conditions.

Stands of *A. aneura* exhibit two quite distinct types of tree distribution. Almost all stands north of the MacDonnell Ranges and small areas south of them exhibit a marked contiguous distribution with groves varying from 20 to 400 yd long and 5 to 50 yd wide of medium dense to dense trees, and intergroves, generally several times larger, with few or no trees (Plate 7, Fig. 1). In areas where groves are typical, slopes are gentle and the groves tend to be aligned along contours. On sandier soils, particularly south of the MacDonnell Ranges and on stony hills, the stands exhibit a more random distribution of sparse to medium dense trees.

The commonest understorey communities associated with *A. aneura* are *Eragrostis eriopoda* (woollybutt) and short grasses and forbs, with smaller areas of 16 other understorey communities. Associated shrubs may be absent, sparse, or medium dense and may include *Eremophila* spp., *Cassia* spp., or *Acacia* spp. Associated low trees are absent or occur sparsely and include *Canthium latifolium*, *Hakea intermedia* (corkwood), *H. lorea*, *Atalaya hemiglauca* (whitewood), and *Acacia estrophiolata* (ironwood).

(ii) Acacia kempeana (*Witchetty Bush*).—This community is widespread and is particularly common on shallow calcareous soils (Plate 8, Fig. 1). It also occurs on stony skeletal soils on igneous and metamorphic rocks in the MacDonnell Ranges. It is not confined to calcareous soils but is also common on red earth soils under drier conditions than *A. aneura*. Thus on acid soils in the southern part of the area *A. kempeana* is more common than *A. aneura*, which is restricted to better watered areas, e.g. broad depressions, but north of the MacDonnell Ranges *A. aneura* is more common and *A. kempeana* is restricted to drier habitats, e.g. low rises.

A. kempeana is a shrub 4–8 ft high and is normally fairly sparsely distributed to form a shrubland. The commonest of the associated lower-storey communities is short grasses and forbs, including *Enneapogon* spp., *Aristida arenaria* (kerosene grass), and *Helipterum floribundum* (white daisy). Smaller areas of six other ground-storey communities are associated with it.

(iii) Acacia georginae (*Gidgee*).—This community is extensive in the north-eastern part of the area and mainly occurs on calcareous rocks, especially limestones and dolomites (Plate 7, Fig. 2). It is common on shallow calcareous soils and on somewhat acid soils (red earths) overlying limestone. However, it has been recorded on deep sandy soils without lime, stony hill slopes mainly on limestone but locally on sandstone, and heavy clay soils.

A. georginae is normally a low tree 10–25 ft high and normally forms a woodland (Plate 16, Fig. 2). In small areas it grows in dense stands forming a low forest. The commonest associated ground-storey community is short grasses and forbs including *Enneapogon* spp., *Aristida arenaria* (kerosene grass), and *Helipterum floribundum* (white daisy), but 11 other ground-storey communities are associated with it to a lesser extent.

(iv) Acacia calcicola (*Myall*).—Except for small isolated stands this community occurs only in the southern part of the area (south of lat. 25°S.) and is restricted to calcareous rocks, on soils which vary from calcareous to somewhat acid. It is commonest within an area of 50 miles radius from Kulgera homestead under a mean annual rainfall less than 7 in. of which $2\frac{1}{2}$ in. falls in the winter. In this area it occurs on the small calcareous parts of the granite peneplain and on Mesozoic sediments, the soils being calcareous earths or texture-contrast soils of variable depth.

The community is a woodland composed of trees 8–15 ft high. The commonest ground-storey community is short grasses and forbs, but smaller areas are characterized by *Bassia* spp. and other forbs and short grasses; *Atriplex vesicaria* (bladder saltbush) or *Kochia astrotricha* (bluebush) also occur.

(v) Acacia brachystachya (*Umbrella Mulga*).—Small areas on sand or calcareous soils south of lat. 25°S. are characterized by *A. brachystachya*, a low tree 10–15 ft high. The community is woodland.

Short grasses and forbs are the commonest associated ground storey with small areas on sandy soils characterized by *Eragrostis eriopoda* (woollybutt) or *Triodia basedowii* (spinifex).

(vi) *Sparse Low Trees*.—This community (Plate 1, Fig. 1; Plate 8, Fig. 2) is characterized by *Acacia estrophiolata* (ironwood), *Atalaya hemiglauca* (whitewood), *Ventilago viminalis* (supplejack), and *Hakea intermedia*. It ranges from a grassland with scattered trees to a very sparse woodland and mainly occurs north of lat. 24°S. It is commonest in two main habitats, firstly on coarse to medium-textured alluvial plains or flood-plains (Plate 5, Fig. 1) and secondly on gently undulating country with fairly shallow soils over granite, schist, and gneiss. It is floristically variable but normally one or more of the above species are present. Other species locally present are *Eucalyptus papuana* (ghost gum), *E. terminalis* (bloodwood), *Acacia aneura* (mulga), and *Grevillea striata* (beefwood). Shrubs occur very sparsely and include *Carissa lanceolata* and *Eremophila* spp.

The commonest ground-storey community is short grasses and forbs. Areas of *Eragrostis eriopoda* (woollybutt) or *Aristida browniana* (kerosene grass) occur on sandier soils, and *Chrysopogon fallax* (golden-beard grass), *Themeda avenacea* (oat grass), and *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop) communities occur in small, better-watered depressed areas particularly in the northern part. Where the community occurs along or in broad shallow drainage lines it is associated with *Chloris acicularis* (curly windmill grass) community and in drier or somewhat saline or calcareous areas *Bassia* spp. and other short grasses and forbs are characteristic.

(vii) Eucalyptus microtheca (*Coolibah*).—Small areas of woodland characterized by *E. microtheca* occur throughout the area, generally in temporarily flooded habitats (Plate 4, Fig. 1), such as along broad shallow stream-lines and in depressions, on an extremely wide range of soil types ranging from acid to alkaline, and from coarse to fine-textured. Over the wide geographic and soil range *E. microtheca* is associated with 18 of the ground-storey communities. On deep sandy soils it is associated with *Triodia basedowii* (spinifex), *T. pungens* (soft spinifex), *Plectrachne schinzii* (spinifex), *Aristida browniana* (kerosene grass), and *Zygochloa paradoxa* (cane grass) communities; on medium-textured soils *Eragrostis eriopoda* (woollybutt), *Themeda avenacea* (oat grass), *Themeda australis* (kangaroo grass), *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop), *Chrysopogon fallax* (golden-beard grass), *Aristida pruinosa* (three-awned spear grass), and short grasses and forbs communities; on heavy clays with *Eragrostis xerophila* (neverfail), *Astrebla lappacea* (curly Mitchell grass), *Muehlenbeckia cunninghamii* (lignum), *Chenopodium auricomum* (bluebush), and *Atriplex nummularia* (old-man saltbush) communities. It is also associated with *Chloris acicularis* (curly windmill grass) community along depression lines, and in some depressions the ground storey is absent.

(viii) Eucalyptus papuana (*Ghost Gum or Carbeen*).—Although *E. papuana* is widespread throughout the area, it normally occurs as isolated or scattered trees, and the areas in which it is characteristic are very small. It is commonest along the levees of the major rivers in the northern half of the area, but even in this habitat occupies less area than the sparse low tree community, in which *E. papuana* occurs as scattered trees. Where *E. papuana* is characteristic it is a tree 20–50 ft high and forms a woodland.

It is associated with several ground-storey communities on small areas of sandy flood-plain with *Eragrostis eriopoda* (woollybutt) community; medium-textured soils (red earths and yellow podzols) on flood-plains in the northern part of the area with *Chrysopogon fallax* (golden-beard grass) community; on sandy lower slopes of hills in the northern part of the area with *Triodia pungens* (soft spinifex) community; and in and near small billabongs with *Muehlenbeckia cunninghamii* (lignum) community.

(ix) Eucalyptus oleosa.—This community is commonest south of the MacDonnell Ranges although it has been recorded north of them. It occupies only small areas, mainly on the lower slopes of limestone hills characterized by *Triodia longiceps* (porcupine grass) community, which forms a lower storey of the *E. oleosa* community in these habitats. *E. oleosa* and *Triodia longiceps* are also associated on low limestone rises and on small areas of dissected calcareous river terraces along the Finke River. On the calcareous dissection slopes of piedmont terraces in the western MacDonnell Ranges *E. oleosa* is associated with *Triodia clelandii* (spinifex) community. On the limestone plains south of lat. 24°S., particularly in and near shallow depression lines and on low calcareous rises, there are very small areas of *E. oleosa* associated with the short grass–forb community.

E. oleosa is a low tree about 20 ft high, generally with a mallee habit, and in these communities grows at about woodland density.

(x) Eucalyptus brevifolia (*Snappy Gum*).—In the Barkly and Ord–Victoria areas there are large areas (where the mean annual rainfall is less than about 27 in.) characterized by *E. brevifolia*. In the Alice Springs area the community occurs only where the rainfall is greater than about 13 in., i.e. mainly north of lat. 21 °S. It mainly occurs on stony hill slopes on quartzite and sandstone where it is associated with *Plectrachne pungens* (spinifex) and/or *Triodia pungens* (soft spinifex) communities. It also occurs associated with *T. pungens* community on the peneplains of the Wonorah land system (Plate 3, Fig. 1). On small areas on the lower slopes with stony texture-contrast soils it is associated with *T. longiceps* (porcupine grass) community.

E. brevifolia is a low tree about 20 ft high and forms sparse woodlands.

(xi) Eucalyptus camaldulensis (*River Red Gum*)–Acacia estrophiolata (*Ironwood*).—This community is a fringing one and occurs along stream-lines throughout the area. The floristic composition varies with the size of the channel with *Eucalyptus camaldulensis* occurring in almost monospecific stands 50–60 ft high along the large channels (Plate 4, Fig. 2), *E. camaldulensis* in stands 30–40 ft high intermixed with other species along medium-sized channels, and with *Acacia estrophiolata* and other species 25–30 ft high along small channels. The commonest ground-storey community is characterized by *Chloris acicularis* (curly windmill grass) and other perennial tussock grasses 2–4 ft high, but small areas of other ground-storey communities occur. In very sandy areas *E. camaldulensis* is associated with *Zygochloa paradoxa* (cane grass) or *Aristida browniana* (kerosene grass) communities; along small channels with short grass–forb community; in rocky areas with *Triodia pungens* (soft spinifex) community; and in the far north of the area with *Bothriochloa ewartiana* (blue grass)–*Eulalia fulva* (silky browntop) community.

(xii) Casuarina decaisneana (*Desert Oak*).—Some of the areas of sand plains and dunes characterized by the *Triodia basedowii* (spinifex) lower-storey community carry an upper-storey community characterized by *Casuarina decaisneana*. The ecological significance of its distribution is not clear, there seems to be no environmental difference between areas of sand plain carrying *C. decaisneana* and areas not carrying it. It is commonest in a belt of mainly irregular dune country extending from the north-western edge of the Simpson Desert westwards and is thus mainly south of the MacDonnell Ranges. However, in the western part of the area it extends northwards almost to the Stuart Bluff Range where small areas are associated with *Triodia pungens* (soft spinifex) community.

C. decaisneana is a well-shaped tree generally 30–60 ft high and forms sparse woodlands.

(xiii) Melaleuca glomerata (*Tea-tree*).—This is a dense low community 10–15 ft high fringing salt pans and their tributary channels and depressions. Commonly the understorey community is either absent or characterized by *Bassia* spp. or other chenopods. In small areas where sand plain is adjacent to the pans, especially near Central Mount Wedge homestead, *Triodia pungens* (spinifex) or *Plectrachne pungens* (spinifex) are characteristic of the ground-storey community.

(xiv) Acacia kempeana (*Witchetty Bush*)-Cassia *Spp.* (*Turkey Bushes*).—This community is almost restricted to stony hill slopes or outcrops on limestones and metamorphic rocks and consists of sparse to medium dense shrubs 2–6 ft high. It is almost invariably associated with the sparse forb and grasses ground-storey community but in some areas, particularly less stony ones, it is associated with the short grass–forb community.

(xv) Cassia eremophila.—Only small areas of this community occur in the area, mainly on the sandier parts of flood-plains or outwash plains. It is more common in the southern half of the area and normally consists of a fairly dense layer of shrubs approximately 5 ft high. The ground-storey community is generally either a sparse to medium dense cover of short grasses and forbs, particularly *Aristida arenaria* (kerosene grass) and *Senecio gregorii* (yellow daisy) or *Eragrostis eriopoda* (woollybutt). Some areas in the southern part of the area have a ground storey characterized by *Bassia* spp.

(xvi) Eremophila *Spp.*-Hakea leucoptera (*Needle Bush*).—This community occurs mostly in the central and southern part of the area and is restricted to texture-contrast soils. It is a very sparse community consisting of scattered shrubs 4–10 ft high. In the central parts the *Eremophila* spp. are *E. duttonii* and *E. sturtii* (turpentine), in the southern parts mainly *E. calycina.*

The ground-storey communities are either short grasses and forbs, particularly *Helipterum charsleyae* (yellow daisy), or *Bassia* spp.

(xvii) *Sparse Shrubs and Low Trees.*—Most of the spinifex sand plains and dune fields and much of the stony hilly and mountainous country have no defined upper-storey community. They have a cover of shrubs and low trees which mostly varies in density from very sparse to sparse, with minor areas of medium density. A relatively large number of species are involved and large floristic variations occur over short distances. Some common sand plain and dune field species are *Eucalyptus gamophylla* (blue mallee), *E. dichromophloia* (bloodwood), *Acacia coriacea*, *A. patens*, *A. dictyophleba*, *A. stipuligera*, *Grevillea juncifolia*, *Hakea lorea*, *Keraudrenia integrifolia*, *Petalostylis labicheoides*, and *Dodonaea cuneata.* On hills the cover is generally sparser and there is a different assemblage. Some common low trees are *Eucalyptus dichromophloia* (bloodwood), *E. papuana* (ghost gum or carbeen), *Ficus platypoda* (fig), *Callitris columellaris* (cypress pine), *Atalaya hemiglauca* (whitewood), and *Hakea lorea.* Common shrubs are *Eremophila freelingii*, *Grevillea wickhamii*, *Eucalyptus gamophylla* (blue mallee), *Acacia* spp., and *Cassia* spp.

(xviii) *Absent.*—Some habitats have no upper-storey community.

The absence of any upper-storey community is the common condition with the *Eragrostis xerophila*, *Astrebla pectinata* (Plate 9, Fig. 1), *A. lappacea*, *Chenopodium auricomum*, *Atriplex nummularia*, *A. vesicaria* (Plate 10, Fig. 1), *Kochia astrotricha*, and *K. aphylla* ground-storey communities. Ten other ground-storey communities occur without an upper storey in some habitats.

(*b*) *Ground-storey Communities*

(i) Plectrachne schinzii (*Feathertop Spinifex*).—This is one of the spinifex communities of the sand plains and is particularly common north of lat. 23°S. *P. schinzii* forms tussocks about 12 in. high, 12 to 18 in. in diameter, and 12–24 in. apart (Plate 2, Fig. 2). It seldom forms "rings". The flowering culms are very numerous and in good seasons form a dense mass up to 5 ft high. Nunn and Suijdendorp (1954) state that this species is the most palatable spinifex in Western Australia. It is likely to be similarly so in central Australia.

In small areas the community is associated with recognizable upper storeys (*Acacia aneura* (mulga), *Eucalyptus microtheca* (coolibah), and *E. brevifolia* (snappy gum) communities) but more commonly it occurs with sparse shrubs and low trees. These vary from place to place but the commonest and most widespread are *Acacia* spp. (including *A. patens*, *A. murrayana*, *A. kempeana* (witchetty bush), *A. dictyophleba*, *A. coriacea* (dogwood), *A. leursenii*, and *A. stipuligera*), *Eucalyptus pachyphylla*, *E. gamophylla* (mallees), *Cassia eremophila*, *Petalostylis labicheoides*, *Grevillea juncifolia*, *Santalum lanceolatum* (sandalwood), *Keraudrenia integrifolia*, *Eremophila longifolia* (long-leaved fuchsia), and *E. latrobei* (fuchsia). In some areas very sparse low trees of *Eucalyptus terminalis* (bloodwood) may occur. Small grasses and forbs are rare but a number of species have been recorded.

(ii) Plectrachne pungens (*Feathertop Spinifex*).—In the northern part of the area many of the rocky hills of intermediate and acid rocks carry a vegetation characterized by *P. pungens*. The community is almost restricted to hills but small areas were recorded on sand plain near Central Mount Wedge homestead. There small areas of the community occurred under a low tree storey characterized by *Melaleuca glomerata* (tea-tree) but more generally the upper storey is absent or consists of sparse shrubs and low trees.

P. pungens occurs as tussocks about 12 in. in diameter and 12 in. high with the flowering culms growing to about 3 ft. On hillsides the tussocks are interspersed with rocks, and the upper storey is either absent or consists of sparse shrubs and low trees of which *Acacia* spp., *Grevillea wickhamii*, *Eucalyptus gamophylla* (mallee), and *E. brevifolia* (snappy gum) are the commonest and most wide-spread.

(iii) Triodia basedowii (*Hard Spinifex*).—This is the commonest community in the area. It occurs on sand plains and dune fields (Plate 3, Fig. 2) throughout the area but especially south of lat. 23°S. North of this line the *Plectrachne schinzii* (feathertop spinifex) community also occurs on these habitats. The species is a coarse grass forming tussocks up to about 30 in. in diameter and 12 in. high or "rings" (with open centres) generally 3 to 8 ft in diameter but in isolated examples growing to 25 ft in diameter (Plate 2, Fig. 1). The flowering culms vary from about 2 to 4 ft in height.

In small areas the community is associated with the *Acacia aneura* (mulga), *A. brachystachya* (mulga), *Eucalyptus microtheca* (coolibah), and *Casuarina decaisneana* (desert oak) upper-storey communities, but most commonly *Triodia basedowii* is the characteristic species of a community in which the associated species are sparse shrubs and low trees. The community is commonly a grassland with scattered shrubs but varies from open grassland to shrubland.

The commonest of the associated shrubs and low trees are *Acacia* spp. (*A. patens*, *A. kempeana* (witchetty bush), *A. dictyophleba*, *A. estrophiolata* (ironwood), *A. aneura* (mulga), *A. stipuligera*, *A. lysiophloia* (turpentine), *A. leursenii*, *A. coriacea* (dogwood), *A. cuthbertsoni*, *A. ancistrocarpa*, *A. murrayana*, *A. adsurgens*, *A. ramulosa*, and *A. ligulata*), *Eucalyptus gamophylla* (mallee), *E. pachyphylla* (mallee), *E. papuana* (ghost gum or carbeen), *E. setosa* (bloodwood), *E. terminalis* (bloodwood), *Cassia* spp., *Grevillea juncifolia*, *G. stenobotrya*, *G. eriostachya*, *Hakea lorea*, *Atalaya hemiglauca* (whitewood), *Codonocarpus continiifolius* (desert poplar), *Eremophila latrobei* (fuchsia), *E. longifolia* (long-leaved fuchsia), *Dodonaea cuneata* (hopbush), and *Keraudrenia integrifolia*. *Thryptomene maisonneuvii* is common in the southern, lower-rainfall parts.

Grasses and forbs occur only sparsely but *Calandrinia balonensis* (parakeelya), a good fodder plant, is common in favourable seasons in some parts.

More complete floristic lists are given by Chippendale (1958) and Crocker (1946).

(iv) Triodia pungens (*Soft Spinifex*).—This community occurs on both plains (Plate 3, Fig. 1) and rocky hills (Plate 14, Fig. 1) in the northern half of the area. It is characteristic of gently undulating peneplains (Wonorah land system) but north of lat. 20°S. it tends to replace *T. basedowii* (hard spinifex) and *Plectrachne schinzii* (feathertop spinifex) on sand plains. It also extends southwards to about lat. 23°S. in small slightly more favoured habitats, such as long shallow depressions within the sand plain. On rocky hills of intermediate to acid rocks, it is common north of lat. 23°S. and in small areas it occurs as far south as lat. 24°S. On some hills it is intermixed with *Plectrachne pungens* (feathertop spinifex) or *Triodia spicata* (spinifex).

The tussocks are irregularly shaped and vary from 1 to 3 ft high and 1 to 5 ft in diameter. "Ring" formation occurs but is not common. There is less bare ground than in other spinifex communities.

The community is associated with a number of upper-storey communities, including *Acacia aneura* (mulga), *Eucalyptus microtheca* (coolibah), *E. papuana* (ghost gum), *E. brevifolia* (snappy gum), *E. camaldulensis* (river red gum)–*Acacia estrophiolata* (ironwood), *Casuarina decaisneana* (desert oak), *Melaleuca glomerata*, and *Cassia eremophila* communities, but most commonly *Triodia pungens* is the characteristic plant in a community containing sparse shrubs and low trees. On sand plains and peneplains the commonest of these are *Acacia coriacea* (dogwood), *A. estrophiolata* (ironwood), *A. kempeana* (witchetty bush), *A. dictyophleba*, *A. ancistrocarpa*, *A. patens*, *A. leursenii*, *A. hilliana*, *Eucalyptus gamophylla* (mallee), *E. pachyphylla* (mallee), *E. odontocarpa* (mallee), *E. setosa* (bloodwood), *E. dichromophloia* (bloodwood), *E. papuana* (ghost gum or carbeen), *Grevillea juncifolia*, *G. wickhamii*, *Hakea lorea*, *H. macrocarpa*, *Cassia* spp., *Petalostylis labicheoides*, *Atalaya hemiglauca* (whitewood), *Carissa lanceolata* (konkerberry), *Melaleuca lasiandra*, *Eremophila latrobei* (fuchsia), *E. longifolia* (long-leaved fuchsia), *Notoxylinon australe* (desert rose), and *Keraudrenia integrifolia*. Grasses and forbs are not common.

On rocky hills the community has much the same form but there is slight floristic difference in the associated plants. The commonest of these are *Acacia dictyophleba*, *A. ancistrocarpa*, *A. wickhamii*, *A. monticola*, *A. patens*, *A. stipuligera*, *A. kempeana* (witchetty bush), *A. hilliana*, *A. aneura* (mulga), *A. estrophiolata* (ironwood), *Eucalyptus gamophylla* (mallee), *E. intertexta* var. *fruticosa* (mallee), *E. pachy-*

phylla (mallee), *E. brevifolia* (snappy gum), *E. terminalis* (bloodwood), *Cassia* spp., *Petalostylis labicheoides*, *Eremophila freelingii*, *E. latrobei* (fuchsia), *Callitris columellaris* (cypress pine), *Erythrina vespertilio* (coral tree), *Atalaya hemiglauca* (whitewood), *Hakea lorea*, and *Grevillea wickhamii*.

(v) Triodia hubbardii.—Very small areas of steep rocky slopes are characterized by *T. hubbardii*. Sparse shrubs and low trees occur with it.

(vi) Triodia clelandii (*Spinifex*).—This is the common spinifex community on rocky hills and terraces of mainly intermediate to acid rocks south of about lat. 23°S. The tussocks are 12 to 18 in. high and up to 4 ft in diameter with flowering culms growing to about 3 ft high. Ring formation is rare.

In most areas the upper storey consists of shrubs and low trees, the commonest of which are *Eremophila freelingii*, *Hakea lorea*, *Eucalyptus gamophylla* (mallee), *E. oleosa* var. *glauca* (mallee), *E. terminalis* (bloodwood), *E. papuana* (ghost gum or carbeen), *Erythrina vespertilio* (coral tree), *Callitris columellaris* (cypress pine), *Pandorea doratoxylon* (spearwood), *Dodonaea* spp. (hopbush), *Atalaya hemiglauca* (whitewood), *Acacia aneura* (mulga), *A.* sp. aff. *notabilis*, *A. kempeana* (witchetty bush), and *A. estrophiolata* (ironwood).

A number of smaller plants occur sparsely between the spinifex tussocks.

(vii) Triodia spicata (*Spinifex*).—The tussocks of *T. spicata* are probably the smallest of any spinifex. They rarely exceed 9 in. in height and 9 in. in diameter and "ring" formation was recorded only on terraces on Weldon land system. The "rings" are almost perfect circles 2 to 3 ft in diameter with about 9 in. of vegetative annulus.

The community occurs on terraces and rocky hills mainly of intermediate to acid rocks, in the north-western quarter of the area. In some parts it intermixes with the *T. pungens* (soft spinifex) and *T. clelandii* (spinifex) communities.

In small areas the community is associated with an *Acacia aneura* (mulga) upper storey but more commonly there is a sparse layer of shrubs and low trees. The commonest of these are *A. dictyophleba*, *A. estrophiolata* (ironwood), *A. hilliana*, *A. aneura* (mulga), *A. kempeana* (witchetty bush), *Atalaya hemiglauca* (whitewood), *Eucalyptus gamophylla* (mallee), *E. oleosa* var. *glauca* (mallee), *E. intertexta* var. *fruticosa* (mallee), *E. dichromophloia* (bloodwood), and *E. papuana* (ghost gum). On the terraces of Weldon land system *Acacia* sp. aff. *notabilis* is predominant.

Grasses and forbs are rare.

(viii) Triodia longiceps (*Spinifex or Porcupine Grass*).—This community occurs throughout the area on rocky hill slopes on basic rocks (Plate 15, Fig. 2) and, to a lesser extent, on stony texture-contrast soils. The total area is relatively small.

T. longiceps is one of the largest and coarsest species of *Triodia*, the tussocks attaining 8 ft in height and 20 ft in diameter. More commonly they are 2 to 3 ft high and 4 to 6 ft in diameter. It does not form "rings". The spacing of tussocks is very variable.

In small areas the community is associated with the *Acacia kempeana* (witchetty bush), *A. georginae* (gidgee), *Eucalyptus oleosa* (mallee), or *E. brevifolia* (snappy gum) upper-storey communities but most commonly it is characterized by sparse shrubs and low trees. The commonest of these are *E. oleosa* var. *glauca* (mallee), *E. terminalis* (bloodwood), *E. intertexta* var. *fruticosa* (mallee), *E. brevifolia* (snappy gum), *Acacia kempeana* (witchetty bush), and *Cassia* spp. (turkey bushes). In some areas there are very scattered plants of *Atriplex vesicaria* (bladder saltbush) and *Bassia* spp.

(ix) Triodia irritans (*Spinifex*).—This community is the common spinifex community of southern Australia and in the Alice Springs area it was recorded only in isolated localities south of latitude 25°S. It occurs on rocky hills generally of sandstone or quartzite.

The sparse associated shrubs and low trees include *Callitris columellaris* (cypress pine), *Ficus platypoda* (fig), *Eremophila freelingii*, *Eucalyptus dichromophloia* (bloodwood), and *Acacia* spp. In a very small area it was recorded growing in association with *A. aneura* (mulga) community.

(x) Eragrostis eriopoda (*Woollybutt*).—This community is common on coarse to medium-textured acid soils (red earths and red clayey sands) throughout the area. It is commonly associated with *Acacia aneura* (mulga) community and to a lesser extent with *A. kempeana* (witchetty bush), *A. georginae* (gidgee), *A. brachystachya* (umbrella mulga), sparse low trees, *Eucalyptus microtheca* (coolibah), and *E. papuana* (ghost gum or carbeen) communities.

In a few places it occurs without an upper storey. Typically *Eragrostis eriopoda* forms tussocks 6 to 12 in. high and about 9 in. in diameter with inflorescences about 18 in. high, but under grazing, tussock height may be reduced to 2 to 3 in. The tussocks are generally 12 to 24 in. apart but spacing is variable, especially in grazed areas.

The spaces between the tussocks are commonly bare but *Kochia tomentosa* and *Neurachne mitchelliana* often grow within the tussocks. In good seasons short grasses and forbs such as *Aristida arenaria* (kerosene grass), *Enneapogon polyphyllis*, *Helipterum floribundum* (white daisy), and *Ptilotus helipteroides* grow between the tussocks.

(xi) Eragrostis xerophila (*Neverfail*).—North of lat. 22°S., this community is common on fine-textured soils (mainly coarse-structured clay and texture-contrast soils). Except for small areas associated with *Acacia aneura* (mulga), *A. georginae* (gidgee), or *Eucalyptus microtheca* (coolibah) communities it occurs without an upper storey. In some areas it intermixes with the *Astrebla pectinata* (barley Mitchell grass) community.

Eragrostis xerophila and *E. setifolia*, a closely related species which occurs in the community in some parts, are tussock grasses 6 to 9 in. high and about 9 in. in diameter with inflorescences 9 to 18 in. high. Grazed tussocks may be shorter. Spacing of the tussocks is variable but they are generally 1 to 2 ft apart.

The interspaces may be bare but in good seasons there is a cover of short grasses and forbs.

(xii) Astrebla pectinata (*Barley Mitchell Grass*).—This community is restricted to fine-textured soils (coarse-structured clays and variants of texture-contrast soils) and although it occurs throughout the area, it is commonest in the northern half. It generally occurs without an upper-storey community but in small parts in the north-eastern quarter it occurs in association with *Acacia georginae* (gidgee) community. It intermixes with the *Eragrostis xerophila* community.

The tussocks of *Astrebla pectinata* are generally about 9 to 12 in. in diameter and 9 in. high (Plate 9, Fig. 1) with inflorescences growing to about 18 in. but in between watered areas they may be larger and under grazing they may be smaller. Tussock spacing is variable but they are commonly to 2 ft apart (Plate 9, Fig. 2) in the northern half of the area and much more distant in the southern half.

The interspaces may be bare but in good seasons there is a dense growth of short grasses and forbs with *Iseilema* spp. (Flinders grasses) common in the north, *Helipterum charsleyae* (yellow daisy) and *H. floribundum* (white daisy) in the centre, and *Bassia* spp. in the south.

(xiii) Astrebla lappacea (*Curly Mitchell Grass*).—Only small areas of this community occur in the area and they are on coarse-structured clay soils in depressions north of lat. 21½°S. The community is a grassland.

The tussocks are about 12 in. high, 9 to 12 in. in diameter, with inflorescences to 24 in., and are spaced 1 to 2 ft apart. In favourable seasons the interspaces have a dense growth of short grasses and forbs. Isolated plants of *Chenopodium auricomum* (bluebush) may also occur.

(xiv) Aristida pruinosa (*Three-awned Spear Grass*).—This community is common in the northern part of northern Australia and only isolated small areas occur in depressions in the northern part of the Alice Springs area (north of lat. 21°S.). It occurs in association with *Eucalyptus microtheca* (coolibah) community or without an upper storey.

A. pruinosa is a tussock grass about 2 to 3 ft high and with a basal diameter of 3 to 6 in. Spacing is very variable and several other tussock grasses of similar height occur in the community. These include *Eulalia fulva* (silky browntop), *Themeda australis* (kangaroo grass), and *Chrysopogon fallax* (golden-beard grass). Smaller grasses and forbs are also common. Scattered shrubs such as *Carissa lanceolata* (konkerberry), *Acacia* spp., and *Cassia* spp. (turkey bushes) also occur.

(xv) Aristida browniana (*Kerosene Grass or Wire Grass*).—This community occurs on coarse-textured (sands and clayey sands) soils throughout the area, and is particularly common on Kanandra land system. In some parts it grows in habitats similar to those on which *Triodia basedowii* (hard spinifex) or *Plectrachne schinzii* (feathertop spinifex) grow but normally it occurs in areas more favoured hydrologically and on less mature soils.

In a few parts it occurs with only sparse shrubs and low trees but normally it is associated with various upper storeys, especially the sparse low tree community.

Small areas also occur in association with *Acacia aneura* (mulga), *A. georginae* (gidgee), *Eucalyptus microtheca* (coolibah), and *E. camaldulensis* (river red gum)–*Acacia estrophiolata* (ironwood) communities.

Aristida browniana is a wiry tussock grass 12 to 18 in. high and about 6 in. in diameter. The tussock spacing is variable and normally the interspaces contain a medium dense cover of short grasses and forbs of which *A. arenaria* (kerosene grass) is the commonest. Others include *Salsola kali* (roly-poly), *Swainsonia canescens* (vetch), and *Senecio gregorii* (yellow daisy).

(xvi) Themeda australis (*Kangaroo Grass*).—This is a community common in the higher-rainfall parts of northern Australia but which occurs in a few favoured localities in the northern part of the Alice Springs area. It is associated with *Acacia aneura* (mulga) or *Eucalyptus microtheca* (coolibah) upper-storey communities.

Themeda australis is a tussock grass about 3 ft high and with basal diameter of 3 to 6 in. Tussock spacing is variable but is normally 1 to 2 ft. Other tussock grasses such as *Eulalia fulva* (silky browntop), *Aristida pruinosa* (three-awned spear grass), and *Bothriochloa ewartiana* (desert blue grass) also occur in the community. A number of species of short grasses and forbs occur sparsely.

(xvii) Themeda avenacea (*Native Oat Grass*).—This community is more typical of higher-rainfall areas of northern Australia but occurs in small, better-watered parts of the Alice Springs area north of lat. 23°S. It grows in depressions with red or yellow earth soils under *Eucalyptus microtheca* (coolibah) or the sparse low trees upper-storey communities.

Themeda avenacea is a large tussock grass, the base being 9 to 12 in. in diameter and the foliage up to 18 in. high. The inflorescence may grow to 7 ft. The tussocks are generally 2 ft or more apart and are frequently "pedestalled".

The interspaces may be bare but in favourable seasons a dense cover of short grasses and forbs occurs. The species vary from season to season.

(xviii) Chrysopogon fallax (*Golden-beard Grass*).—This is another community more common in higher-rainfall areas but which grows in the more favourable habitats north of lat. 23°S. It mainly occurs on red or yellow earth soils in depressions associated with *Eucalyptus microtheca* (coolibah) community but also occurs in association with *E. papuana* (ghost gum) or the sparse low tree communities.

Chrysopogon fallax is a tussock grass with a base about 9 in. in diameter and growing to about 12 in. high. The inflorescence grows to about 4 ft. In favourable seasons the tussocks are generally 1 to 3 ft apart and the interspaces have a dense cover of short grasses and forbs.

(xix) Bothriochloa ewartiana (*Desert Blue Grass*)–Eulalia fulva (*Silky Browntop*).—This is another community more common in higher-rainfall areas but which occurs in the northern and particularly the north-eastern parts of the Alice Springs area. It mainly occurs in broad, shallow, unchannelled drainage lines or on flats adjacent to creeks. It is associated with *Acacia aneura* (mulga), *A. georginae* (gidgee), *Eucalyptus microtheca* (coolibah), or *E. camaldulensis* (red gum)–*Acacia estrophiolata* (ironwood) upper-storey communities.

The characteristic species are tussock grasses 2 to 3 ft high with bases up to 6 in. in diameter. Several other similar grasses such as *Themeda australis* (kangaroo grass), *Dichanthium fecundum* (blue grass), *Chloris acicularis* (curly windmill grass), and *Aristida* spp. (three-awned spear grass) occur in the community. Sparse bushes of *Carissa lanceolata* (konkerberry) and *Eremophila longifolia* (long-leaved fuchsia) are also common.

The tussocks are generally close together but in favourable seasons a dense growth of various short grasses and forbs occurs between them.

(xx) Chloris acicularis (*Curly Windmill Grass*).—This is the common community along drainage channels, large and small, throughout the area. It is commonly associated with *Eucalyptus camaldulensis* (red gum)–*Acacia estrophiolata* (ironwood) upper-storey community. It also occurs under *Acacia aneura* (mulga), *A. georginae* (gidgee), sparse low trees, and *Eucalyptus microtheca* (coolibah) communities and in a few small isolated areas occurs without an upper storey.

Chloris acicularis is a tussock grass growing to about 2 ft high. *Aristida sciuroides* (three-awned spear grass) is commonly associated with it and many short grasses and forbs also occur.

(xxi) Zygochloa paradoxa (*Sandhill Cane Grass*).—This community is characteristic of loose sandy areas either on the crests of sand dunes (Plate 3, Fig. 2) or associated with levees or flood-outs of creeks. The characteristic species has more the appearance of a shrub than a grass and is very variable in size, ranging from 1 to 8 ft in diameter and 1 to 3 ft high. The tussocks are commonly widely spaced with "blow-out" areas of bare, windswept sand between them. *Crotalaria cunninghamii* (parrot-pea or bird flower) is a common associated plant. On crests of sand dunes there is normally no upper storey but scattered *Atalaya hemiglauca* (whitewood) trees occur locally. When associated with drainage channels the tussocks are closer together and *Aristida browniana* (kerosene grass) and *Senecio gregorii* (yellow daisy) are common in the interspaces. In these sites the community may be associated with the *Eucalyptus microtheca* (coolibah) or *E. camaldulensis* (red gum)–*Acacia estrophiolata* (ironwood) upper-storey communities.

(xxii) *Short Grasses and Forbs*.—This is the commonest understorey community in the area and occurs under most of the upper-storey communities and in some areas without an upper storey (Plate 4, Fig. 1; Plate 5, Fig. 1; Plate 6, Figs. 1 and 2; Plate 7, Fig. 2; Plate 8, Figs. 1 and 2; Plate 17, Fig. 1). The floristic composition of the community is variable but, until more information is available on seasonal floristic changes in each locality, it is not practicable to subdivide it.

The community consists of a variable cover about 6 in. high composed of short grasses and forbs. Summer rains tend to favour grasses and winter rains forbs. The commonest of the short grasses are *Aristida arenaria* (kerosene grass) and *Enneapogon* spp., and of the forbs, *Helipterum floribundum* (white daisy), *H. charsleyae* (yellow daisy), *Stenopetalum* spp., and *Ptilotus helipteroides*. Other grasses and forbs may become dominant over large areas following falls of rain which particularly favour them.

(xxiii) *Sparse Forbs and Grasses*.—Throughout the area, where rocky hills do not carry spinifex communities the common ground vegetation is sparse and variable, with *Eriachne mucronata* and *Ptilotus obovatum* being the commonest and most constant plants. Other common species are *Digitaria adscendens* (summer grass), *Hibanthus aurantiacus*, *Enneapogon oblongus*, and many short grasses and forbs.

Most commonly the community is associated with the *Acacia kempeana* (witchetty bush)–*Cassia* spp. upper-storey community but small areas also occur under *Acacia aneura* or with sparse shrubs and low trees.

(xxiv) Muehlenbeckia cunninghamii (*Lignum*).—Isolated small areas of this community occur in depressions, which are flooded for periods after rain, throughout the area. As the flood waters recede the ground between the characteristic plants either is left cracked and bare or develops a cover of ephemeral short grasses and forbs.

The community is commonly associated with *Eucalyptus microtheca* (coolibah), but also occurs to a very small extent under *Acacia aneura* (mulga) and *Eucalyptus papuana* (ghost gum or carbeen) communities or without an upper storey.

(xxv) Chenopodium auricomum (*Bluebush*).—This community occurs throughout the area in depressions which are flooded for fairly long periods after rains (Plate 5, Fig. 2). The soils are mainly fine-textured. *C. auricomum* is a shrub which grows to about 3 ft high and 2 to 3 ft in diameter, although under grazing it is often smaller. It is a palatable plant with a high nutritive value.

The interspaces between the shrubs are commonly bare cracked soil but may be covered by short grasses and forbs. Scattered tussocks of *Eragrostis xerophila* (neverfail) are present in some stands.

The community occurs without an upper storey or associated with *Eucalyptus microtheca* (coolibah) community.

(xxvi) Atriplex nummularia (*Old-man Saltbush*).—In small more favoured localities in the southern half of the area *A. nummularia* is characteristic, either without an upper storey or associated with *Eucalyptus microtheca* (coolibah) community. These localities are generally flooded for short periods following rain.

Atriplex nummularia is a dense, very leafy shrub which grows to about 6 ft high and 4 to 6 ft in diameter. It is very palatable and under heavy grazing is reduced to a few almost leafless branches growing from a low mound of earth.

(xxvii) Atriplex vesicaria (*Saltbush*).—This and the next community are the common shrubland (or "shrub-steppe") communities in arid southern Australia and are common in the Alice Springs area south of lat. 21 °S. The *A. vesicaria* community is common on coarse to medium-textured topsoils, generally with a clay pan, and on stony slopes of low hills, particularly where the underlying rock is shale.

A. vesicaria is a shrub 1 to 2 ft high and 1 to 3 ft in diameter (Plate 10, Fig. 1). The spacing of individual plants is very variable and the community varies from isolated small plants to well-grown plants with only 1 to 2 ft between them. The interspaces may be almost bare but more commonly short forbs, of which *Bassia* spp. are the most important, form a variable cover.

Most commonly the community occurs without an upper storey but it is also associated with *Acacia aneura* (mulga), *A. kempeana* (witchetty bush), *A. georginae* (gidgee), and *A. calcicola* (myall) communities.

(xxviii) Kochia astrotricha (*Bluebush*).—The geographic distribution of this community (Plate 16, Fig. 2) is similar to that of the previous one but it tends to occur on finer-textured soils and is not common on hills.

Structurally the community is similar to the previous one and the associated plants and upper-storey communities are also similar.

(xxix) Kochia aphylla (*Cotton-bush*).—Within the Alice Springs area this community has a wider geographic distribution than the previous two communities but it is restricted to depressions, most commonly with texture-contrast soils. In the southern part of the area the associated species are commonly short *Bassia* spp. but further north the commonest associated species is *Helipterum charsleyae* (yellow daisy).

Most commonly the community occurs without an upper storey but in small areas it is associated with *Acacia aneura* (mulga), or *A. georginae* (gidgee) communities.

(xxx) Arthrocnemum *Spp.* (*Samphire*).—This community is common on small salt pans, around the edges of larger salt lakes, in the small channels near salt lakes, and also occurs on small areas of texture-contrast soil. It is variable and occurs without any associated upper-storey community.

(xxxi) Bassia *Spp.*—In the southern half of the area, this community largely replaces the short grass–forb communities. It is similar in structure and is seasonally variable in density and composition but *Bassia* spp. are more prominent.

It occurs without an upper storey or in association with several upper-storey communities, including *Acacia aneura* (mulga), *A. kempeana* (witchetty bush), *A. georginae* (gidgee), *A. calcicola* (myall), sparse low trees, *Melaleuca glomerata* (tea-tree), *Cassia eremophila*, and *Eremophila* spp.–*Hakea leucoptera* (needlebush) communities.

(xxxii) *Absent.*—Salt pans (Plate 13, Fig. 2), clay pans, rock faces, and areas under dense groves of trees (particularly *Acacia georginae*) are naturally bare of ground vegetation. Additional areas are bare as a result of grazing.

III. Acknowledgments

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IV. References

Burbidge, Nancy T. (1946).—Morphology and anatomy of the Western Australian species of *Triodia* R. Br. II. Internal anatomy of leaves. *Trans. Roy. Soc. S. Aust.* **70**: 221–34.

Chippendale, G. M. (1958).—Notes on the vegetation of a desert area in central Australia. *Trans. Roy. Soc. S. Aust.* **81**: 31–41.

Crocker, R. L. (1946).—The soils and vegetation of the Simpson Desert and its borders. *Trans. Roy. Soc. S. Aust.* **70**: 235–58.

Gardner, C. A. (1942).—The vegetation of Western Australia. *J. Roy. Soc. W. Aust.* **28**: xi–lxxxvii.

Nunn, W. M., and Suijdendorp, H. (1954).—The value of "deferred grazing". *J. Dep. Agric. W. Aust.* **3**: 385–7.

Shreve, F. (1951).—Vegetation of the Sonoran Desert. Carnegie Inst. Wash. Publ. No. 591.

PART X. FORESTRY OF THE ALICE SPRINGS AREA

By W. Bateman*

I. Introduction

Central Australia, with its dry, severe climate and small population was not until recently considered from the point of view of forestry operations.

With increasing population, supervision has been given to firewood cutting and more recently to a small amount of logging in the river red gum, but no other forestry work has ever been undertaken. Because of the harsh conditions, the forestry potential is limited and the normal forestry techniques of southern Australia are inapplicable.

Land use in this area must aim at the minimum disturbance to the vegetation, and the avoidance of erosion and over-grazing are problems of the first importance. Protection will be the main role of forestry, as the quantity of timber produced will always be small.

II. Plant Communities with Forestry Potential with Past and Present Production

In the past, the small population made little demand on the timber resources and the effect on the communities was small. With increasing population, greater inroads are being made and the effects are more marked, particularly in the areas where grazing and firewood extraction are concentrated. Production of utilizable timber is restricted mainly to the four plant communities discussed below.

(*a*) *The Mulga* (Acacia aneura) *Community*

This is the most extensive and one of the most important tree communities in central Australia, covering more than 10,000 sq. miles in the area and extending into Queensland, New South Wales, South Australia, and Western Australia. The phyllodes of some mulga types form an important stock fodder, and the timber is used locally by the pastoralists for firewood, fence posts, and occasionally in the round for rough sheds, yards, etc. For reasons not yet understood, mulga dies, apparently at all ages and sizes. The dead trees are a feature of all heavy stands of mulga and form an excellent firewood, some 6000 tons being used in 1957 in Alice Springs. It is estimated that by 1967 consumption will be 9000 tons per year, unless other forms of fuel are introduced.

Though it is not considered that the disturbance to the country caused by the removal of dead mulga for firewood is serious, supervision is necessary to keep disturbance to a minimum. As this community forms the bulk of the grazing country and is the main source of firewood in the area, it follows that it has received more disturbance than any other in central Australia. Reliable informants speak of areas which 30 years ago carried mulga so dense that camel teams had difficulty in forcing

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a way through, but today carry only small isolated remnants of the original stand. South of Alice Springs the disappearance of mulga has been caused by burning, and at present mulga has almost disappeared in some areas. Under present legislation, pastoralists and lessees are allowed to use mulga for station purposes, but it is not possible to give an estimate of the quantity of mulga so used.

Scattered throughout the mulga stands in certain areas are bloodwoods (*Eucalyptus terminalis*) which yield a small log 8–12 in. in diameter. They are sought for fence posts and yards, and are gradually disappearing near Alice Springs, owing to the weak coppicing habit of the tree and the almost complete lack of regeneration on all areas seen.

(*b*) *The Coolibah* (Eucalyptus microtheca) *Community*

On many of the flats adjacent to the watercourses, and in areas subject to short periods of flooding, stands of *E. microtheca* occur. This tree is a useful addition to the timber available for station use, and is often felled for posts and stock-yard construction. A few logs have been milled from the stands along the Todd River near Alice Springs, but no great quantity of mill logs is available.

Regeneration is to be seen on some areas and the coppicing habit is stronger than in *E. terminalis*, so that under present conditions it is not considered that the stands will become depleted. The tree provides an excellent firewood, but the total quantity available is not large enough to contribute materially to the firewood supply of Alice Springs.

(*c*) *The River Red Gum* (Eucalyptus camaldulensis) *Community*

This community (Plate 19, Fig. 1) forms the largest source of millable timber and provides a small quantity of sawn timber for use in Alice Springs, the bulk of the conversion being sawn into sleepers for the Commonwealth Railways. About 30,000 sleepers have been produced to date. Red gum occurs in small stands of up to 300 ac in area, on the river flats, in valleys in the MacDonnell Ranges, and as a fringe of trees along the watercourse banks. Because of the diffuse nature of the stands, and the scarcity of trees of millable size and quality, logging operations are not expected to have any adverse effect on the stands. Coppicing from the stumps is vigorous, and the shoots appear capable of replacing the felled trees. As an example, coppice five years old attained 23 ft in height and $3\frac{1}{2}$ in. diameter breast height.

The tree produces seed prolifically, but because of grazing, rabbits, and drought after germination, regeneration is scarce. Near Alice Springs little or no regeneration is to be seen, and the stands are composed of large over-mature trees which appear to be nearing the end of their physical rotation. As these red gums have a decided aesthetic value, and are a tourist attraction, some rehabilitation of these areas of old trees appears desirable.

At the present rate of operations, it is estimated that the red gum stands accessible from Alice Springs will have all millable logs removed in 3–4 years. From then on until the coppice resulting from the present felling operations matures, only a few trees will reach mill log size each year and sleeper production will cease, or become sporadic.

(*d*) *The Desert Oak* (Casuarina decaisneana) *Community*

Occurring as a belt to the south and west of Alice Springs are stands of desert oak, which reach their best development in sandhill country with 5–8 in. annual rainfall. A graceful tree, 50–60 ft in height, with a dark green rounded crown and a dark grey to black deeply-furrowed bark is unusual in such arid conditions. The timber, extremely durable, heavy, and hard, has been tried as building scantling in Alice Springs, but is not favoured by carpenters because, unless it is used green off the saw, its hardness is such that nail holes must be drilled in it.

The stands occur pure in small patches, or as a very open savannah associated with *Triodia basedowii*. Regeneration does not appear to be a problem, the stands are in no danger of depletion at present, and it is not anticipated that the timber will ever be used extensively.

III. Minor Plant Communities

There are a number of communities which produce little except firewood or an occasional small log, but which have a considerable protection value. The shrub communities are purely protective, but logs from the ghost gum (*Eucalyptus papuana*), ironwood (*Acacia estrophiolata*), corkwood (*Hakea intermedia*), beefwood (*Grevillea striata*), and cypress pine (*Callitris columellaris*) communities are used, though they will never be of great importance.

IV. Present Conditions of the Plant Communities and Factors affecting their Condition

The major plant communities show a tendency towards over-maturity, with lack of regeneration, where disturbances to the country have been concentrated, to a more marked degree than do the minor plant communities. The increase in population from 2785 in 1954 to 3300 in 1957, increasing numbers of tourists, and increased pastoral activity all play a part in affecting the vegetation. Away from these influences, the communities are in good condition with regeneration a prominent feature, particularly in the mulga areas.

V. Possible Future Developments and Recommendations

As research in this area has only recently begun, it is difficult to forecast what the future holds. Research in arid areas in other parts of the world may also assist to solve the problems. In the light of present knowledge, it appears that a programme of research into the silvicultural requirements of the native species, with the establishment of trial plots and arboreta of native and suitable exotic species and the fencing off of protection areas in the mulga, should yield information on which the future handling of these plant communities can safely be based.

PART XI. NATURAL PASTURES OF THE ALICE SPRINGS AREA

By R. A. Perry*

I. Introduction

In higher-rainfall parts of Australia pastures generally comprise only the understoreys of the vegetation communities, but under arid conditions many of the trees and shrubs are also grazed by stock. These "top-feed" or "browse" species are mostly drought-resisting rather than drought-evading, and are particularly important in long drought periods when the ground storeys are in a state of very low or no productivity.

In Part IX the plants were classified into three groups, perennial drought-resisting plants, perennial drought-evading plants, and ephemeral drought-evading plants. The perennial drought-resisting plants can be further subdivided according to their life form into the following four subgroups which are pastorally distinct.

Shrubs and low trees, mainly sclerophyllous, are the important top-feed plants of central Australia which provide stock with a sustenance diet through long dry periods. They are generally palatable or moderately so and of moderate nutritive value. The most important are mulga (*Acacia aneura*), ironwood (*A. estrophiolata*), witchetty bush (*A. kempeana*), gidgee (*A. georginae*), whitewood (*Atalaya hemiglauca*), and supplejack (*Ventilago viminalis*), but there are many others.

Relatively few *semi-succulent shrubs* occur in central Australia. They are limited to chenopods. Bladder saltbush (*Atriplex vesicaria*), old-man saltbush (*A. nummularia*), and southern bluebush (*Kochia astrotricha*) occur mostly in the southern part of the area and are nutritious and moderately palatable. Small areas of northern bluebush (*Chenopodium auricomum*) occur throughout the area but mostly in the northern half. It is highly palatable and highly nutritious.

The only *sclerophyllous drought-resisting grasses* are the various types of spinifex (*Triodia* spp. and *Plectrachne* spp.). They are all strongly lignified, some more than others. Soft spinifex (*Triodia pungens*) and feathertop spinifex (*Plectrachne schinzii*) have a low palatability and a low nutritive value, the others are virtually useless.

Very few *evergreen forbs* occur in the area and they persist for shorter periods than the other drought-resisting forms. The most important are the parakeelyas (*Calandrinia* spp.), succulent plants which grow in spinifex country.

Animals grazing in country where all groups are represented adjust their grazing habits to the available fodder. During favourable periods, especially following summer rains, they graze mostly on the soft and nutritious ephemeral drought-evading plants (short grasses and forbs), to a lesser extent on the perennial drought-evading species (tussock grasses), and to a small extent on the perennial drought-resisting plants (top feed). Under these conditions they gain weight rapidly. With the onset of drought conditions most of the ground-storey plants die off but stock

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still preferentially graze the short grasses in the dry state while they are available. However, they are progressively forced to graze more of the less attractive tussock grasses and top feed, and if these are all that are available they maintain their weight or perhaps lose slightly. If the drought continues for a long period the stock are

TABLE 20

MAIN CHARACTERISTICS OF THE PASTURE TYPES

Type of Characteristic Plants	Pasture Type	Associated Plant Storeys	Remarks
Ephemeral drought-evading plants	Short grass–forb	Palatable top feed including mulga, witchetty bush, gidgee, myall, ironwood, whitewood, supplejack, and others	Capable of fattening stock after rain, top feed sustains stock in droughts
	Bassia spp.	Top feed generally absent or very sparse	Good fodder after rain, poor during drought
Perennial drought-evading plants	Woollybutt (*Eragrostis eriopoda*)	Mainly under mulga; short grasses and forbs may occur in favourable seasons	Good fodder for some months after rains, top feed sustains stock in droughts
	Mitchell grass (*Astrebla* spp.)	No top feed; short grasses and forbs may occur in favourable seasons	Good fodder for some months after rains but degenerates to very poor in long dry periods
	Neverfail (*Eragrostis xerophila*)	No top feed; short grasses and forbs may occur in favourable seasons	Good fodder for some months after rains but degenerates to very poor in long dry periods
	Kerosene grass (*Aristida browniana*)	Sparse cover of top-feed species, including whitewood, ironwood, supplejack, and mulga; short grasses and forbs in favourable seasons	Good fodder after rains, top feed sustains stock in droughts
	Medium-height perennial tussock grasses	Various top-feed species	Fair fodder for some months after rain; top feed sustains stock in droughts
Perennial drought-resisting plants–sclerophyllous grasses	Soft spinifex (*Triodia pungens*)	Sparse top feed	Poor fodder in both good and bad seasons; small areas used as drought reserves
	Feathertop spinifex (*Plectrachne schinzii*)	Very sparse top feed	Poor fodder in both good and bad seasons; small areas used as drought reserves
	Hard spinifex (*Triodia basedowii*)	Very sparse top feed	Generally regarded as useless for grazing

TABLE 20 (*Continued*)

Type of Characteristic Plants	Pasture Type	Associated Plant Storeys	Remarks
Perennial drought-resisting plants—semi-succulent low shrubs	Northern bluebush (*Chenopodium auricomum*)	Top feed absent; short grasses and forbs may occur after flooding	Nutritiously good, high stocking rate
	Bladder saltbush (*Atriplex vesicaria*)	Top feed generally absent, small area with mulga; short grasses and forbs present in favourable seasons	Good in favourable seasons; fair in droughts; low stocking rate
	Southern bluebush (*Kochia astrotricha*)	Top feed generally absent; short grasses and forbs present in favourable seasons	Good in favourable seasons; fair in droughts; low stocking rate
	Cotton-bush (*Kochia aphylla*)	Top feed generally absent; short grasses and forbs present in favourable seasons	Fair in favourable seasons; poor in droughts
	Old-man saltbush (*Atriplex nummularia*)	Top feed generally absent; short grasses and forbs present in favourable seasons	Good pasture; high stocking rate

forced to eat less attractive fodder and to walk further for it. Under these conditions they lose weight. In parts of the area where there are no edible perennial drought-resisting species, stock mortalities occur during long droughts.

Although the groups, subgroups, and individual species occur in different proportions in various parts of the area it is possible to recognize a number of pasture types which have fairly uniform assemblages of ground-storey plants. They may be variable as regards top feed.

Pasture types are floristically fairly uniform and mostly do not occur in areas individually large enough to map at the scale of the survey. However, their distribution is related to environmental factors and each land system has a definite pattern of pasture types. The land systems can be grouped according to their major pasture types into eight pasture lands, each of which has a relatively simple distribution.

Adequate description of the natural pastures of the area therefore requires firstly a description of the pasture types and secondly a description of the pasture lands. The main features of the pasture types are summarized in Table 20.

II. Pasture Types

(*a*) *Pasture Types Characterized by Ephemeral Drought-evading Plants*

These types are characterized by plants which grow only during favourable periods and survive long droughts as seeds. Such plants survive in the arid environment only because they avoid droughts.

(i) *Short Grass–Forb Pastures.*—This type (Plate 4, Fig. 1; Plate 5, Fig. 1; Plate 6, Figs. 1 and 2; Plate 7, Fig. 2; Plate 8, Figs. 1 and 2; Plate 17, Fig. 1) contains few or no perennial ground-storey species. After summer rain the pasture is mainly kerosene grass (*Aristida arenaria*) and/or oat grass (*Enneapogon* spp.), but after winter rains forbs, particularly composites such as white daisy (*Helipterum floribundum*) and crucifers, are more common.

In most places there are associated top-feed species of which mulga (*Acacia aneura*) is the most widespread. Gidgee (*A. georginae*), witchetty bush (*A. kempeana*), and myall (*A. calcicola*) are more common in some parts, particularly on limestone. A tree storey characterized by sparse low trees including ironwood (*A. estrophiolata*), whitewood (*Atalaya hemiglauca*), supplejack (*Ventilago viminalis*), and others is common on alluvial soils and some gently undulating country on granite and metamorphic rocks.

The summer-growing grasses are highly palatable and nutritious and are good fattening pastures for short periods after rain. The winter-growing forbs are less valuable. Neither last for more than a few months after rain and during longer dry periods the associated top feed provides a subsistence diet.

This pasture type carries most of the stock in the area. Its stocking rate varies with rainfall, soil and rock types, and associated top feed, but under the existing management regime is from 5 to 10 cattle per sq. mile year-long. It produces fat cattle in favourable seasons.

It is the most extensive type in two pasture lands, namely short grass–forb pastures on young alluvia, and short grass–forb pastures on flat or undulating country. Smaller areas occur in other pasture lands. It is a prominent constituent of Sandover, Finke, McGrath, Ammaroo, McDills, Todd, Woodduck, Adnera, Hamilton, Boen, Bushy Park, Alinga, Lindavale, Leahy, Lucy, Ooratippra, Pulya, Ringwood, Delny, Muller, Outounya, Alcoota, Ryan, Ennugan, Jinka, Anderinda, Barrow, Indiana, Unca, Dinkum, Warburton, Titra, and Woolla land systems and occurs to a lesser extent in many others.

(ii) Bassia *Spp. Pastures.*—In the southern half of the area *Bassia* spp. characterize a pasture type similar in most respects to the short grass–forb pastures. It occurs mainly under a mean annual rainfall less than 8 in. and is commonly associated with texture-contrast soils and calcareous earths. Top-feed species are mainly absent.

The floristic composition, vigour, and yield of the type vary seasonally and its year-long stocking rate is low (less than 5 cattle per sq. mile).

It is commonest in the short grass–forb pastures on flat to undulating country (Chandlers land system) and short grass–forb pastures on young alluvia (Deering land system) pasture lands, but occupies small areas in many others.

(*b*) *Pasture Types Characterized by Perennial Drought-evading Plants*

Perennial drought-evading plants are either deciduous shrubs or trees or tussock grasses. The former are uncommon in central Australia and in any case of little pastoral value. The tussock grasses grow rapidly from root bases or rhizomes after adequate summer rain but consist of dry straw for most of the year. The nutritive value of the grasses is moderate to low when green, but low or very low when dry.

They are, however, an important source of fodder. Common representatives in the area are woollybutt (*Eragrostis eriopoda*), neverfail (*E. xerophila*), Mitchell grasses (*Astrebla pectinata* and *A. lappacea*), kangaroo grass (*Themeda australis*), golden-beard grass (*Chrysopogon fallax*), desert blue grass (*Bothriochloa ewartiana*), curly windmill grass (*Chloris acicularis*), and kerosene grass (*Aristida browniana*).

(i) *Woollybutt Pastures*.—Pastures characterized by woollybutt (*Eragrostis eriopoda*) occur under similar environmental conditions to the short grass–forb pastures but are much less extensive. Similar top-feed species are present. The tussocks, including inflorescence, are generally 9 to 15 in. high and about 9 in. in diameter. Spacing varies from irregularly scattered tussocks to fairly regular stands with tussocks about 2 ft apart. In some places there may be associated ephemeral drought-evading species in favourable seasons.

Woollybutt grows rapidly after summer rains, but is only moderately palatable. Where the pasture includes ephemeral grasses it is capable of fattening stock. Under the present management system the stocking rate varies from 5 to 10 cattle per sq. mile year-long.

The type occurs mainly in two pasture lands, short grass–forb pastures on young alluvia and short grass–forb pastures on flat or undulating country. It is prominent in Karee and Tietkins land systems and occupies small parts of many others including Boen and Bushy Park.

(ii) *Mitchell Grass Pastures*.—In the Alice Springs area Mitchell grass (mostly *Astrebla pectinata*, some *A. lappacea*) pastures occur on heavy clay soils which are of limited extent. Mitchell grass is a perennial drought-resisting tussock grass, the tussocks, including inflorescence, growing to 12 to 24 in. high and about 9 in. in diameter (Plate 9, Figs. 1 and 2). They are generally fairly evenly spaced 2 to 3 ft apart and grow rapidly following adequate falls of summer rain. After such falls the interspaces are covered with short grasses and forbs but during long dry periods they are bare. There are no associated top-feed species.

When short grasses and forbs are present the pasture type has a relatively high stocking rate (about 20 per sq. mile) but with the onset of dry conditions the palatable ephemerals are rapidly utilized and the animals are forced to graze the low-quality dry Mitchell grass tussocks which constitute only a subsistence diet. In long dry periods mortalities occur unless stock are moved.

The pasture type occupies most of the area of one pasture land (Mitchell grass country), the total area of which is only 300 sq. miles. It includes Undippa and Ambalindum land systems. Small areas occur in other pasture lands and other land systems. Sparsely distributed tussocks of Mitchell grass are also associated with gilgais in some of the saltbush country in the southern half of the area.

(iii) *Neverfail Pastures*.—Small areas of heavy clay or texture-contrast soils are characterized by neverfail (*Eragrostis xerophila*), which is a perennial, drought-evading, tussock grass with tussocks about 9 in. in diameter and 9 to 12 in. high.

In most characteristics this type is similar to the previous one—it has no top feed and it provides good, high-carrying pasture during favourable periods but has a very low value during long dry periods.

Small areas occur in several pasture lands. It is not a major part of any land system but is commonest in Ambalindum, Delny, Ringwood, McGrath, Table Hill, Undippa, and Hamilton. Other land systems contain small areas.

(iv) *Kerosene Grass Pastures*.—Small areas of coarse sandy soils carry a pasture characterized by kerosene grass (*Aristida browniana*). It is a perennial drought-evading tussock grass growing to a height of 12 to 18 in. and a diameter of 3–6 in. In favourable seasons short grasses and forbs occur in the interspaces. A sparse cover of top-feed species is normally present.

In the young state kerosene grass is reasonably palatable but mature stands have a low palatability and a low nutritive value. It is mostly stocked at a rate of about 5–10 cattle per sq. mile year-long.

The type is common in Kanandra land system and small areas occur in others. Kanandra land system has been included in the short grass–forb on young alluvia pasture land.

(v) *Medium-height Perennial Tussock Grass Pastures*.—Small areas, mainly in favourable habitats such as along drainage lines in the northern half of the area, are characterized by various medium-height perennial tussock grasses including three-awned spear grass (*Aristida pruinosa*), kangaroo grass (*Themeda australis*), native oat grass (*T. avenacea*), golden-beard grass (*Chrysopogon fallax*), desert blue grass (*Bothriochloa ewartiana*), silky browntop (*Eulalia fulva*), and curly windmill grass (*Chloris acicularis*). These are all drought-evading species, their foliage dying after maturity but remaining standing. The dry foliage provides a maintenance diet during drought periods when the more palatable and nutritious shorter species have been utilized. A range of top-feed species is generally present.

The type occurs as small areas in a number of pasture lands and land systems. Because of the narrow linear nature of its occurrence it is difficult to assess its stocking rate. However, the presence of the type has the general effect of raising the carrying capacity of adjacent country.

(c) Pastures Characterized by Perennial Drought-resisting Sclerophyllous Grasses

(i) *Soft Spinifex Pastures*.—Soft spinifex (*Triodia pungens*) pasture occurs on sandy soils in the far north of the area, where the mean annual rainfall is greater than about 12 in. It also occurs in small, better-watered areas, such as in broad, shallow depression lines in sand plains further south.

Soft spinifex grows in straggly tussocks varying from 1 to 3 ft high and from 1 to 4 ft in diameter. The leaves and stems are coated with a resinous exudation. It is more palatable than other species of *Triodia* probably because of the smaller amount of lignified tissue in its leaves (Burbidge 1946). This is probably also correlated with a higher nutritive value. The spaces between the tussocks are mostly bare but more grasses and forbs tend to be present than in spinifex communities of drier areas. Sparse to medium dense cover of shrubs 4 to 8 ft high, some of which are slightly palatable to stock, is characteristic. In some areas scattered trees of snappy gum (*Eucalyptus brevifolia*) also occur (Plate 3, Fig. 1).

The type has a low stocking rate (less than 5 cattle per sq. mile year-long) and mostly has not been developed for grazing. However, because soft spinifex is a drought-resisting plant, its stocking rate is not greatly affected by droughts and some properties have developed areas for drought reserves. During long droughts it has a higher stocking rate than much of the normally better-class country. Even in favourable seasons soft spinifex pastures are not fattening pastures, and in some areas at least, stock restricted to them show signs of nutritional deficiencies.

The pasture is limited mainly to one pasture land (spinifex sand plains, dune fields, and plains) but small areas occur in another (hills and lowlands). It is the major constituent of Wonorah and Tennant Creek land systems and occurs to a lesser extent in many others.

(ii) *Feathertop Spinifex Pastures.*—Northwards from latitude 23°S. increasingly larger proportions of the spinifex sand plain are characterized by feathertop spinifex (*Plectrachne schinzii*) (Plate 2, Fig. 2). It has tussocks about 12 in. high, 12 to 18 in. in diameter, and 12 to 48 in. apart. The spaces between the tussocks are generally bare, but in favourable seasons scattered grasses and forbs occur. A sparse to medium dense cover of shrubs 4 to 8 ft high, few of which are palatable, is normal.

The type has a low (less than 5 cattle per sq. mile year-long) stocking rate and provides subsistence rather than fattening pasturage. It is used mainly as a drought reserve.

It is mainly restricted to one pasture land (spinifex sand plains, dune fields, and plains) and forms a prominent constituent of Singleton and Aileron land systems. Minor areas occur in other pasture lands and other land systems.

(iii) *Hard Spinifex Pastures.*—Pastures characterized by hard spinifex (*Triodia basedowii*) are more extensive than any others and cover more than half of the Alice Springs area. Hard spinifex forms tussocks about 1 ft high and 1 to 3 ft in diameter or "rings" up to 20 ft in diameter (Plate 2, Fig. 1). The foliage is highly lignified (Burbidge 1946) and has a low palatability and a low nutritive value. A sparse to medium dense cover of shrubs is normal, but few are palatable.

It has a very low or nil stocking rate and stock feeding on it develop nutritional deficiencies. It is almost completely undeveloped for grazing.

It is a major constituent of the spinifex sand plains, dune fields, and plains pasture land and Singleton, Ewaninga, Angas, Middleton, Amulda, and Simpson land systems.

(d) Pastures Characterized by Perennial Drought-resisting Semi-succulent Low Shrubs

(i) *Northern Bluebush Pastures.*—Northern bluebush (*Chenopodium auricomum*) is not very common in the Alice Springs area, but is locally important because of the high carrying capacity of pastures characterized by it. It grows to about 3 ft high and has slightly succulent leaves and young stems. It grows in habitats which are seasonally flooded for short periods (Plate 5, Fig. 2) and is commonest on heavy clay soils.

Following flood periods northern bluebush grows very rapidly and as the water recedes a dense growth of small herbs may occur in the interspaces. Associated trees or shrubs are absent normally, but in some parts coolibah (*Eucalyptus microtheca*) forms a sparse cover. Northern bluebush has a high protein and phosphorus content and is a palatable and nutritious fodder plant. The pasture type has a high stocking rate, possibly 80 to 100 cattle per sq. mile, and withstands heavy grazing well. It will regenerate even after the stems have been grazed almost to ground level. However, because of its palatability it is selectively grazed by stock and many small areas surrounded by less palatable pastures have been overgrazed and destroyed.

The type occurs as small areas on flood-plains and alluvial plains. It comprises the main part of Utopia land system and occurs to a minor extent in Sandover, Ammaroo, McDills, Undippa, Hamilton, Alinga, Ringwood, Wilyunpa, and Endinda land systems.

(ii) *Bladder Saltbush Pastures*.—In the southern half of the Alice Springs area, pastures characterized by bladder saltbush (*Atriplex vesicaria*) are important, particularly on medium-textured soils with a relatively high soluble salt content. Bladder saltbush has slightly succulent foliage and grows to 1 or 2 ft high and 1 to 3 ft in diameter (Plate 10, Fig. 1). The spacing of the individual plants varies from scattered plants to fairly even stands with only 1 to 3 ft between plants. The interspaces are bare during droughts but have a cover of short grasses and forbs, among which *Bassia* spp. are prominent, in favourable periods. In the denser stands of bladder saltbush, only a sparse cover of short grasses and forbs ever develops. The pasture type is normally treeless, and therefore without top feed, but a small area near Kulgera has a cover of mulga (*Acacia aneura*).

The pasture type provides fairly palatable and nutritious fodder and fattens stock in favourable periods when short grasses and forbs are present. In drought periods the bushes of bladder saltbush provide most of the fodder, and particularly where the bushes are widely spaced, they may be heavily grazed and destroyed. The stocking rate is low, less than 5 cattle per sq. mile year-long, but is fairly stable.

This type is confined mainly to one pasture land, viz. bluebush and saltbush country, but smaller areas occur in other pasture lands particularly in the southern part of the area. It is an important constituent of Kulgera, Wilyunpa, Peebles, Endinda, and Kalamerta land systems and small areas occur in many others.

(iii) *Southern Bluebush Pastures*.—This type occurs under similar conditions to the bladder saltbush pastures and is also restricted to the southern half of the area. It tends to occur on finer-textured soils. Top feed is generally absent.

Southern bluebush (*Kochia astrotricha*) has a habit similar to bladder saltbush and the community is similar in form. The stocking rate is low, less than 5 cattle per sq. mile year-long, but is fairly stable through drought periods. The type is mostly confined to one pasture land (bluebush and saltbush country) and is an important constituent of Lilla, Ebenezer, and Renners land systems with smaller areas in others.

(iv) *Cotton-bush Pastures*.—This type is widely distributed throughout the area but occurs mainly in the southern half. Individual areas are small and limited to depressions with texture-contrast soils. Cotton-bush (*Kochia aphylla*) is a shrub 1–2 ft high and 1–2 ft in diameter and generally the stands are sparse. The interspaces are commonly covered with forbs and short grasses, *Bassia* spp. being the most common in the south and yellow daisy (*Helipterum charsleyae*) in the north. Top-feed species are absent or occur only very sparsely.

The stocking rate is lower than that of the southern bluebush type.

It occurs as small areas in a number of pasture lands and land systems, in fact almost anywhere in the area where there are texture-contrast soils.

(v) *Old-man Saltbush Pastures*.—Pastures characterized by old-man saltbush (*Atriplex nummularia*) occur in small areas which are seasonally flooded for short periods. They are mainly restricted to the southern half of the area.

Old-man saltbush grows to about 6 ft high and has slightly succulent leaves. Locally it is associated with sparse coolibah (*Eucalyptus microtheca*) but trees are absent normally. Where the bushes are closely spaced the interspaces are bare or almost so, but in sparse stands an associated cover of short grasses and forbs is present during favourable periods.

The bushes are palatable and nutritious and the pasture has a high stocking rate and withstands grazing well. However, because of its palatability it is selectively grazed and many small areas surrounded by poorer pasture have been very heavily grazed and destroyed.

Small areas of old-man saltbush occur in several land-use groups. It is a minor constituent of McDills, Finke, Endinda, and several other land systems.

III. Pasture Lands

Pasture lands consist of a recurrent pattern or complex of pasture types and each has its characteristic pastoral value and developmental problems (Perry 1960; and Part XII).

A map of the pasture lands, showing their constituent land systems, accompanies this report. It shows that in broad terms the area consists of a matrix of spinifex sand plains, dune fields, and plains intersected by several belts of mountainous or hilly country flanked by better-class country. The locations of the stock watering points are also shown. The relationship between the location of these and the pasture lands is obvious.

The main characteristics of the pasture lands and their constituent land systems are presented in Table 21.

(*a*) *Spinifex Sand Plains, Dune Fields, and Plains*

This pasture land consists mainly of slightly uneven sand plains (Plate 2, Figs. 1 and 2) or dune fields (Plate 3, Fig. 2), in either case with very permeable and well-drained, coarse sandy, infertile red soils. It mainly carries the hard spinifex (*Triodia basedowii*) pasture type, with smaller areas of the feathertop spinifex (*Plectrachne schinzii*) and soft spinifex (*Triodia pungens*) types. Some of the land systems also contain a proportion of other pastures, particularly the short grass–forb and woollybutt (*Eragrostis eriopoda*) types, and on some there is a proportion of stony or hilly country.

The lack of organized drainage indicates that most of the rainfall penetrates where it falls.

Five of the land systems (Singleton, Ewaninga, Angas, Middleton, and Amulda), are mainly sand plain, with red clayey sands, carrying hard spinifex pastures. As a group, these are more extensive north of the MacDonnell Ranges where mean annual rainfall is 9 to 12 in. Singleton is the largest land system and consists almost entirely of monotonous spinifex country. Ewaninga land system comprises several areas, immediately south of the MacDonnell Ranges, of irregularly undulating, sandy country overlying conglomerate (Pertnjara "series") at relatively shallow depth. It consists almost entirely of hard spinifex country with a sparse to medium dense cover of mulga (*Acacia aneura*), 10 to 20 ft high. Angas land system is restricted to the southern half of the area, and comprises a number of small areas where hard spinifex country is intermixed with stony, heavier soils carrying southern bluebush (*Kochia astrotricha*) or *Bassia* spp. pasture types. Where large enough areas of these latter types occur the country has a low stocking rate. Middleton land system is also restricted to the southern half of the area. It consists of hard spinifex sand plain country with some inaccessible hilly country. Amulda land system comprises a number of small areas in the southern half of the area. It occurs in valleys or adjacent to hills and consists of hard spinifex sand plain with small areas of flood-plains. The latter carry short grass–forb pastures and occur where small streams from the hills flow onto the plains.

Simpson land system includes all the dune fields and is more common in the southern half of the area. Both dunes and swales carry mainly hard spinifex pastures.

Wonorah and Tennant Creek land systems are mainly plains. Their red earth soils contain a higher proportion of clay than the sand plain soils. The two land systems occur near the northern margin of the area where mean annual rainfall is about 12 in. and both carry mainly soft spinifex (*Triodia pungens*) pastures (Plate 3, Fig. 1) under a sparse to medium dense cover of shrubs and low trees. Wonorah land system consists of plains with isolated low hills. Tennant Creek land system has a greater proportion of hilly country.

(*b*) *Short Grass–Forb Pastures on Young Alluvia*

This pasture land consists mainly of flat to gently sloping areas of recent alluvia, and occurs either as the flood-plains of the major watercourses (Plate 4, Fig. 1) or as alluvial fans (Plate 5, Fig. 1) adjacent to mountains and hills. It includes most of the favoured areas, i.e. areas which receive water run-on and thus have more moisture available for plant growth than is contributed directly from rainfall (Plate 5, Fig. 2). The major proportion does not receive run-on but at least does not suffer from run-off. The soils are mainly red earths or undifferentiated alluvia and range from very permeable, well-drained sands to poorly drained clays. They commonly carry short grass–forb pastures mainly under a sparse cover of low trees, most of which are palatable to stock. Many other pasture types occur in small proportions.

Sandover and Finke land systems consist mainly of coarse-textured flood-plains along the middle and upper sections of the major streams in the north and south of the area respectively. Finke land system has a higher proportion of calcareous soils

TABLE 21

MAIN CHARACTERISTICS OF THE PASTURE LANDS

Pasture Land	Area (sq. miles)	Stocking Rate (cattle/sq. mile)	Topography	Common Soil	Common Vegetation	Stock-water Resources	Land Systems
Spinifex sand plains, dune fields, and plains	82,700	0 (small areas up to 4)	Uneven plains or dune fields	Red clayey sands or red sands	Spinifex–*Triodia* spp., *Plectrachne schinzii*	Ground water generally available — depth and quality variable	Singleton, Ewaninga, Angas, Middleton, Amulda, Simpson, Wonorah, Tennant Creek
Short grass–forb pastures on young alluvia	6200	7 (common range 5–20)	Flat or gently sloping	Red earths or undifferentiated alluvia, mainly coarse-textured	Sparse low trees over short grasses and forbs	Ground water generally available at shallow to moderate depths — temporary and permanent water-holes in channels	Sandover, Finke, McGrath, Ammaroo, McDills, Kanandra, Todd, Woodduck, Adnera, Deering, Hamilton, Utopia
Short grass–forb pastures on flat or undulating country	21,900	7 (range 5–10)	Flat to undulating	Red earths, less commonly calcareous earths and texture-contrast soils	Short grasses and forbs under mulga, gidgee, witchetty bush, or sparse low trees	Ground water generally available, depth and quality variable. In most areas without ground water, surface catchments can be used	Boen, Bushy Park, Karee, Tietkins, Lindavale, Leahy, Alinga, Lucy, Ooratippra, Pulya, Ringwood, Delny, Muller, Outounya, Ryan, Alcoota, Ennugan, Anderinda, Barrow, Jinka, Indiana, Dinkum, Warburton, Unca, Chandlers, Woolla, Titra

TABLE 21 (*Continued*)

Pasture Land	Area (sq. miles)	Stocking Rate (cattle/sq. mile)	Topography	Common Soil	Common Vegetation	Stock-water Resources	Land Systems
Saltbush and bluebush country	3300	5	Undulating to low hilly	Texture-contrast soils or calcareous earths	Saltbush and bluebush—treeless	Suitable ground water difficult to locate in some parts, but surface catchments mostly suitable	Ebenezer, Renners, Lilla, Wilyunpa, Kulgera, Peebles, Endinda, Kalamerta
Mitchell grass country	300	10–20	Flat or gently sloping	Coarse-structured clay soils	Mitchell grass—treeless	Ground water generally available, surface catchments suitable	Undippa, Ambalindum
Alternating hills and lowlands	13,500	5 (range 0–10)	Alternating hills and lowlands	Shallow and stony alternating with red earths or calcareous earths	Lowlands, mainly short grasses and forbs under mulga, gidgee, witchetty bush, or sparse low trees	Very variable but either ground water or surface catchments generally suitable	Gillen, Pularoo, Napperby, Aileron, Ilbumric, Hann, Weldon, Chisholm, Allua, Hogarth, Bond Springs, Kernot, Rumbalara, Table Hill, Ilgulla, Coghlan, Cavenagh, Stokes, Kurundi
Mountains and hills	14,500	0	Steeply sloping	Rock outcrop with pockets of shallow gritty soil	Spinifex or sparse forbs and grasses	Not required	Pertnjara, Sonder, Harts, Krichauff, Cherry Creek, Huckitta, Reynolds, Santa Teresa, Berrys Pass, Davenport, Tomahawk
Salt lakes	1800	0	Flat	Saline	Bare	Not required	Amadeus

than Sandover. As well as the major element (coarse-textured soils with short grass–forb pastures under sparse low trees) the important minor elements are:

(1) Stream channels with medium-height perennial tussock grass under coolibah (*Eucalyptus microtheca*) or river red gum (*E. camaldulensis*).

(2) Levees with medium-height perennial tussock grass or short grass–forb pastures under scattered trees.

(3) Sandy banks with hard spinifex (*Triodia basedowii*) or short grass–forb pastures.

(4) Alluvial basins with heavier soils and a variety of pasture types including Mitchell grass (*Astrebla pectinata*), neverfail (*Eragrostis xerophila*), northern bluebush (*Chenopodium auricomum*), old-man saltbush (*Atriplex nummularia*), medium-height perennial tussock grass, or short grass–forb pastures, either open or under coolibah.

McGrath land system occurs in the central part of the area and consists mainly of flood-plains with medium-textured soils (red earths) carrying short grass–forb pastures under either sparse low trees or mulga (*Acacia aneura*).

Ammaroo and McDills land systems are the terminal flood-plains of water-courses in the north and south of the area respectively, and therefore occur down-stream from Sandover and Finke land systems. They are generally more open with a greater proportion of alluvial basins carrying barley Mitchell grass (*Astrebla pectinata*), neverfail (*Eragrostis xerophila*), northern bluebush (*Chenopodium auricomum*), or old-man saltbush (*Atriplex nummularia*) pastures.

The remaining land systems of the pasture land are alluvial fans or mixed fans and flood-plains. Kanandra land system mostly occurs along the northern margin of Harts Range and consists of coarse-textured alluvium carrying mainly kerosene grass (*Aristida browniana*) pastures under sparse low trees. Todd land system consists of flood-plains of the Todd River and alluvial fans on the southern margin of the MacDonnell Range. It has mainly coarse to medium-textured alluvia, derived from igneous and metamorphic rocks, carrying short grass–forb pastures under sparse low trees.

Woodduck land system consists of a number of small alluvial fans associated with sandstone hills in the northern half of the area. The main components are fans carrying short grass–forb pastures under scattered low trees, and sand plain with hard spinifex (*Triodia basedowii*). Small areas of channels with river red gum (*Eucalyptus camaldulensis*) over medium-height perennial tussock grasses, and alluvial basins with coolibah (*E. microtheca*) over medium-height perennial tussock grasses also occur. Adnera land system comprises a few small areas of alluvial fans associated with sandstone hills in the north-eastern part of the area. Very little is known of this land system, but from interpretation of aerial photographs the largest part is mulga (*Acacia aneura*) country probably with short grass–forb or woollybutt (*Eragrostis eriopoda*) pastures. Areas of this are separated by a series of roughly parallel small channels and associated small flood-plains which terminate in alluvial basins. The flood-plains and terminal basins appear to be open or fairly open with the short grass–forb pastures. Small areas of coolibah (*Eucalyptus microtheca*) with medium-height perennial tussock grasses also occur.

Deering land system consists mainly of treeless areas of texture-contrast soils carrying *Bassia* spp. pasture type.

Hamilton land system occurs mostly adjacent to the northern side of the MacDonnell Ranges. It is mainly alluvial fans with fairly heavy soils (mainly texture-contrast) carrying short grass–forb pastures. Smaller areas of northern bluebush (*Chenopodium auricomum*) and cotton-bush (*Kochia aphylla*) pastures also occur. These plains alternate with areas of coarse-textured soils carrying mulga (*Acacia aneura*) over short grass–forb or woollybutt (*Eragrostis eriopoda*) types.

The largest part of Utopia land system consists of heavy clay soil "swamps", periodically flooded to a shallow depth and carrying northern bluebush (*Chenopodium auricomum*) pastures.

(*c*) *Short Grass–Forb Pastures on Flat or Undulating Country*

In general this pasture land has flat to undulating topography, although some of the land systems contain a proportion of stony or hilly country. A variable density of small channels carry run-off and indicate that most parts receive less water than contributed by rainfall. Some small areas such as the broad shallow depressions in Boen land system receive run-on. The soils are mainly red earths, of shallow to medium depth, with medium permeability and good internal drainage, and generally of low fertility. Less common are calcareous earths and texture-contrast soils which form a predominant part of several land systems and a small proportion of others. Short grass–forb pastures predominate in all the land systems although many other types also occur. Most of the country has a sparse to medium dense cover of low trees many of which are palatable to stock and provide valuable top feed especially during long dry periods.

The 28 land systems of this pasture land can best be considered in groups with similar top feed.

(i) *Mulga Country*.—10,100 sq. miles—Boen, Bushy Park, Karee, and Tietkins land systems. The largest part of this group, most of Boen and Bushy Park land systems, occurs as a belt 10–50 miles wide extending along the northern flanks of the MacDonnell and Strangway Ranges. It is flat or gently sloping with red earth soils and carries mulga growing in dense groves interspersed with open intergroves. Boen land system occurs over mainly metamorphic rocks and Bushy Park over stable alluvia (Plate 6, Figs. 1 and 2). Boen land system is characterized by a gently undulating topography with gently sloping low rises interspersed with broad, shallow, linear depressions. Karee and Tietkins land systems are restricted to the southern margin of the area and although the topography and vegetation are similar the soils are coarser textured. In all four land systems there is a proportion of the country which carries woollybutt (*Eragrostis eriopoda*) pastures.

(ii) *Mulga Country mixed with Spinifex Sand Plain*.—2000 sq. miles—Lindavale, Leahy, and Alinga land systems. Although the major unit in these land systems consists of mulga over short grass–forb or woollybutt (*Eragrostis eriopoda*) pastures, they also contain a fairly large proportion of spinifex country. Lindavale land system occurs in the southern half of the area and consists of a limestone plain with red earth soils partly covered with sand plain. Leahy land system is very complex and is developed on alluvia mainly near Ongeva Creek. Alinga occurs in the north-eastern part of the area and consists of mulga country developed on Palaeozoic sandstone, shale, and thin limestone, intermixed with sand plain.

(iii) *Gidgee Country*.—2200 sq. miles—Lucy, Ooratippra, Pulya, Ringwood, and part of Delny land systems. Gidgee (*Acacia georginae*) country is mainly restricted to the north-eastern part of the area and is commonly associated with limestone (Plate 7, Fig. 2). In topography and soils it is similar to mulga country.

Lucy and Ooratippra land systems are both developed over dolomite and limestone. The former consists almost exclusively of gidgee, in varying densities, over short grass–forb pastures but the latter also includes broad alluvial tracts with red earth soils carrying mulga. Pulya and Ringwood land systems are both small and occur mainly in the eastern MacDonnell Ranges. Pulya consists of broad valleys between ranges and Ringwood occurs on alluvia and contains as a minor constituent some northern bluebush (*Chenopodium auricomum*) pastures. The part of Delny land system in this group is very complex. It is developed over metamorphic rocks, laterite, and Tertiary sediments and mainly consists of gidgee and mulga country.

(iv) *Witchetty Bush Country*.—1000 sq. miles—Muller and Outounya land systems. The major part of both land systems consists of gently undulating country (Plate 8, Fig. 1), with relatively shallow red soils carrying short grass–forb pastures under a sparse to medium dense cover of witchetty bush (*Acacia kempeana*). Smaller areas of shallow linear depressions receive run-on from adjacent country and commonly carry mulga (*A. aneura*) over short grasses and forbs.

Muller land system is developed over conglomerate in the central part of the area. Outounya land system occurs on granite and schist near the southern margin of the area.

(v) *Sparse Low Tree Country*.—4400 sq. miles—Ryan, Alcoota, Ennugan, Anderinda, Barrow, Jinka, Delny (part), Indiana, Dinkum, Warburton, and Unca land systems. This comprises most of the gently undulating to undulating country developed on granite or metamorphic rocks (Plate 8, Fig. 2). Mostly the soils are relatively shallow and the vegetation consists of sparse trees (mulga, ironwood, whitewood, and corkwood) over short grass–forb pastures. The trees vary from medium dense in Warburton land system to almost absent in Ryan, Alcoota, and Ennugan land systems. There are numerous small areas of minor elements. Small channels and associated frontage areas with perennial grasses and various trees are common, as are low stony rises and hills. In some parts areas of texture-contrast soils carrying *Bassia* spp., cotton-bush (*Kochia aphylla*), bladder saltbush (*Atriplex vesicaria*), Mitchell grass (*Astrebla pectinata*), or neverfail (*Eragrostis xerophila*) pastures occur.

Ryan, Alcoota, and Ennugan land systems consist of slightly dissected country on weathered granite, gneiss, or schist. They all have a proportion of texture-contrast soils which are generally treeless or almost so and carry short grass–forb or cotton-bush (*Kochia aphylla*) pastures. Ryan land system has a greater proportion than the other two. Alcoota and Ennugan both contain areas of mulga country.

Anderinda, Barrow, and Jinka land systems are undulating plains on granite, schist, or gneiss in the northern half of the area. Anderinda land system contains a proportion of treeless texture-contrast soils and some red earth soils carrying mulga. Barrow land system is developed on granite and consists of shallow red earths and red clayey sands, either open or with sparse low trees. Jinka land system (Plate 1, Fig. 1) is characterized by the presence of steeply sloping quartz reefs and has broad depressions with medium-height perennial tussock grasses. The part of Delny land system in this group consists of erosional plains developed on metamorphic rocks and contains a small proportion of low hills and of shallow depressions with medium-height perennial tussock grasses.

Indiana land system occurs in the eastern part of the area and consists of schist and gneiss plains dissected to a depth of about 30 ft. It has mainly shallow texture-contrast soils with short grass–forb pastures under sparse low trees. There are minor areas of sandy red earths carrying spinifex. Unca land system is fairly flat sandy country developed over granite, schist, and gneiss, near the eastern margin of the area. Dinkum land system occurs in the eastern part of the area and consists of a hummocky sand plain over schist and gneiss, with red clayey sand or sandy red earth soils, mainly open or with sparse low trees over short grass–forb pastures.

Warburton land system occurs in the north-east of the area and consists of undulating plains on granite, schist, and gneiss, with red earth soils and a medium dense cover of low trees over either short grass–forb or woollybutt (*Eragrostis eriopoda*) pastures.

(vi) *Open Country with* Bassia *Spp. Pastures*.—1000 sq. miles—Chandlers land system. This occurs in the southern half of the area and the major element consists of texture-contrast soils which carry *Bassia* spp. pastures with occasional bushes of southern bluebush (*Kochia astrotricha*) and bladder saltbush (*Atriplex vesicaria*). It includes some inaccessible hills.

(vii) *Variable Sparse Low Vegetation*.—1200 sq. miles—Woolla and Titra land systems. Both land systems are restricted to the northern half of the area and consist mainly of limestone plains carrying sparse low trees or witchetty bush (*Acacia kempeana*) over the short grass–forb pastures. Spinifex sand plain is also a common constituent.

Woolla land system consists of a number of linear limestone plains and Titra comprises several areas of limestone plains adjacent to the salt lakes within the Burt plain.

(*d*) *Saltbush and Bluebush Country*

Most of this pasture land occurs in the southern half of the area on undulating to low hilly country on calcareous rocks, on stony tablelands, or on stony low hilly or undulating country dissected from the tablelands. Except for the tablelands, a variable density of small watercourses carry run-off out of the pasture land. Most of the country has texture-contrast soils which are impermeable and poorly drained and generally have stony surface pavements (Plate 11, Fig. 2). Areas of calcareous earths also occur. The country is mainly treeless and commonly carries bladder saltbush (*Atriplex vesicaria*) (Plate 10, Fig. 1) or southern bluebush (*Kochia astrotricha*) pastures. The cover of bladder saltbush and southern bluebush varies from sparse (Plate 11, Fig. 1) to medium dense. *Bassia* spp. and other forbs and short grasses occur in the interspaces in favourable seasons. In small areas of heavier soils, and particularly where gilgais are present, Mitchell grass (*Astrebla pectinata*) and neverfail (*Eragrostis xerophila*) pastures occur.

Southern bluebush pastures characterize three land systems. Lilla land system is comprised of terraces carrying southern bluebush with smaller areas of stony slopes carrying bladder saltbush. Ebenezer land system consists of undulating stony, calcareous plains, fairly uniformly carrying southern bluebush. Renners land system is mainly undulating shale and limestone country carrying sparse southern bluebush with smaller areas of stony rises carrying witchetty bush (*Acacia kempeana*).

The other five land systems of the pasture land are characterized by the bladder saltbush pastures. All but one of these, Kalamerta land system, are treeless. Kalamerta land system occurs near Kulgera homestead, and consists of an area of sandy plain, with a clay subsoil. It carries mainly bladder saltbush (*Atriplex vesicaria*) growing under mulga (*Acacia aneura*). Smaller areas of the woollybutt (*Eragrostis eriopoda*) and/or short grass–forb pastures also occur under mulga. The land system is flat and run-off is slight. Wilyunpa land system consists of the stony tablelands near the southern margin of the area. Peebles land system is undulating to low hilly country dissected from the stony tablelands and Endinda consists of plains on which dunes have encroached on small areas. Characteristically the soil surface of these three land systems has a heavy stone mantle and there is only a sparse cover of bladder saltbush. Near gilgais stands of bladder saltbush are denser and barley Mitchell grass (*Astrebla pectinata*) and neverfail (*Eragrostis xerophila*) also occur. Kulgera land system comprises a small area of very mixed country with the bladder saltbush pastures on texture-contrast and calcareous desert soils and with small areas of inaccessible low hills.

(*e*) *Mitchell Grass Country*

This pasture land consists of flat or gently sloping plains with mainly Mitchell grass (*Astrebla pectinata*) and neverfail (*Eragrostis xerophila*) pastures on impermeable, poorly drained, heavy clay soils. It is invariably treeless (Plate 9, Fig. 1).

Undippa land system occurs on fine-textured alluvium along the northern margin of the central mountain ranges from which it receives run-on. It contains small areas of northern bluebush (*Chenopodium auricomum*) pastures. Ambalindum land system occurs mainly in basins within the ranges and is more complex. It has a sparse pattern of shallow channels which carry run-off from the land system and the Mitchell grass pastures are mostly sparse. Smaller areas of the bladder saltbush, southern bluebush, cotton-bush (*Kochia aphylla*), and *Bassia* spp. pastures also occur.

(*f*) *Alternating Hills and Lowlands*

This pasture land comprises areas where mountainous or hilly country is closely interspersed with valleys, plains, or undulating country (Plate 12, Figs. 1 and 2; Plate 15, Fig. 2) generally carrying short grass–forb pastures with associated top-feed species.

The 19 land systems differ mainly in the geology of the hilly parts, which are fairly uniformly inaccessible to stock. Thus the differences between the land systems have little pastoral significance.

(*g*) *Mountains and Hills*

This pasture land consists of steep stony or rocky slopes (Plate 13, Fig. 1; Plate 14, Fig. 1) which are inaccessible to stock. The 10 land systems differ mainly in geology.

(*h*) *Salt Lakes*

This pasture land consists of bare salt lakes and some associated spinifex dune fields (Plate 13, Fig. 2).

IV. References

BURBIDGE, NANCY T. (1946).—Morphology and anatomy of the Western Australian species of *Triodia* R. Br. II. Internal anatomy of leaves. *Trans. Roy. Soc. S. Aust.* **70**: 221–34.

PERRY, R. A. (1960).—Pasture lands of the Northern Territory, Australia. C.S.I.R.O. Aust. Land Res. Ser. No. 5.

PART XII. PRESENT AND POTENTIAL LAND USE OF THE ALICE SPRINGS AREA

By R. A. Perry*

I. Introduction

(a) *General*

Parts I–XI have been concerned with the scientific classification and description of environmental features or land characteristics of the area. These are factual accounts based on field observations and interpretations from aerial photographs, and constitute a basic record which should remain unaltered for a long time. In this part an attempt is made to interpret these facts in the light of present experience in Australia and overseas, with the object of assessing the land-use potential of the area. It is inevitable that this interpretation of the best form of land use and its production potential will be modified as more information becomes available, and by changes in the economic situation and available markets in other parts of Australia and of the world.

(b) *Relation to Arid Zone of Australia*

The area is fairly centrally placed in the vast arid part of Australia which stretches from western New South Wales and south-western Queensland, across South Australia and the Northern Territory, to the western coastline of Western Australia. The northern half of the area, where winter rainfall is relatively unimportant and which mainly comprises spinifex sand plain with smaller areas of mulga country, is fairly typical of arid northern Australia, and in the southern half the areas of saltbush and bluebush country are typical of arid southern Australia. Most of the common land forms, soil types, and vegetation communities of arid Australia are represented within the Alice Springs area.

In common with other arid parts of Australia the genus *Eucalyptus*, generally regarded as a ubiquitous feature of Australian landscapes, is unimportant, and the commonest trees are *Acacia* spp.

(c) *Relation to Other Arid Parts of the World*

In comparison with most other arid areas of the world where total annual rainfall is similar, the rainfall of central Australia is less effective because of its marked summer incidence and high variability. The mean annual rainfall is not as low as in some other desert areas but is lower and more variable than in any other areas which support a population mainly dependent on natural rain-fed agriculture. No permanent rivers occur in the area.

Topographically, central Australia is a relatively flat area with no high mountain ranges to act as centres of high rainfall or of snow accumulation. It has a continental climate with high diurnal temperature range. At Alice Springs frosts may occur during

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a 102-day period but the northern part of the area is frost-free. No snow falls occur in any part of the area.

A feature of central Australia in comparison with deserts in other countries is the large areas of well-developed soils, some of which contain appreciable quantities of clay. However, most of the soils are infertile, some extremely so. Most other deserts are rocky or are covered with coarse deposits exhibiting little or no soil profile development. Deposits of salt, gypsum, or limestone are not extensive in central Australia.

Central Australia is covered by a well-adapted vegetation. Large areas carry useless spinifex (*Triodia* spp. and *Plectrachne* spp.) which will provide strong competition for more useful plants which may be introduced. In comparison with other vegetated deserts of the world spiny plants and succulents are uncommon.

II. Climate and Land Use

Rainfall varies from about 5 in. in the south-east to about 14 in. in the north of the area. Although the seasonal distribution shows a marked summer peak and a minor winter peak, the distribution is extremely erratic both annually (deviation from mean varies from about 25% in the north to 40% in the south) and seasonally. Slatyer has assessed in Part III the frequency of falls of rain significant in promoting growth in two critical amounts, viz. "initial effective rainfall" and "effective carryover rainfall". From his results (Tables 5 and 6) it seems that the country north of Alice Springs can expect more than two periods of initial effective rainfall during the summer months, and that in the same area the winter expectation falls from about 1·5 at Alice Springs to 0·5 at Tennant Creek. At Charlotte Waters the respective figures are 0·6 and 1·0. The higher annual expectation at Alice Springs than at either Charlotte Waters or Tennant Creek is probably due to the greater altitude.

The expected number of periods of effective carryover rainfall are less than those of initial effective rainfall. From Alice Springs northwards the annual expectation is roughly constant and slightly greater than 2·0 per year, the higher summer expectation at Tennant Creek being more than compensated for by the higher winter expectation at Alice Springs. At Charlotte Waters a period of effective carryover rainfall can be expected only about once every two years.

The fact that even in the higher-rainfall parts of the area only two growth periods of any length can be expected each year is an indication of the aridity of the area. Thus regular dry-land cropping is not possible and, as will be discussed later, increases in productivity of the pastoral industry appear more likely as a result of increased efficiency of utilization of the natural pastures than by the introduction of new plants.

III. Present Land Use

The earliest settlement was associated with the overland telegraph line, which was completed in 1872. A number of wells were developed during construction and repeater stations were established at Charlotte Waters, Alice Springs, and Barrow Creek.

The telegraph line and its associated wells and permanent habitation encouraged more active exploration, and it was not long before land was taken up for cattle- and sheep-grazing. Much of the land at present grazed was alienated in the three decades from 1880 to 1910, although the grazing industry did not prosper until the completion of the railway line to Adelaide in 1929. The decade beginning 1950 was a period of further expansion and many new properties were established, particularly to the east of Alice Springs, where settlement now extends to the Queensland border.

Sheep-grazing has been attempted on a number of properties but the total sheep population is now less than 30,000 and the industry is relatively unimportant. The main industry is, and is likely to remain, cattle-grazing on an extensive scale. Areas of individual properties range from about 300 to 5000 sq. miles, the average size being about 1000 sq. miles. The total area leased or licensed for grazing purposes is about 95,000 sq. miles, but of this about 53,000 sq. miles is regarded as useless.

Although the pastoral industry is by far the most important, others are worthy of mention. One of these is mining (Plate 19, Fig. 2), which plays an important part in the economy of the region. Another, the tourist industry (Plate 20, Fig. 1), has expanded considerably over the last few years, and if adequate facilities are provided it could become a very important source of income to the area. The main tourist attractions are the spectacular MacDonnell Ranges and the mild dry winter climate.

Agriculture is confined to a few small irrigated farms near Alice Springs producing mainly fruit and vegetables.

IV. Grazing Value of the Pasture Lands

Eight pasture lands were described in Part XI. Their distribution is shown on an accompanying map and their main characteristics in Table 21. Each has a characteristic pastoral value and developmental problems.

(a) *Spinifex Sand Plain, Dune Fields, and Plains*

This pasture land is generally considered as useless for grazing purposes, although small areas, particularly of the soft spinifex or feathertop spinifex pasture types, are lightly grazed or are held as drought reserves. Future development depends on the introduction and cheap establishment of better-quality plants and the development of management systems to utilize them safely. Even if species are found which can be established and maintained in competition with spinifex, the inherent infertility of the country will always limit stocking rates and productivity.

The combination of higher, more reliable rainfall and slightly heavier soils makes range seeding with species such as buffel grass (*Cenchrus ciliaris*) a more likely proposition on the soft spinifex country of Wonorah and Tennant Creek land systems than on the spinifex sand plains further south.

Large areas of similar country extend northwards into the Barkly and Ord–Victoria areas.

(*b*) *Short Grass–Forb Pastures on Young Alluvia*

In this pasture land the present stocking rate averages about 7 cattle per sq. mile, year-long, and ranges from less than 5 to about 20. Because of the occurrence of water-holes in the channels and the general availability of ground water at relatively shallow depths, many of these areas were among the first to be developed. Consequently much of the pasture land has a longer grazing history than adjacent country, and many areas have been heavily grazed, pastures have degenerated, and soils have been scalded. This is more noticeable in the southern, lower-rainfall half of the area.

Proper range management is essential to regeneration of the degraded areas and to the maintenance of productivity of other areas. The favoured habitats offer the best prospects for pasture improvement in the area and some of these lands appear to have prospects for artificial water-spreading.

(*c*) *Short Grass–Forb Pastures on Flat or Undulating Country*

This is the largest of the pasture lands at present utilized for grazing, and includes the mulga, gidgee, and witchetty bush country. The average year-long stocking rate is about 7 cattle per sq. mile and the range is about 5 to 10. In general this pasture land contains a much smaller proportion of favoured habitats that receive additional water by run-on than the previous pasture land, and thus the opportunity for pasture improvement and/or water-spreading is less. Correct range management to maintain the native pastures is thus even more important in this pasture land.

Pasture degradation and soil erosion are not marked in this pasture land. In some areas the lower parts of the top-feed species have been completely grazed off and thus, although top-feed species are present, they do not provide any forage. The feasibility of utilizing this inaccessible forage during drought periods by lopping, bulldozing, or chaining and the subsequent regeneration of top-feed species should be investigated.

A considerable proportion of this pasture land does not have adequately-spaced watering points and further development in this field could lead to considerably increased production.

The mulga country is mostly developed for grazing. It is regarded as good cattle country. Shallow depressions in Boen land system that receive run-on carry tall dense stands of inaccessible mulga. There appears to be scope for clearing and pasture improvement in these sites.

The mulga country mixed with spinifex sand plain has been developed for grazing where the areas of mulga country are sufficiently large and ground water is available.

Gidgee country is light-carrying country and is mostly developed. Gidgee (*Acacia georginae*) is under some conditions a poisonous plant in the areas immediately to the east of the Alice Springs area but it is responsible for few or no cattle deaths in the survey area, and is a useful top feed.

Witchetty bush country occurs under lower rainfall (6–8 in.) than mulga and gidgee. It is grazed at low stocking rates. Increases in productivity can be expected only by improved management practices.

Sparse low tree country is considered to be above average, possibly because the more fertile residual soils produce more nutritious pastures. In many parts groundwater supplies are difficult to locate. Many sites are suitable for catchment tanks but the soils are generally too permeable for efficient storage. The development of relatively cheap and effective methods of sealing earth tanks would allow most of this country to be developed.

The open country with *Bassia* spp. pastures has mostly been developed for grazing. It provides reasonable grazing at low stocking rates for short periods after rains but in long dry periods it provides very little grazing as it has only sparse blue bush and saltbush and no perennial grasses or top feed. Pasture degeneration has occurred in heavily grazed parts.

The variable sparse low vegetation country is mostly stocked at low rates. Its short grass–forb pastures are supported by a range of sparsely distributed top-feed species. Some areas appear to offer scope for pasture improvement and/or water-spreading but mostly it will remain as low stocking country.

(*d*) *Saltbush and Bluebush Country*

Most of this pasture land has been developed for grazing at a year-long stocking rate of 5 or less cattle per sq. mile, and in favourable seasons "fats" are produced. In some areas the pastures have degenerated because of heavy grazing.

Ground water of suitable quality is difficult to locate in some parts, but the country is generally suitable for surface catchment tanks, many of which have been constructed.

(*e*) *Mitchell Grass Country*

This has an average year-long stocking rate of 10 to 20 cattle per sq. mile in better years. During long dry periods the carrying capacity of the Mitchell grass is very low and the small areas of associated bluebush and saltbush pastures have mostly deteriorated under the heavy grazing during these periods.

(*f*) *Alternating Hills and Lowlands*

Generally the hilly parts of this country are inaccessible to stock and therefore useless for grazing, but the intervening lowlands are mainly similar to short grass–forb pastures on flat to undulating country or short grass–forb pastures on young alluvia. In many areas water runs from the hills onto the adjacent lowlands creating a natural water-spreading effect and possibilities exist for artificial water-spreading. Where individual areas of lowland are large enough to warrant the construction of stock waters, they have mostly been developed. The overall stocking rate is about 5 cattle per sq. mile, year-long.

(*g*) *Mountains and Hills*

The steep stony or rocky slopes which comprise this pasture land are inaccessible to stock and therefore the country is useless for grazing. The mountains are important run-off areas and provide most of the flood waters which run off to the flood-plains.

(*h*) *Salt Lakes*

This country is useless for grazing.

V. Regional Carrying Capacity

For general purposes the above description of the pastoral value of the pasture lands can be simplified. Three of the pasture lands (spinifex sand plains, dune fields, and plains; mountains and hills; and salt lakes), comprising 99,000 sq. miles, are useless or almost so. The other five pasture lands are useful: 21,900 sq. miles of short grass–forb pastures on flat to undulating country, stocking rate about 7; 6300 sq. miles of short grass–forb pastures on young alluvia, stocking rate about 7; 13,500 sq. miles of alternating hills and lowlands (also with short grass–forb pastures), stocking rate about 5; 3300 sq. miles of saltbush and bluebush country, stocking rate about 5; and 300 sq. miles of Mitchell grass country, stocking rate 10–20. Because of the very small area of Mitchell grass its higher stocking rate has little effect on the average of the useful country. Therefore the area can be considered as consisting of 99,000 sq. miles of useless country and 45,300 sq. miles of useful country with a year-long stocking rate of about 7 cattle per sq. mile.

The classification into useless and usable country is in agreement with current land use in that 92% of the country regarded as usable is within pastoral leases. The other 8% consists of a large number of small areas scattered throughout the vacant crown-land. In order to circumscribe the usable country large areas of useless country are also included in the properties. Actually useless country accounts for 56% of the leased country although the area involved is only 54% of the total area of useless country.

VI. Relation of Stock Waters* to Potential

Although surface waters are common in the area, most of them are non-permanent, and some of the permanent ones are situated in poor pastoral country. Stock are therefore mostly dependent on man-made watering points. These watering points comprise bores and wells, which tap supplies of ground water, and dams and tanks which catch and store surface run-off.

By utilizing surface catchments where underground supplies are not available and *vice versa* it is possible to construct man-made watering points in most parts of the area. However, the individual cost varies tremendously from place to place with depth of aquifers and with suitability of terrain and rainfall for surface reservoirs. Pastoralists have to balance the initial cost and maintenance of each watering point against the returns in cattle from it. In many parts of the three useless pasture lands it is physically possible to provide stock waters but it is obviously uneconomic to do so. On the other hand it is safe to assume that stock water can be provided over most of the area of the five useful pasture lands, although it is more difficult in some parts than in others.

An attempt was made to locate on the pasture lands map all the stock watering points in the area. In all, 907 man-made waters (which include bores, wells, dams, and tanks) have been located. These are regarded as permanent waters. In addition 139

* The term "waters" is commonly used in Australia to mean a place where stock can obtain drinking-water. "Waters" can be natural or artificial and include water-holes in rivers, soaks, springs, bores, wells, tanks, and dams.

natural waters, including water-holes and springs, have been plotted. Unfortunately little is known of the duration of each; some last only a month or so after rain and some are permanent. All available sources were used in locating the watering points and it is thought that more than 90% are plotted. The association of the stock waters, especially the man-made ones, with the five useful pasture lands is obvious from even a cursory examination of the map.

In order to determine the area of country accessible from the present watering points the effective grazing distance of stock must be known. In the absence of accurate information determinations were made for two assumed grazing distances:

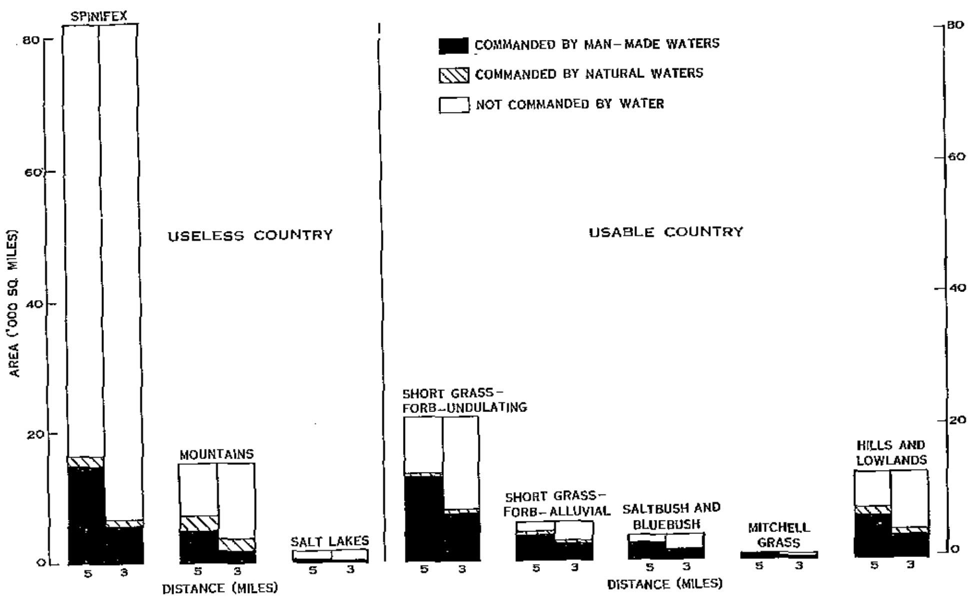


Fig. 15.—Proportion of areas of the pasture lands watered by man-made waters, by natural waters, and not watered, assuming effective grazing distances of 5 and 3 miles.

5 miles, because this is commonly considered by pastoralists as the distance cattle will walk for fodder, and 3 miles, because from limited general observations pastures show little grazing effect beyond this distance.

On the pasture lands map, circles of radii 5 and 3 miles were drawn around each watering point. The areas of each pasture land commanded by man-made waters and natural waters and not commanded by waters were then determined.

In Figure 15 the areas of each pasture land commanded by man-made waters, natural waters, and not commanded by waters are shown for grazing distances of 5 and 3 miles. From the figure it is clear that, on the 5-mile basis, the area of spinifex pasture land (regarded as useless) commanded by water is greater than that of any other pasture land. The reason for this is that many waters sited in and commanding usable country also have large areas of spinifex country within a 5-mile radius, though on the 3-mile basis more short grass–forb country is commanded by water than spinifex country. However, the proportions of spinifex and other useless

TABLE 22

PROPORTIONS OF PASTURE LANDS COMMANDED BY WATER

Pasture Land	Proportion Commanded by Water (%)	
	5-Mile Basis	3-Mile Basis
Spinifex sand plains, dune fields, and plains	20	9
Mountains and hills	47	21
Salt lakes	31	14
Short grass–forb pastures on young alluvia	79	53
Short grass–forb pastures on flat to undulating country	63	34
Saltbush and bluebush country	74	43
Mitchell grass country	97	78
Alternating hills and lowlands	56	32

pasture lands commanded by water are small compared with usable country commanded (Table 22).

Assuming that it is possible to provide waters over all parts of the usable country (and this is mostly true), the area beyond effective grazing distance from present watering points represents the undeveloped potential. This is represented diagrammatically in Figure 15 by the blank part of the histograms for the usable pasture lands. In Table 23 the areas of usable country within and beyond 5 and 3 miles of watering points are presented.

The figures in Table 23 indicate the present degree of development and the future potential. Considering that the grazing industry has been operating for less than 100 years the development of about two-thirds of the usable area, on the 5-mile basis, is a commendable achievement. Theoretically, the provision of watering points to command the usable country at present beyond effective grazing distance would enable the present cattle population of approximately 300,000 to be raised to about 450,000 on the 5-mile basis, or to about 800,000 on the 3-mile basis.

TABLE 23

AREAS OF USABLE COUNTRY WITHIN AND BEYOND 5 AND 3 MILES OF WATERING POINTS

	Assumed Grazing Distance	
	5 Miles	3 Miles
Area within grazing distance of man-made waters (sq. miles)	27,000	15,600
Area within grazing distance of natural water (sq. miles)	2100	1300
Area beyond grazing distance of water (sq. miles)	16,300	28,500
Total usable country (sq. miles)	45,400	45,400
Proportion beyond grazing distance (%)	36	63

VII. Pasture and Stock Management

At present the grazing industry is conducted on an extensive scale (Plate 16, Fig. 1), and although the standard of stock management and husbandry is relatively better than in other parts of the Northern Territory, little or no conscious pasture management has been attempted. Stock movements within properties are generally the result of short-term extreme factors such as failure of water supplies, severe over-utilization of pasturage, or seasonal occurrence of poisonous plants, rather than of any long-term effort to improve the overall stability and productivity of the property.

Compared with other districts of the Northern Territory, properties are somewhat smaller, with a higher proportion of resident owner-managers who are personally interested in the welfare and improvement of properties and who are mostly progressive (Perry 1960*). The absence of any conscious attempt to implement improved pasture management practices stems not so much from lack of desire or enthusiasm on their part as from a lack of any accurately based information.

All the better pastures are protected from fires but spinifex is burnt. The young growth of spinifex and the associated plants which follow fires are softer and more palatable and have a low carrying capacity.

At the present stage of development, control of stock movements is mainly through the distribution of watering points. On the assumption that cattle can graze to a distance of 5 miles from watering points, these are generally placed at about 10-mile intervals, which is largely effective in discouraging movement of stock from one to another. Most of the properties have part, at least, of their boundaries fenced, but there are few subdividing fences.

As already mentioned, the few general observations made during the survey of pasture utilization by large concentrations of stock centred on watering points suggest that although some animals do graze to a distance of 5 miles, the main grazing effects on pastures are confined to a distance of about 3 miles. On the 5-mile basis there is a tendency for three zones to develop:

(1) An inner zone of complete or over-utilization (or destruction by trampling) of pasturage, which can be regarded as a sacrifice area and which normally extends from about $\frac{1}{4}$ to $\frac{1}{2}$ mile from the watering point (Plate 16, Fig. 1).

(2) A surrounding zone extending from about $\frac{1}{2}$ to 3 miles from the watering point, in which pasture utilization varies from high to low with increasing distance.

(3) An outer zone extending from 3 to 5 miles, within which pastures are under-utilized.

The sacrifice area normally occupies about 1%, the zone of utilization about 35%, and the under-utilized zone the remaining 64% of the total area. Thus the effect of large concentrations of stock on widely-spaced watering points is an extremely uneven grazing pattern. One objective in the development of improved management practices is to secure more even pasture utilization.

*Perry, R. A. (1960).—The pasture lands of the Northern Territory, Australia. C.S.I.R.O. Aust. Land Res. Ser. No. 5.

The general solution is to intensify the pattern of watering points without over-increasing the stocking rate. In doing this it is not essential or necessarily economic for all of them to have year-long capacity, and in fact a form of compulsory pasture management may result if a proportion are short-term waters. The most economical system is likely to be one in which some watering points last only a few months after rain, some last perhaps 6 months, some 12 months, and some are permanent. Most bores are permanent supplies and the short-term waters would most probably be small surface catchment tanks.

An increase in the density of watering points may cause a breakdown of the present system of stock control, which relies to a large extent on distance between adjacent waters. This may necessitate the construction of subdividing fences which, although expensive, will have the additional advantage of permitting closer control of stock and the implementation of better stock and pasture management practices. It is the most likely way of increasing production from the area.

In addition to the uneven pasture utilization around watering points, production of fodder varies greatly with season and to a lesser extent with habitat. Knowledge of the effect of grazing various pasture types under various seasonal conditions, or of any critical periods during which certain pasture types should not be grazed, is slight at present. In the absence of such information better pasture management practices (e.g. deferred grazing) cannot be intelligently formulated. However, it is clear even with the present state of our knowledge that it is necessary to maintain adequate drought reserves of some kind or another, whether these be provided by reserving some parts of the property or by growing or buying some kind of fodder.

The present average branding percentage (i.e. number of calves reared to 3 to 6 months of age expressed as percentage to number of potential breeders) is about 60. Most pastoralists agree that a higher percentage of calves is dropped and that mortality from birth to branding is high. This is blamed on two main factors, dingo attacks and the low survival rate of calves dropped during long dry periods when mothers are weak and have little or no milk. It is also suspected that some deaths, of both mothers and calves, are due to heifers calving too young. Calving too young leads also to early sterility and affects quality of mothers and calves especially when subject to evolutionary selection.

Improved stock husbandry could include supplementary feeding, controlled mating, controlled weaning, and segregation of bulls, cows, heifers, steers, bullocks, and spayed cows. These practices should result in a higher branding percentage, lower breeder mortality and therefore lower heifer replacement, higher turn-off numbers, and heavier turn-off weights.

VIII. Range Condition and Trend

The basic concept behind any soundly-based form of pasture utilization is to maintain the plant–animal system in the state of equilibrium which gives the maximum live-stock production consistent with the maintenance of land resources. The key to the attainment of this lies in sound management practices based on a thorough knowledge of the native vegetation and its normal seasonal changes, the grazing animals and their grazing and breeding habits, and the influence of one on the other.

In the Alice Springs area pasture degeneration caused by heavy grazing and trampling is obvious in the "sacrifice areas" near watering points. Large bare areas also occur further from watering points and beyond the range of grazing animals, particularly during long drought periods, and considerable areas of dead shrubs and trees occur in the southern half. Surface erosion and scalding of soils are associated with these in part. However, it is difficult to assess how much of this bareness is normal and how much is induced by grazing. It is a well-known feature of the region that vast areas of bare country become covered with grasses and wildflowers in good seasons. Therefore, before assessment of the effect of grazing on the pastures can be made, the effects of environmental fluctuations must be known. It is important to learn the degenerative and regenerative sequences for each pasture type, to be able to recognize the stage which it has reached, and to determine the direction of change, i.e. whether the pasture is degenerating or improving. It is also important to know what treatments must be applied to induce regeneration. The ecological approach to range management has received little attention in Australia and none in northern Australia.

Range condition and trend studies are the ecological bases used to assess the results of bad management and to formulate better management practices. They aim to detect pasture degeneration (Plate 16, Fig. 2; Plate 17, Fig. 1) before permanent damage is done. This is particularly important in an area where returns per acre from healthy pastures are so low that costs of restoring damaged pastures to this level of productivity are probably uneconomic.

From the limited observations possible during the survey the situation of the pastoral industry in central Australia can be summarized as follows:

(1) As already stressed, large areas of the usable country are under-utilized because they are too distant from water.

(2) Insufficient knowledge of pasture deterioration is available to indicate how much country is affected, how seriously areas are affected, in which direction is the present trend, and if downward, how this can be reversed. On the whole, the pastures are in good condition compared with areas with similar rainfall in Africa and Asia subject to much more intensive use and misuse.

(3) Legislation to control stocking exists but no methods have been formulated for determining the correct rates of stocking consistent with maximum returns and the maintenance of productivity.

IX. Pasture Improvement

(a) *Pasture Reseeding*

The term "pasture improvement" is generally accepted as involving top-dressing, seeding, and possibly cultivation. In these terms no pasture improvement has been practised in central Australia. It is unlikely that in intensive form it will be economic in the future.

The same factors of the environment which cause uneven seasonal production from native species will also affect introduced species. Since the main factor limiting stock numbers is the availability of fodder during long dry periods, it is of little use to increase the amount of fodder produced during periods of present over-production unless part of this can be conserved to increase the amount of fodder available during periods of shortage. Hence pasture improvement to be effective has to be associated with management aiming to conserve fodder for drought periods.

The various types of native pastures and the dependence of the pastoral industry on them have already been described. Broadly they fall into two main classes:

(1) Those which produce variable but mostly good-quality forage for short periods after effective rains but provide only a sustenance ration of mature pasturage for the long periods between falls. The good-quality forage consists mainly of short grasses and forbs, which either are characteristic of the ground vegetation or grow in the spaces between perennial grasses. These pastures are commonly associated with trees or shrubs, most of which are palatable and provide top feed.

(2) Those which produce only poor-quality forage. These comprise the various spinifex pastures which are considered to be useless or to have a very low carrying capacity of a limited value as drought reserves.

The former occupy 43,000 sq. miles, the latter are more extensive and in addition to about 80,000 sq. miles in the surveyed area there are large tracts to the east, north, and west.

From the point of view of pasture improvement the two classes will require different treatment. The primary need of the first group, with its irregular short periods of over-production, is improved stability of production, which may be attained without the addition or substitution of exotic species obviously necessary for the development of the second group.

Economically the costs of treatment must be commensurate with returns and the money spent per unit area on pasture improvement must be guided by the expected increased return per unit area. At present, returns without any pasture improvement range from slightly more than one shilling to nil per acre and therefore pasture improvement would have to be responsible for spectacular increases to be worth while. The costs of pasture improvement will be higher in central Australia than in more favoured parts of the continent but the expected yield, which is largely conditioned by environmental factors beyond control, will be very much lower. On most sites it is unlikely that the increased yield would repay a fraction of the costs involved, particularly as the soils are poor and heavy fertilizer dressings would be required. In addition, seed would have to be sown into dry soil to take advantage of the very few days after rain that the surface soil remains moist, and because of the erratic nature of effective falls, there would be a high risk of complete failure.

Thus it is unlikely that pasture improvement in central Australia can be of a form similar to pasture improvement as it is understood in more favourable parts of Australia. The primary requirements must incorporate a low cost per unit area. Any introduced pasture species must be adapted to poor soils, low and erratic rainfall, high evaporation, and severe temperature extremes. It must be easily established and better than native species as far as forage yield, palatability, and digestibility are concerned. In addition, it must produce quantities of easily harvested seed and compete advantageously with native species. Unless such a species has the capacity for spreading naturally from established nuclei it is unlikely to be a practical addition to or replacement of the native species. The incorporation of any such species into the native vegetation will be a slow process. The combination of characters required imposes stringent restrictions. The most logical possibilities are perennial drought-evading grasses and legumes for the short grass–forb pasture types and perennial drought-resisting shrubs for the spinifex types. So far the few species which have been tested have been unsuccessful.

A species which has received a great deal of publicity in northern Australia and has been hopefully looked to by central Australian pastoralists is buffel grass (*Cenchrus ciliaris*). Many strains of this species exist but so far in both Queensland and Western Australia none of them has been successful below a mean annual rainfall (summer-incident) of 15 in., and the optimum requirements seem to be greater than 20 in. Trials in Queensland have shown that a high soil phosphate status is necessary for establishment. On both these criteria it is an unsuitable species for central Australia except under specially favourable conditions. This has been substantiated by Winkworth (personal communication), who has obtained negative results in experiments designed to establish buffel grass in both spinifex and mulga communities. In both cases a range of clearing, cultivation, and fertilizer treatments was used (although there is some doubt as to whether the fertilizer reached the seed) and falls of effective rain were received soon after seeding. Winkworth has had a slight establishment in depression areas (receiving run-on) within the mulga country and has established a good stand along furrows situated 1 chain apart on bare scalded country (Plate 17, Fig. 2). Successes under such favourable conditions confirm that its use in central Australia is limited. Additional confirmation can be derived from observations of a number of small areas where buffel grass is more or less naturalized but from which it is not spreading. Without exception these areas are near watering points or homesteads from which native species have been removed by trampling and excessive grazing. Such areas are favourable in that competition from native species is negligible, the trampling is in effect similar to cultivation, and heavy accumulations of dung have probably raised the fertility status of the soil.

(*b*) *Clearing the Trees*

Most of the low tree species, including mulga (*Acacia aneura*), ironwood (*A. estrophiolata*), gidgee (*A. georginae*), whitewood (*Atalaya hemiglauca*), and supplejack (*Ventilago viminalis*), are drought-resisting species which are palatable to stock and are generally credited with providing a sustenance ration during long drought periods. However, once the lower branches which cattle can reach are grazed, new growth mainly occurs above this and is inaccessible to stock. These and other non-forage trees utilize water at the expense of the lower vegetation layers and are responsible for reduced yields from these layers. The effect of partial and complete clearing of trees particularly in areas where they are dense should be investigated. The results of such investigations need to be assessed as a compromise between the provision of drought fodder, shade, and possibly erosion control on one hand, against higher yields of pasture from lower layers and possibly an increased density of perennial grasses such as woollybutt (*Eragrostis eriopoda*) on the other.

(*c*) *Water-spreading*

A number of small areas adjacent to hills or on the flood-plains of rivers receive run-on and therefore have a more favourable moisture status. They are characterized by floristically different pastures, higher yields, or longer growing seasons. The application of simple or complex water-spreading systems may increase the number of such areas.

In these areas it may be possible to introduce pasture plants normally considered as suitable only for areas with somewhat higher rainfall. Thus although the rainfall at Alice Springs is too low for buffel grass (*Cenchrus ciliaris*) to be successfully grown over large areas, it may be useful in these small favoured areas. Special attention should be given to management of these areas.

TABLE 24

EXPECTED NUMBER OF WET PERIODS ON WHICH RAINFALL OCCURS IN EXCESS OF 1 IN. AND 2 IN.

	Oct.–Mar.	Apr.–Sept.	Annual
Falls > 1 in.			
Tennant Creek	3·1	0·5	3·6
Alice Springs	2·5	0·8	3·3
Charlotte Waters	1·0	0·2	1·2
Falls > 2 in.			
Tennant Creek	1·6	—	1·6
Alice Springs	1·3	0·2	1·5
Charlotte Waters	0·3	—	0·3

Favoured areas must have two main essentials. The first is that run-off water must be produced upstream. This means that the catchment area must have a combination of topography, geology, soil, climate, and vegetation to give at least a few sudden flows each year large enough to be useful but not too large to be handled. The second essential is that suitable plains must occur on the lower watershed. In particular the soils must be suitable. In central Australia the most doubtful condition is the frequency of run-off flows of sufficient size. Very little information is available on which estimates can be based. The best available is that used in Part III to provide an estimate of frequency of falls of rain adequate to replenish station dams and tanks. It assumes that wet periods in which more than 1·0 in. of rain falls would provide some run-off, and that periods in which 2·0 in. or more falls would provide significant run-off. The relevant figures for Tennant Creek, Alice Springs, and Charlotte Waters are given in Table 24. This indicates that in the northern half of the area falls providing appreciable run-off are likely to occur only three times every two years and almost exclusively in the summer months. These figures are not encouraging, and those for the southern half of the area are less so.

X. Agriculture

Because of the low and erratic rainfall, irrigation is necessary for agriculture. From the topographic and soil aspects large areas of central Australia are suitable, but areas with a suitable supply of water are limited. The amount of suitable water will be the main factor in determining the future of agriculture in central Australia. This has been discussed in more detail in Part VII.

(a) *Water Supply*

Because of the low rainfall and high evaporation the capital cost of surface storage per effective acre-foot is high and the development of large storage reservoirs which could provide water sufficiently cheaply for irrigation is impractical. Therefore any agricultural development will be almost entirely dependent on ground water.

In Table 11 in Part VI are quoted tentative estimates of the amounts of suitable water available in various basins. The estimated annual recharge is 70,000 ac. ft.

Table 25

Net evapotranspiration estimates (in.) at Alice Springs and Tennant Creek

	Alice Springs	Tennant Creek
Annual	85	105·5
October–March	56	59
April–September	29	46·5

for six catchments and storage is adequate. These estimates do not include the small supplies present on almost all properties and suitable for irrigating only a few acres.

Slatyer in Part III gives estimates of net evapotranspiration at various centres. The relevant data for Alice Springs and Tennant Creek are given in Table 25.

Conveyance and application losses must be added to the net irrigation requirements to estimate the gross requirements of water. If these losses can be kept to a minimum, with irrigation areas in the immediate vicinity of wells, an allowance of one-third of the net requirements should be adequate.

The preliminary estimates of the gross irrigation requirements based on the above considerations and data in Table 25 are:

For a perennial crop	10 to 12 ac. ft.
For a summer annual crop (such as cotton)	5 to 6 ac. ft.
For a winter crop	3 to 4 ac. ft.

The estimated annual recharge of 70,000 ac. ft. should be adequate for 6000 to 7000 ac of perennial crops, 11,000 to 14,000 ac of summer crops such as cotton, or a smaller area of summer and winter crops.

This does not take into account the recharge of aquifers in the catchments mentioned in Table 12, or the possibility of using more saline waters. It also assumes that the storage will not be drawn upon. In practice the potentially irrigable area may be much greater than the figures mentioned above.

The existence of water sufficient to irrigate areas of this size would justify the further research needed to permit the establishment of an irrigated agriculture.

(b) *Soils and Topography*

The soils over the aquifers are predominantly coarse-textured and very permeable. However, since only a small proportion of the potentially irrigable area could in fact be irrigated with the water available, in the majority of cases it should be possible to find somewhat heavier and less permeable soils, e.g. red earths with medium-textured topsoils, that would be suitable for flood or furrow irrigation. Coarse-textured soils are less liable to progressive salinization and would be particularly suitable in areas where more saline water has to be used. However, they have a restricted available moisture range (4% in sandy spinifex soils and 7% in red earth mulga soils) and would require very frequent watering and special irrigation techniques such as sprinkling or perforated pipe delivery.

The salt content of the potentially irrigable soils is low and their reaction is not far from neutral. Thus these two factors would not be important in determining the choice of crops where good-quality water is available.

The fertility status of sandy soils and red earths is low and the application of fertilizers would be necessary, although in some areas nitrogen would be supplied naturally in irrigation water. More recent undifferentiated alluvial soils found in most aquifer areas have an above-average phosphate content and a reserve of unweathered minerals.

The topography of the potentially irrigable areas should not present major irrigation difficulties.

(c) *Crops**

Because no areas in Australia with a similar climate have an established agriculture, local experience on which the selection of suitable crops could be based is completely lacking. However, the south-western part of the United States and parts of North Africa are sufficiently similar for experience in those areas to form a useful guide.

Economic factors must also be considered. The area is isolated, being approximately 1000 miles from the nearest large centre of population (Adelaide) and from the nearest seaport. Rail freights per ton per mile to Adelaide are comparatively cheap, but because of the great distance involved total freight costs are high and would be an important consideration in selection of crops. Only crops which have a local market or a high value per unit of weight and bulk could be economically grown.

(i) *Fodder Crops*.—It is difficult to assess the future requirements of the local pastoral industry for fodder crops, and in the absence of such information, it is impossible to assess the economics of large-scale production within the area. Present demands are mostly for supplementary feeding of horses and stud cattle. Supplementary feeding of breeders is not practised and at the present rate of improvement of the industry it is unlikely to be introduced in the near future.

* Much of the information in this section has been contributed by J. J. Basinski (personal communication).

The demand for fodder crops at present and in the foreseeable future could be satisfied by production of small areas on each property. The small quantities of water required are available in most cases. Whether such a practice would compare economically with more centralized, larger-scale production of fodder on a cash crop basis is at present unknown, but needs to be considered before recommending large-scale production. Fodder produced with irrigation by local farmers would also have to compete with fodder grown relatively cheaply under natural rainfall either north or south of the area and freighted to properties.

(1) *Lucerne*.—Many small areas of lucerne have been successfully grown in the area (Plate 18, Fig. 2) and it is well adapted to the local environment. Yields are of the order of 8–10 tons/ac/yr. In some of the areas it has been heavily infested with witches' broom and on sandy soils it is likely to be attacked by nematodes. The area may be well suited for the production of lucerne seed for export to southern Australia.

(2) *Other Leguminous Fodders*.—There are many other legumes which deserve consideration. They include *Dolichos lablab*, a summer crop, which in northern Sudan yields up to 10 tons of hay from 2 or 3 cuts within 5 months of planting, and *Trifolium alexandrinum*, a winter crop with remarkably rapid growth.

(3) *Cereals*.—Some of the underground waters are rich in nitrate (as high as the equivalent of 4 cwt of ammonium sulphate/ac. ft.). With these waters particularly it may be more economic to grow cereal crops rather than legumes. Barley and oats are probably suitable for winter growth and sorghum, maize, and bulrush millet should be investigated for summer growth.

(ii) *Cash Crops*.—The local demand for cash crops is low and will remain so. Local producers of fruit and vegetables may be able to compete with southern and eastern producers for northern markets (mainly Darwin and Mt. Isa) but even including these the total population is less than 30,000. Cash crops therefore would have to be exported to southern markets and because of the high freight cost they would have to have a high value per unit of weight or bulk. The cash crops worth considering fall into several categories:

(1) Those specially suited for growing under irrigation in an arid environment, e.g. cotton and date palms.
(2) Those which produce valuable primary commodities for export and by-products for which there is a local market, e.g. oil crops.
(3) Truck crops (fruit and vegetables) which could be produced out of season in the area and command high prices on southern markets, e.g. tomatoes.
(4) Special crops which, because they are produced in the arid environment, have special advantages over similar crops produced in wetter areas, e.g. weed-free or disease-free seeds of southern crops such as lucerne.

Several are worth considering in more detail.

(1) *Cotton*.—Experience of cotton-growing under irrigation in Australia is slight, and is completely lacking for central Australia. However, general experience in other countries indicates that cotton should be well suited to the environment, and that the more valuable long-staple varieties could be grown.

Cotton produces two valuable primary commodities (lint and oil) which could be exported from the area, and a by-product (protein concentrate) which would have a local market in the pastoral industry. In addition almost all of Australia's cotton requirements are imported and production in central Australia would have an import-saving value. The establishment of cotton-growing in the area could at least double the domestic cotton output of Australia.

(2) *Date Palms*.—Little experience exists of commercial date-growing in Australia, but from observations of isolated trees and of one small orchard at Alice Springs date palms would be well suited to the environment. One thousand acres bearing 3·5 tons/ac would replace present Australian imports, and an additional 600 ac would supply New Zealand. At present import prices the total value would be about £350,000.

Date palms are noted for their salt tolerance and could be grown on waters unsuitable for other crops.

(3) *Oil Crops*.—The area should be suitable environmentally for growing a number of oil crops. The oil produced by these crops has a comparatively high value and could be exported to southern markets. In addition high-quality protein concentrates are produced as a by-product and these should find a local market in the pastoral industry.

Oil crops worth investigating are linseed, safflower, sesame, castor, soya bean, and peanuts.

(4) *Truck Crops*.—It is likely that the area could produce a variety of fruit and vegetables for southern markets during periods when these commodities are out of season in southern Australia. Crops such as tomatoes, capsicums, cucumbers, melons, lettuce, asparagus, eggplants, citrus (particularly grapefruit), strawberries, etc. are worth investigating.

It is unlikely that the demand for crops such as these would be large enough for them to form the basis of irrigated agriculture in the area. However, they would be valuable side lines in an agricultural industry based on growing a crop such as cotton.

(5) *Special Crops*.—In the United States seed supplies of many crops normally grown in more favourable areas are produced in arid areas under irrigation. This can ensure weed-free or disease-free seeds. For example, in Arizona most irrigated lucerne is cut 6–7 times per year and, in addition, one seed crop is produced.

XI. Present and Potential Productivity of the Pastoral Industry

Cattle-grazing is the most important industry of the Northern Territory and accounts for 48% of the total value of exports (Table 26). The Alice Springs pastoral district carries about one-quarter of the total cattle population of the Territory but, because of greater efficiency and better markets, is responsible for 54% of the value of cattle exports and 26% of total export revenue (Table 27). The greater efficiency of the industry in the Alice Springs area compared with other parts of the Northern Territory is due to a number of factors:

(1) More stable markets with higher prices. Central Australian cattle are sold on the Adelaide market for domestic use, while cattle from other areas in the Northern Territory are mostly sold on Queensland markets for the export trade.

(2) More accessible and better marketing facilities. The railhead at Alice Springs is within 300 miles of the most distant properties. In other districts the distances are much greater.

(3) A higher proportion of resident owners on relatively small properties. The greater personal interest of resident owners generally results in a better standard of property management.

(4) Freedom from ticks and pleuro-pneumonia.

TABLE 26

VALUE OF EXPORTS FROM NORTHERN TERRITORY

(Average of 3 years, 1953–56)

Industry	Northern Territory (£'000)	Alice Springs (£'000)
Cattle	2527	1373
Mining (excluding uranium)	2111	379
Pearling	622	—
Total	5260	1752

TABLE 27

CATTLE INDUSTRY, NORTHERN TERRITORY

(Average of 3 years, 1953–56)

District	Total Population ('000)	Turn-off ('000)	Turn-off (%)	Value (£'000)	Percentage of Total Cattle Value	Percentage of Total N.T. Exports
Alice Springs	273	52	19	1373	54	26
Others	735	52	7	1154	46	22
Total N.T.	1008	104	10	2527	100	48

The estimated average cattle population of the Alice Springs pastoral district during the three years 1953–56 was 273,000. The area held under grazing lease or licence was 95,000 sq. miles, of which 42,000 sq. miles was usable. Therefore the average stocking rate of the leased country was 2·9 cattle per sq. mile and of usable leased country 6·5 cattle per sq. mile (Table 28). However, if it is considered that the cattle only effectively graze on the usable country within 3 miles of water (i.e. 17,000 sq. miles), the stocking rate was about 16 cattle per sq. mile. A striking feature of the industry is that although the gross return per acre of leasehold country ($5\frac{1}{2}$d.) is low, the gross return per person is high.

Notwithstanding the greater efficiency and stability of the cattle industry in the Alice Springs district over and above other districts of the Northern Territory, increases in productivity are feasible. The most obvious development would be an intensification of the industry over the 42,000 sq. miles of usable country, and of primary importance in this respect would be the provision of additional watering

TABLE 28

STOCKING RATES, TURN-OFF, AND GROSS RETURN PER UNIT AREA ON VARIOUS BASES AND PER UNIT POPULATION FOR 3 YEARS 1953–56

(Totals: cattle population 273,000, turn-off 52,000, gross return £1,373,000)

Basis	Stocking Rate		Turn-off		Gross Return	
	Cattle per Sq. Mile	Cattle per Acre	Cattle per Sq. Mile	Cattle per Acre	per Sq. Mile	per Acre
Total area 144,000 sq. miles					£9·10·0	
Leased area 95,000 sq. miles	2·9	0·005	0·55	0·001	£14· 9·0	$5\frac{1}{2}$d.
Usable country 42,000 sq. miles	6·5	0·01	1·2	0·002	£32·14·0	1s.
Usable country within 3 miles of water 17,000 sq. miles	16	0·025	3·1	0·005	£80·15·0	2s.6d.
White population approx. 300	900 per person		170 per person		£4600 per person	

points to bring all usable country within effective grazing distance of water. From Table 21 it is clear that, assuming the effective grazing range of cattle to be 5 miles, 64% of the usable area is developed and 36% requires development. On this basis the potential increase in the number of cattle is approximately 150,000, amounting to about 50% of the present population. Assuming that the effective grazing range is 3 miles, 37% of the usable country is developed. The potential increase in cattle numbers with the development of the other 63% is about 450,000, amounting to slightly more than $1\frac{1}{2}$ times the present population. These figures indicate that as far as cattle numbers are concerned further development, although considerable, is not unlimited. Consequently in the long run improvement in turn-off may be more important than increase in numbers.

The development of more, and therefore closer-spaced, watering points would lessen the control of stock by water, and might necessitate the erection of subdividing fences. This, in turn, would allow the implementation of more efficient management systems based on range condition and trend studies. Associated with these developments it is likely that limited areas of pasture improvement and of fodder crop production would be developed and that some supplementary feeding would be practised, particularly if concentrates were available as by-products of irrigated agriculture.

Under higher grazing intensities active range condition control would be necessary to ensure maintenance of pasture productivity, and an efficient transport system would be necessary to move stock in times of climatic crises. Of the 80,000 sq. miles of spinifex country (sand plains and dune fields) considered useless at the present time, the sand plain country (40,000 sq. miles) may have some potential dependent on results of investigations aimed at partly or completely replacing spinifex with more useful species, or through the development of suitable management practices. The stocking rate of spinifex sand plain country will always be limited by the coarse-textured very infertile soils. However, on this large area even low stocking rates would have a significant effect on the total cattle population of the district.

XII. Conclusions

Cattle-grazing on an extensive scale on native pastures is the main industry in the area. The low and irregular rainfall, high evaporation, and infertile soils are likely to maintain this position.

Although the cattle industry is efficient by Northern Territory standards there is room for further intensification. Range management studies, and particularly range condition and trend investigations, are necessary to determine the safe degree of intensification and to enable the country to be developed for optimum production consistent with maintenance of productivity.

An attempt has been made to estimate the available quantities of irrigation water. The estimates are high enough to warrant thorough investigations to prove them. If the estimates are substantiated, 6000–14,000 ac of irrigated agriculture could be established. Cotton and dates are prospective crops.

The mining industry is, at present, small but supports settlement in two areas.

The spectacularly colourful mountain ranges, the appeal of the far outback, and the dry winter climate are tourist attractions. The tourist industry has a high potential.

INDEX TO LAND SYSTEMS, VEGETATION COMMUNITIES, AND PASTURE TYPES

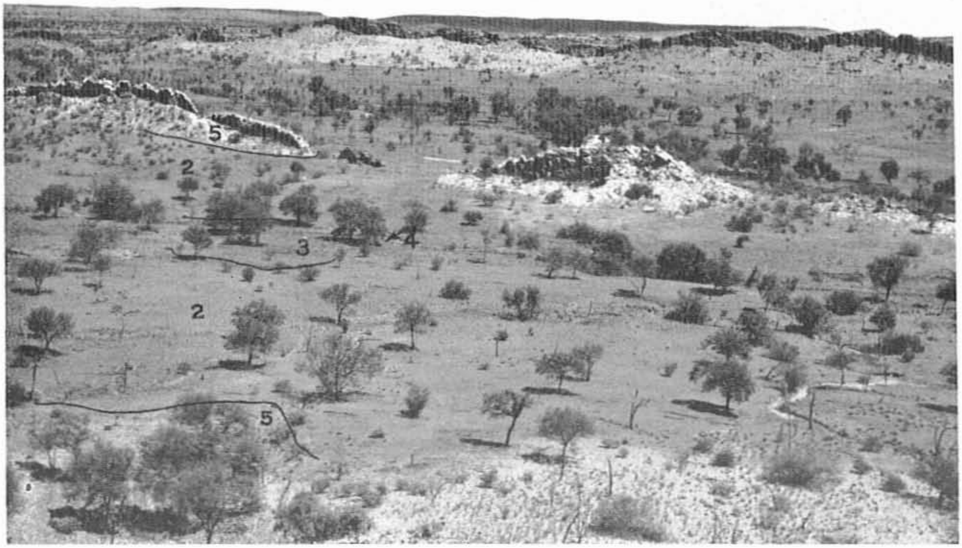


Fig. 1.—The land system ("an area or groups of areas throughout which there is a recurring pattern of topography, soils, and vegetation") has been used to map the lands. For example, in Jinka land system (No. 41), a dissected granite plain traversed by quartz reefs and carrying sparse low trees over short grasses and forbs, the recurrence of the land units indicated by numbers (described in the text) is very evident.

Fig. 2.—Woolla land system is mostly low, stony calcrete platforms and winding unchannelled valley floors in belts up to 2 miles wide. In all, 88 land systems have been mapped and described. These have been grouped into 8 "pasture lands" on the basis of their major pasture types. Because of the arid climate the area is, and will remain, primarily pastoral. Parts of Woolla land system have permeable red earth soils suitable for irrigation on the flat floors between the limestone rises and good quality ground water at shallow depth. Some other lands have soils and ground water suitable for irrigation.

Fig. 1.—Spinifex sand plains, dune fields, and plains comprise the largest (82,700 sq. miles) pasture land. Hard spinifex (*Triodia basedowii*) is characteristic of most of the sand plain (Singleton land system). Mature plants exhibit a typical "ring" formation and cover about 30% of the ground. Hard spinifex is also typical of the dune fields (Simpson land system). It is considered useless for grazing.

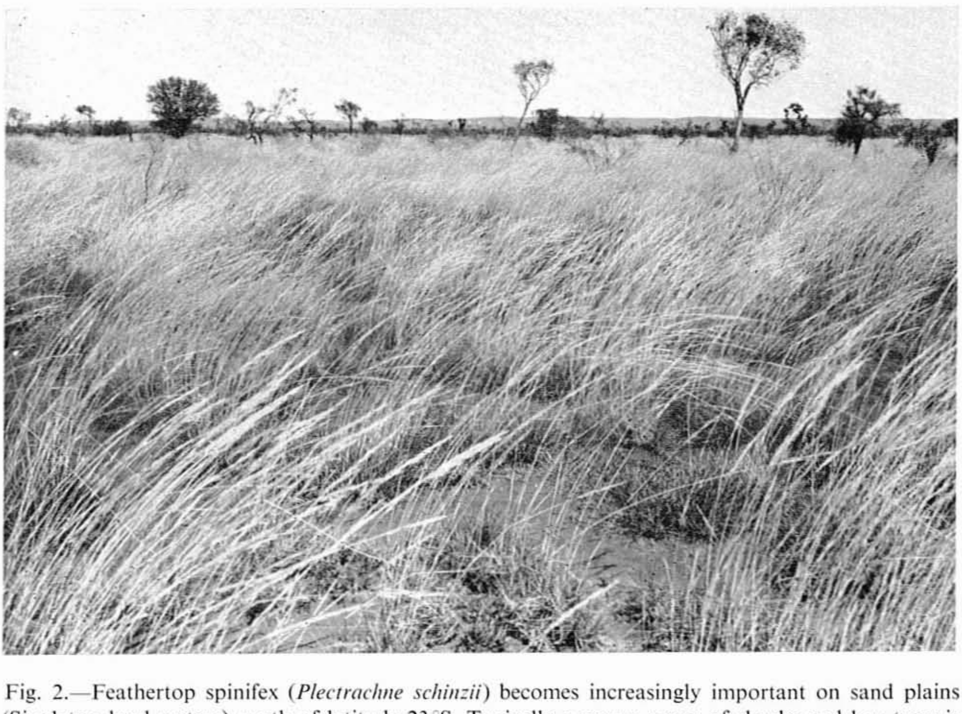


Fig. 2.—Feathertop spinifex (*Plectrachne schinzii*) becomes increasingly important on sand plains (Singleton land system) north of latitude 23°S. Typically a sparse cover of shrubs and low trees is associated with it.

Fig. 1.—Soft spinifex (*Triodia pungens*), in some areas with an upper storey of snappy gum (*Eucalyptus brevifolia*), is typical of some red earth soils on plains in the far north of the area (Wonorah and Tennant Creek land systems). Soft spinifex is grazed at a low stocking rate in some parts, especially during droughts when other pastures deteriorate badly.

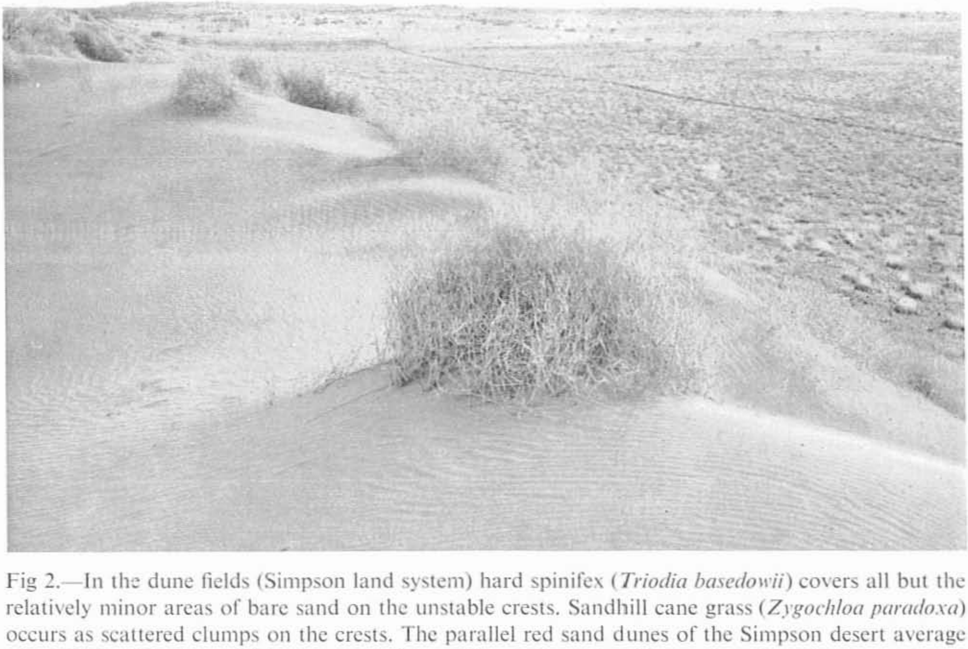


Fig 2.—In the dune fields (Simpson land system) hard spinifex (*Triodia basedowii*) covers all but the relatively minor areas of bare sand on the unstable crests. Sandhill cane grass (*Zygochloa paradoxa*) occurs as scattered clumps on the crests. The parallel red sand dunes of the Simpson desert average about 50 ft high, about 500 yd apart, and have flat sandy swales. The eastern dune faces are steeper than the western.

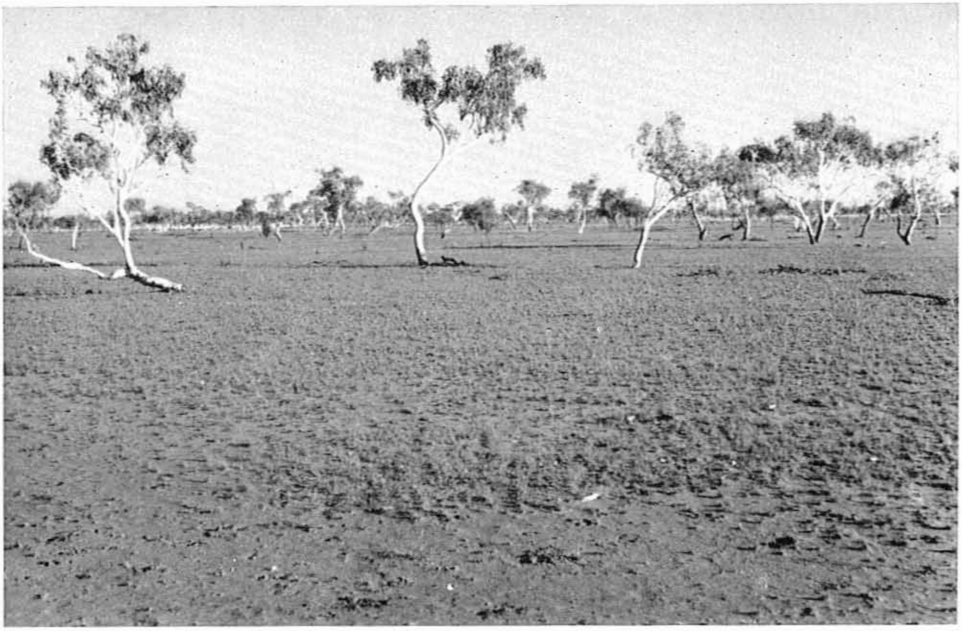


Fig. 1.—The short grass–forb pastures on young alluvia pasture land occupies 6300 sq. miles. Its present year-long stocking rate averages about 7 cattle per sq. mile. Because of the occurrence of water-holes in the channels, and the general availability of shallow ground water, these areas were the first developed and parts have been heavily grazed. Coolibah (*Eucalyptus microtheca*) is characteristic of alluvial basins in some flood-plains, especially where run-on is received.

Fig. 2.—The flood-plains are associated with the major rivers which are shallow sand-filled channels up to 400 yd wide commonly fringed by river red gum (*Eucalyptus camaldulensis*). They only flow for short periods after rain.

Fig. 1.—Alluvial fans occur adjacent to mountain ranges. They mainly have coarse-textured alluvial soils, sparse low trees (many of them palatable), and short grass–forb pastures.

Fig. 2.—Northern bluebush (*Chenopodium auricomum*) is a palatable and nutritious shrub which grows in periodically flooded alluvial basins especially on clay soils. The pasture has a high stocking rate (possibly 80–100 cattle per sq. mile) but is of minor importance in the Alice Springs area.

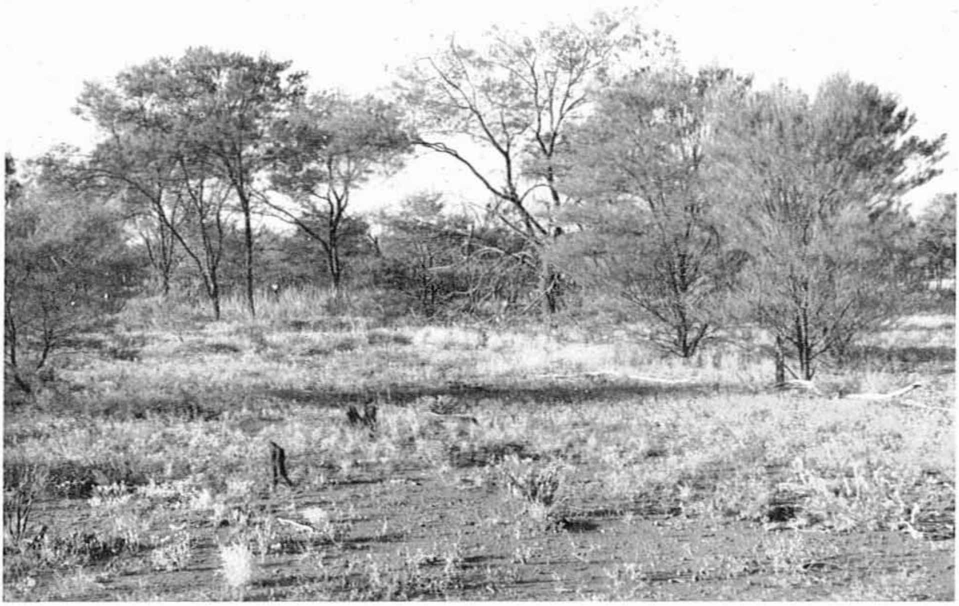


Fig. 1.—Short grass–forb pastures on flat or undulating country occupy 21,900 sq. miles of which 10,000 sq. miles is mulga (*Acacia aneura*) country. The pasture varies seasonally in composition (more grasses after summer rain, more forbs after winter rain) and density but has an average year-long stocking rate of about 7 cattle per sq. mile. Many of the forms of mulga are palatable and provide useful top feed.

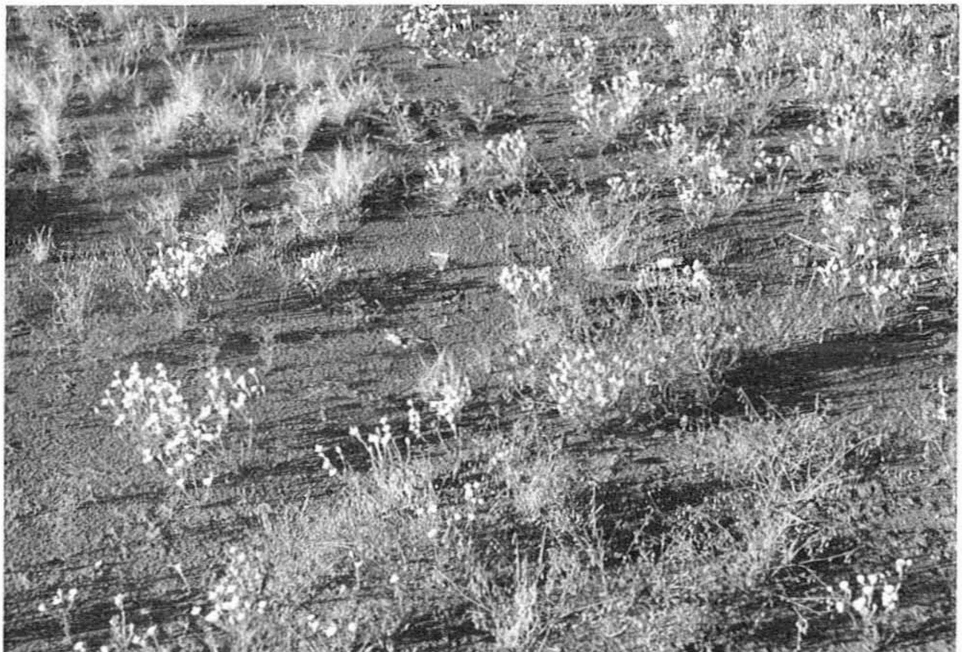


Fig. 2.—Following rains in mulga country short grasses and forbs grow rapidly but never produce a very dense cover.

Fig. 1.—In most of the mulga country the trees are not randomly distributed but occur in dense groves 30–400 yd long and 5–50 yd wide, separated by intergrove areas where trees are absent or sparse. The groves tend to be aligned along contours.

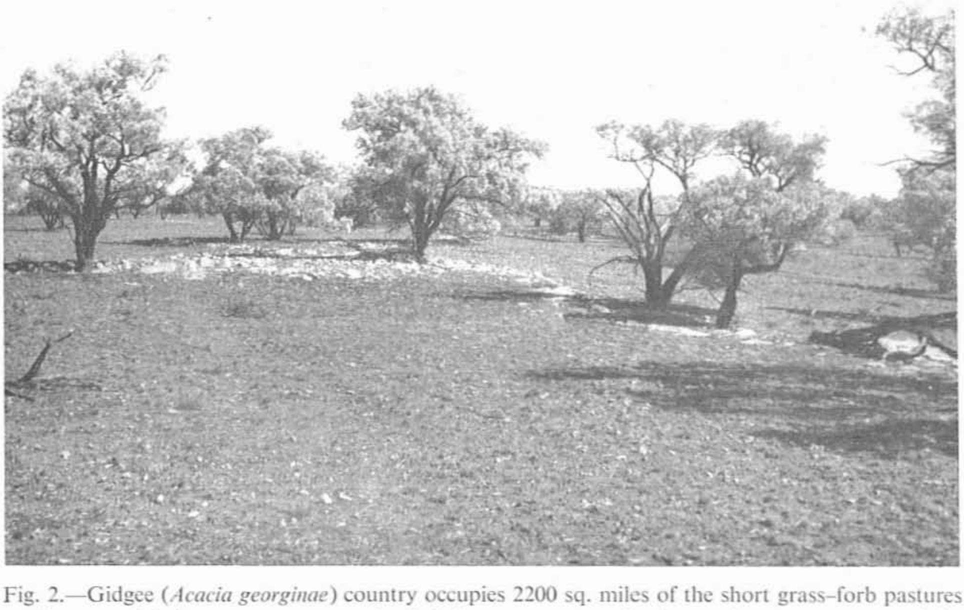


Fig. 2.—Gidgee (*Acacia georginae*) country occupies 2200 sq. miles of the short grass–forb pastures on flat or undulating country pasture land. It is most common in the north-eastern quarter of the area, and is particularly associated with limestone. Gidgee is a top-feed species although in parts of the Northern Territory and Queensland to the east of the Alice Springs area it is poisonous to sheep and cattle in some seasons. However, deaths have not been recorded in the Alice Springs area.

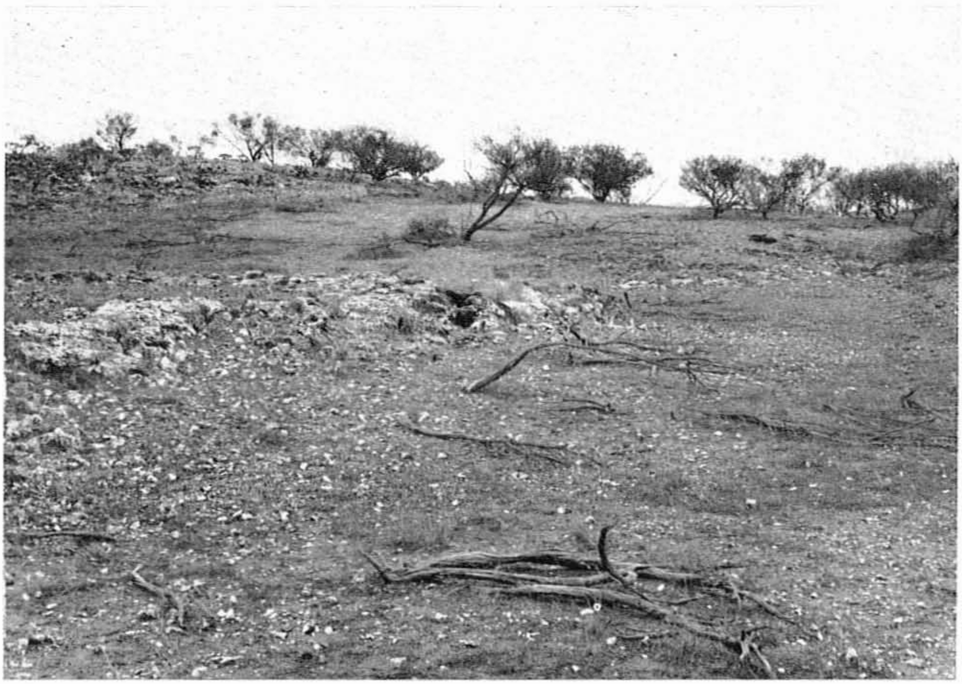


Fig. 1.—Witchetty bush (*Acacia kempeana*) is a top-feed species which characterizes 1000 sq. miles of mostly limestone country.

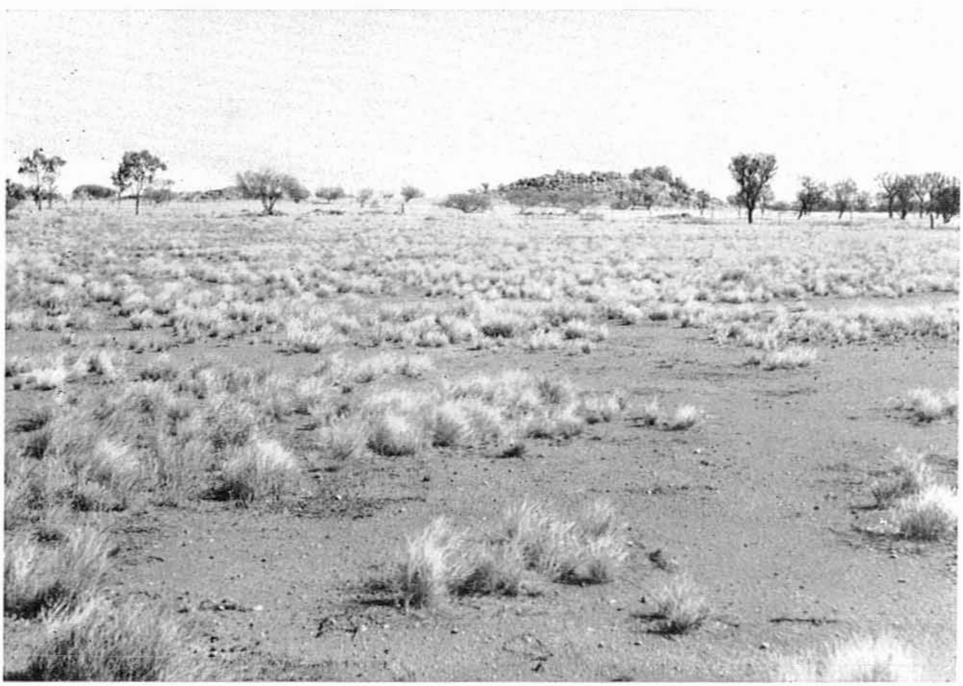


Fig. 2.—Undulating country on granite and metamorphic rocks is characterized by sparse low trees over short grasses and forbs.

Fig. 1.—Only 300 sq. miles of Mitchell grass (*Astrebla pectinata*) occur in the area. The year-long stocking rate is 10–20 cattle per sq. mile.

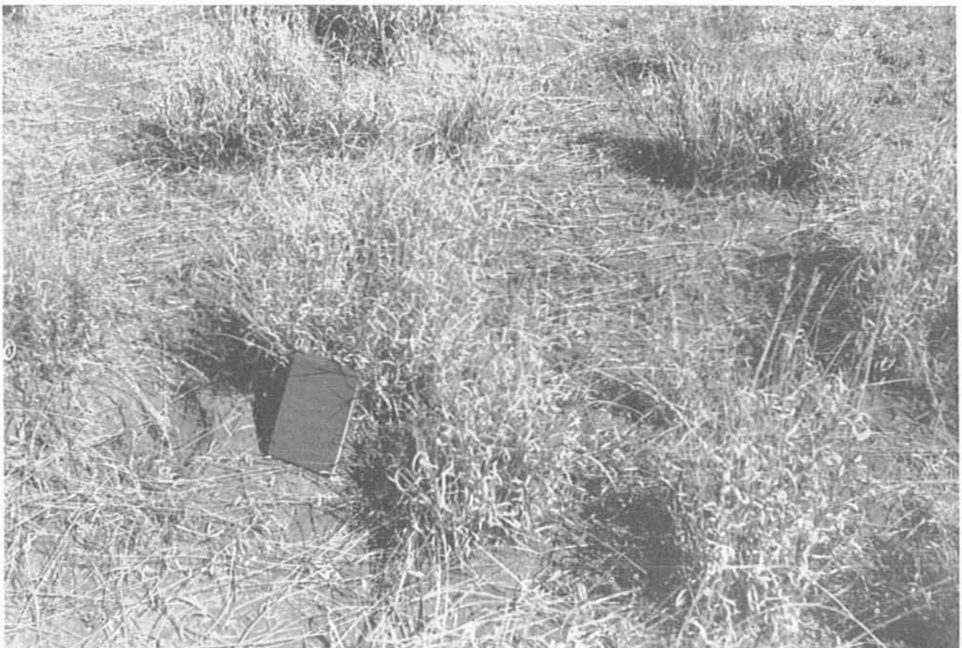


Fig. 2.—Mitchell grass is a perennial drought-evading grass growing in tussocks approx. 18 in. high and 9 in. in diameter. In good seasons the interspaces have a cover of short grasses and forbs.

Fig. 1.—The saltbush and bluebush pasture land occupies 3300 sq. miles mainly in the southern, low-rainfall part of the area. It has a year-long stocking rate of 5 or less cattle per sq. mile. Saltbush (*Atriplex vesicaria*) is typical of the stony plains with texture-contrast soils (Endinda land system) and is generally treeless.

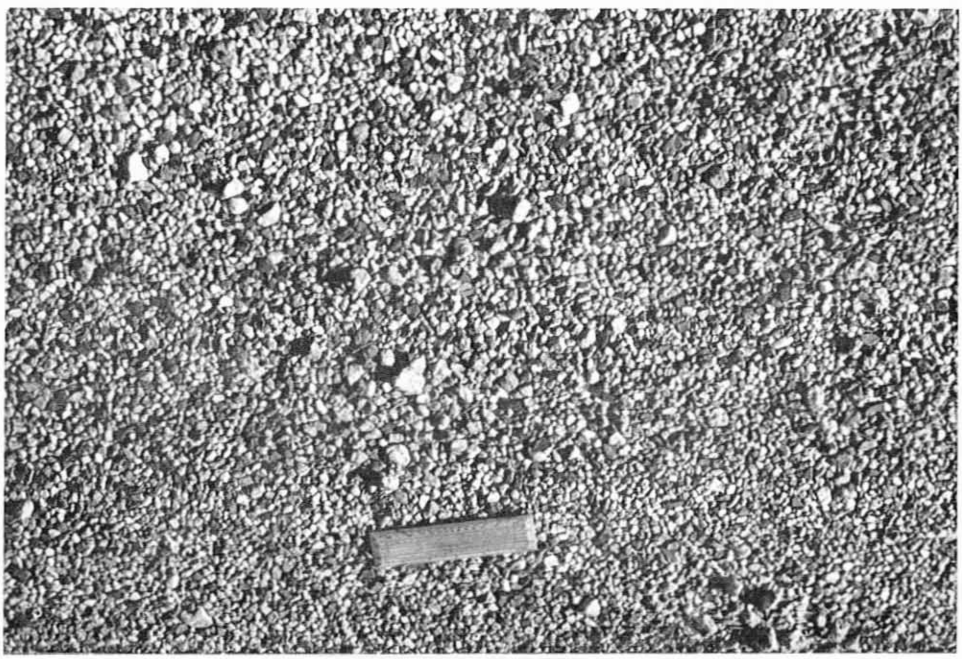


Fig. 2.—A closely packed pavement of small stones is typical of many areas of texture-contrast soils on which saltbush is a common vegetation.

Fig. 1.—The stony tablelands (Wilyunpa land system) in the southern part of the area are treeless and carry a sparse cover of saltbush (*Atriplex vesicaria*) or *Bassia* spp. Mitchell grass (*Astrebla pectinata*) occurs near gilgais.

Fig. 2.—The dissected stony plains of Peebles land system carry sparse saltbush (*Atriplex vesicaria*) or *Bassia* spp. The stone mantle is derived from the destruction of the weathered land surface with its silcrete duricrust.

Fig. 1.—Alternating hills and lowlands occupy 13,500 sq. miles. The hills are useless for grazing but the lowlands are similar to short grass–forb pastures on young alluvia or short grass–forb pastures on flat to undulating country pasture lands. The overall year-long stocking rate is about 5 cattle per sq. mile.

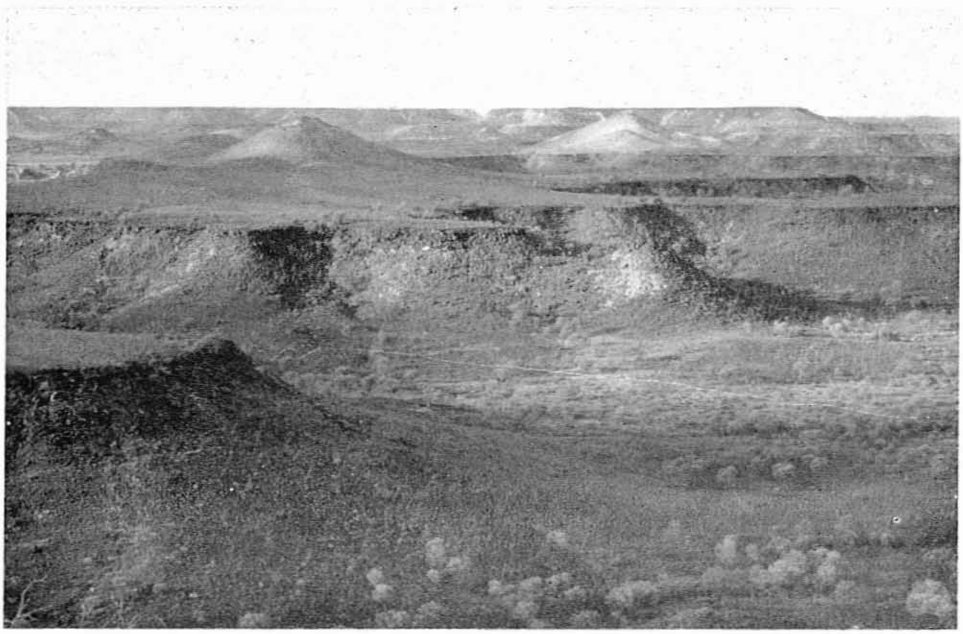


Fig. 2.—The dissected plateau of Rumbalara land system is another example of the alternating hills and lowlands pasture land. The high plateau crest with its silcrete duricrust is the old land surface, here dissected up to 350 ft.

Fig. 1.—Mountains and hills occupy 14,500 sq. miles. The steep rocky slopes are inaccessible to stock and therefore useless for grazing. However, run-off from them forms the major part of annual recharge to ground water.

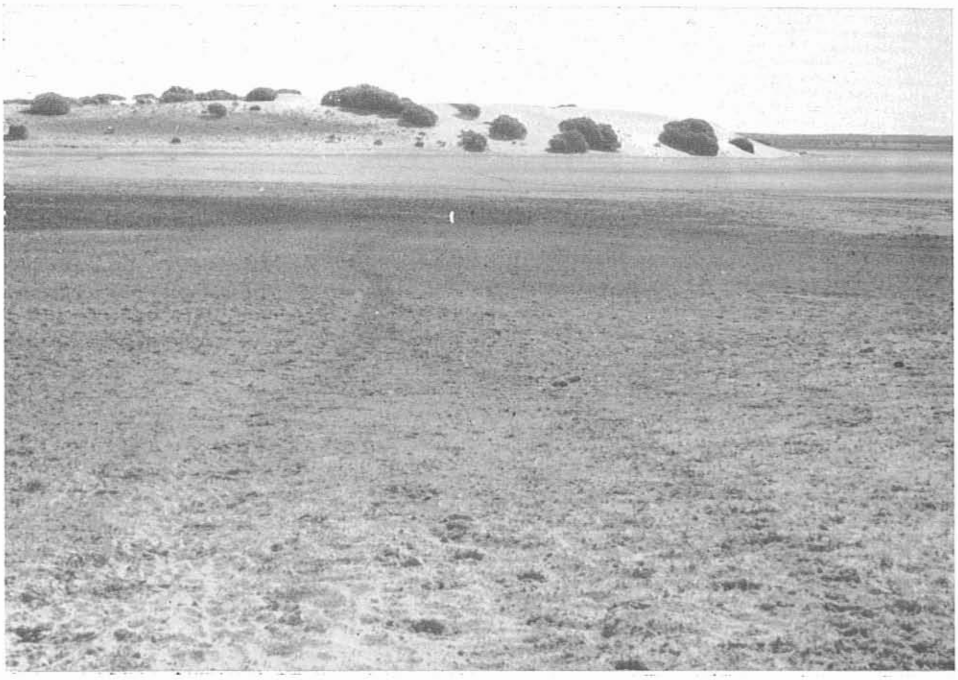


Fig. 2.—Salt lakes (Amadeus land system) with bare floors and fringed by dunes occupy 1800 sq. miles. They are useless for grazing.

Fig. 1.—Landscape evolution can be traced from the Upper Cretaceous when marine withdrawal was followed by a long period of erosion that formed a land surface of little relief. The folded sediments of the Davenport Range were bevelled as shown by the flat crests now surviving.

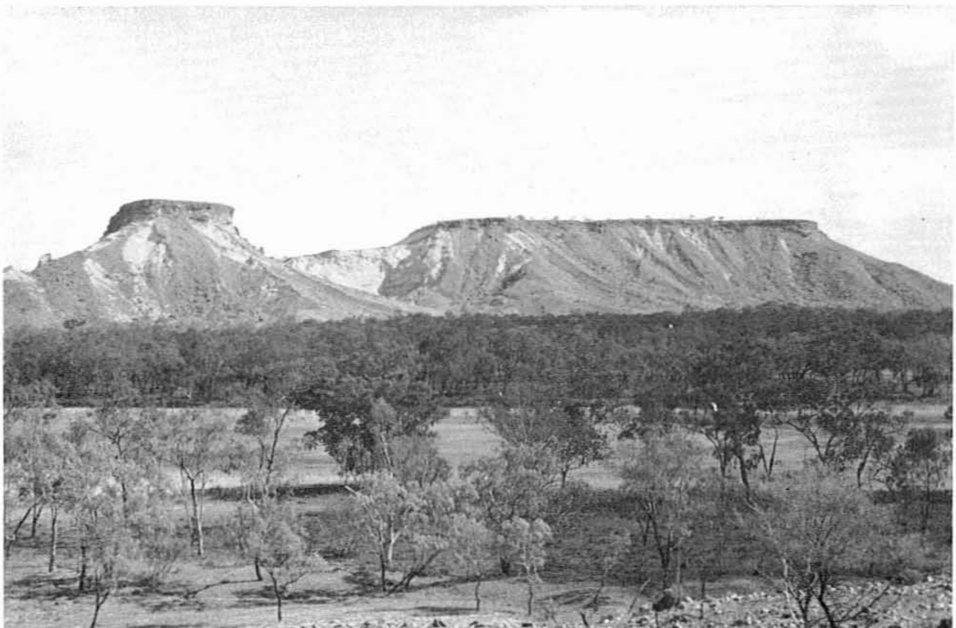


Fig. 2.—The old surface was best developed on the soft, flat-lying Cretaceous sediments in the south-east of the area where it survives in the summits of dissected plateaux.

Fig. 1.—A distinctive pattern of east–west ridges and narrow vales has formed on strongly folded, interbedded, hard and soft rocks in the central part of the area. Transverse drainage is typical.

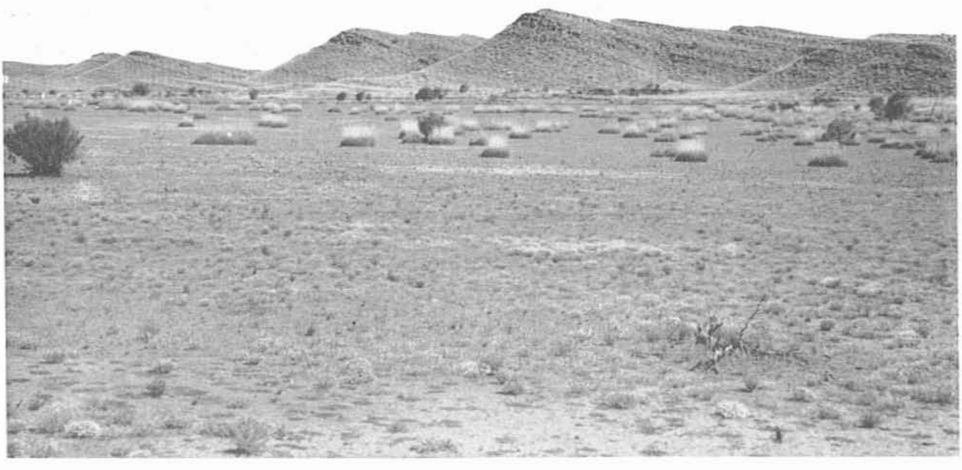


Fig. 2.—On gently dipping rocks, particularly limestones, ridges with smooth, steeply-concave escarpments on a basal apron leading to vale fill have developed. The hills and basal apron have a cover of spinifex (*Triodia longiceps*) and the calcareous soils on the vale fill carry short grass–forb pastures and scattered witchetty bush (*Acacia kempeana*).

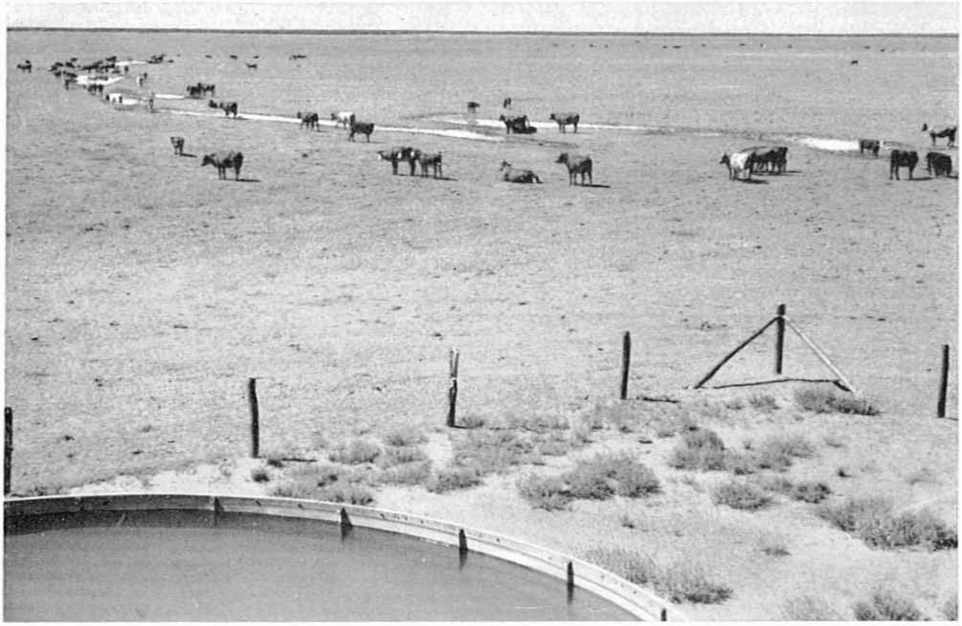


Fig. 1.—Cattle are grazed on an extensive scale and controlled mainly by watering points spaced at about 10-mile intervals. 400–1000 stock may be grazed around each watering point. Under these conditions the pastures in the immediate vicinity of the watering points are completely destroyed but can be regarded as a "sacrifice area", which is a normal feature of extensive grazing systems.

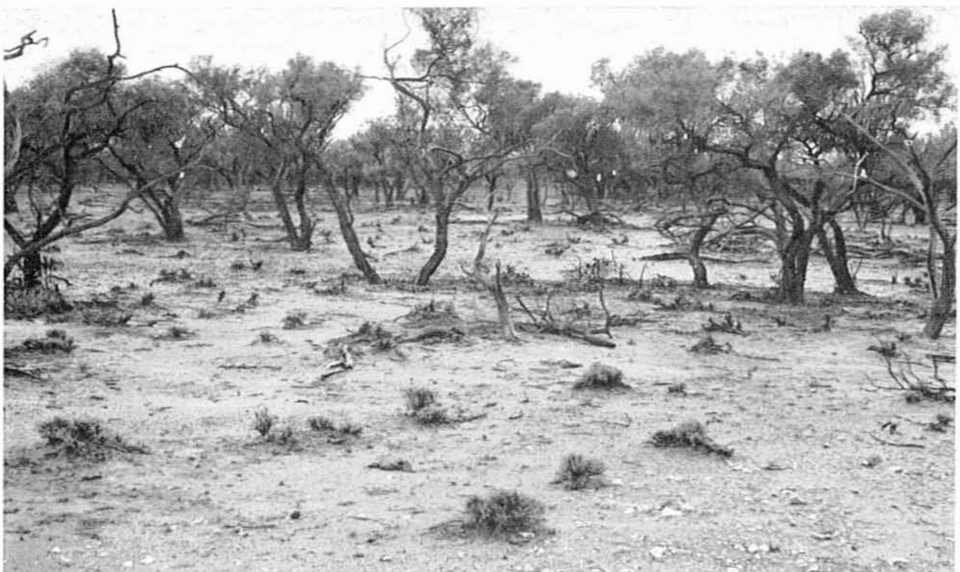


Fig. 2.—A recommendation arising from the survey is the establishment of range condition and trend studies with the object of formulating sound management policies aimed at maximum production from the pastures consistent with the maintenance of productivity. Above is a stand of southern bluebush (*Kochia astrotricha*) growing under gidgee (*Acacia georginae*) which has been over-grazed. Soil removal and the formation of stony pavements have followed.

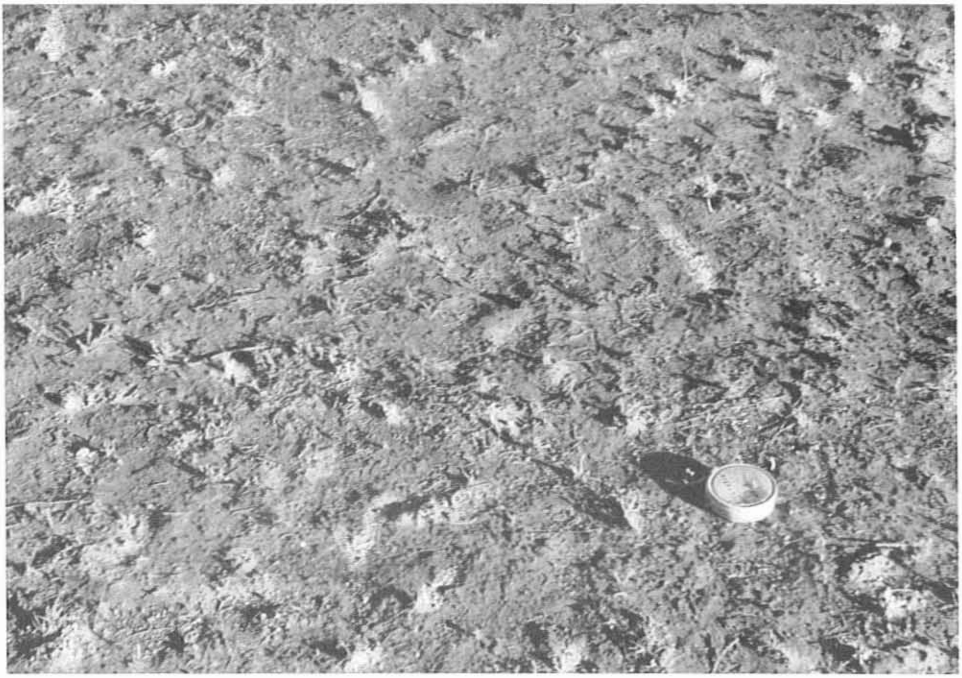


Fig. 1.—Over-stocking will give pasture deterioration leading to bare ground. However, bare ground is a natural feature of ungrazed land during long dry periods where the natural pastures are ephemerals that have dried up and blown away.

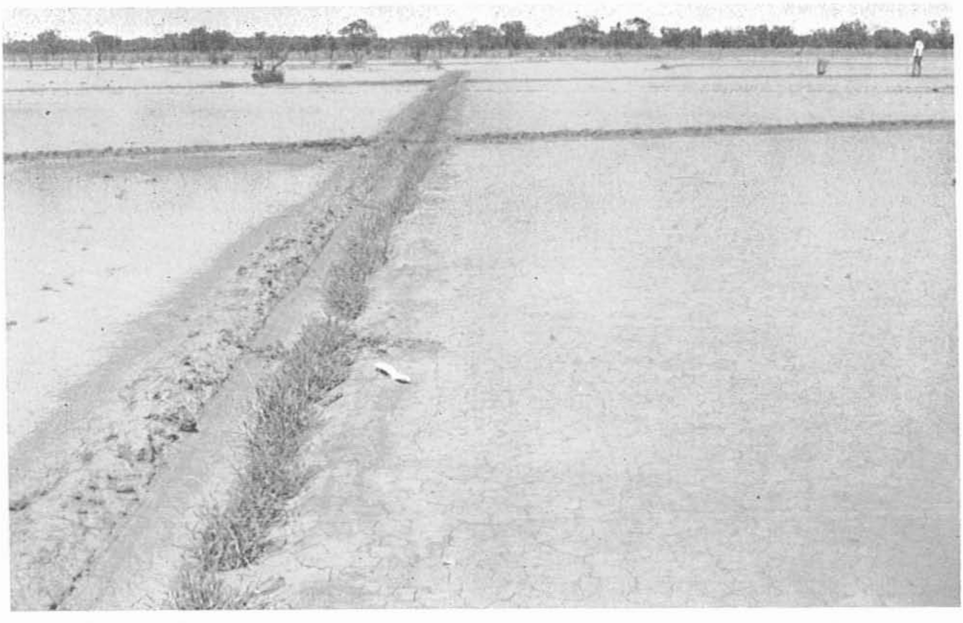


Fig. 2.—Over-grazing on fine-grained sandy and silty soils which blow readily may result in extensive scalds which can only be re-vegetated with the aid of mechanical treatment. Buffel grass has been successfully established in furrows on scalded areas on the Todd River flood-plain.

Fig. 1.—The extensive red earth plains have no organized drainage but sheet flow causes concentration in low parts whence some infiltrates to ground water.

Fig. 2.—Where supplies of suitable-quality ground water are available, crops can be grown under irrigation. Lucerne produced yields of 8 to 10 tons per acre. A range of other crops could also be grown. Water in six basins north of Alice Springs is estimated to be sufficient to irrigate 7000 acres.

(*Photo: Australian News and Information Bureau*)

Fig. 1.—Under such arid conditions the forestry potential is limited. However, narrow stands of mill-size trees of river red gum (*Eucalyptus camaldulensis*) fringe the larger watercourses. The timber is used mainly for railway sleepers.

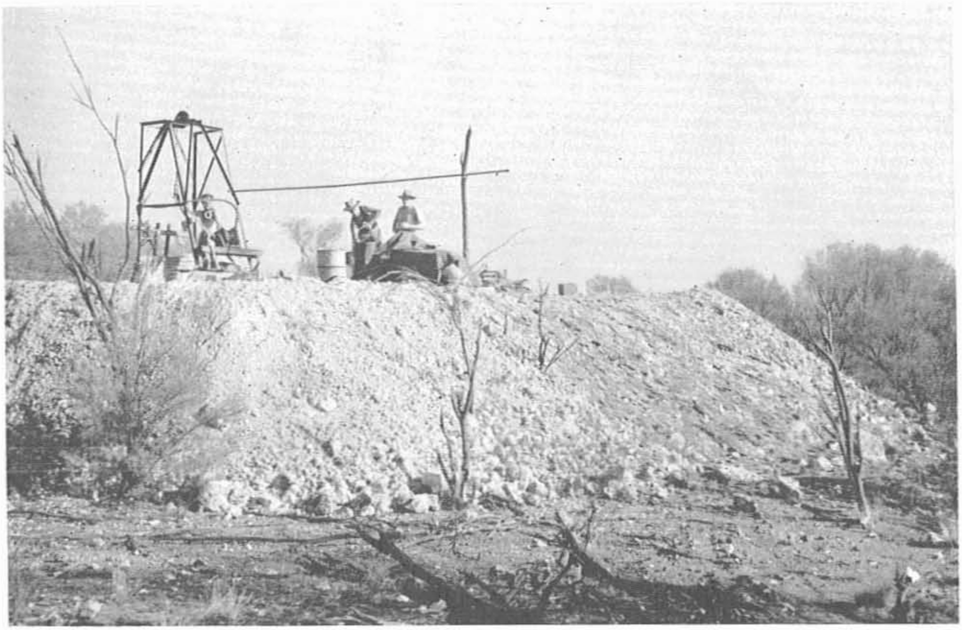
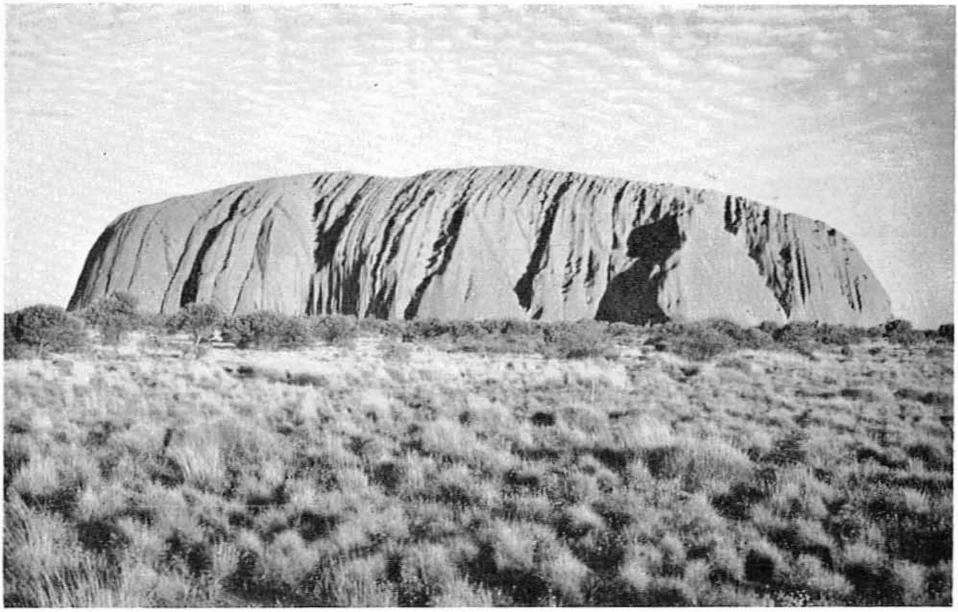


Fig. 2.—The mining industry is small at present but wide areas of potentially mineralized rocks have not been intensively prospected.



(*Photo: Australian News and Information Bureau*)

Fig. 1.—The tourist industry is rapidly increasing in importance and has a large potential. Ayers Rock, which is 5 miles in circumference and rises 1000 ft from the sand plain, is one of the spectacular scenic attractions.

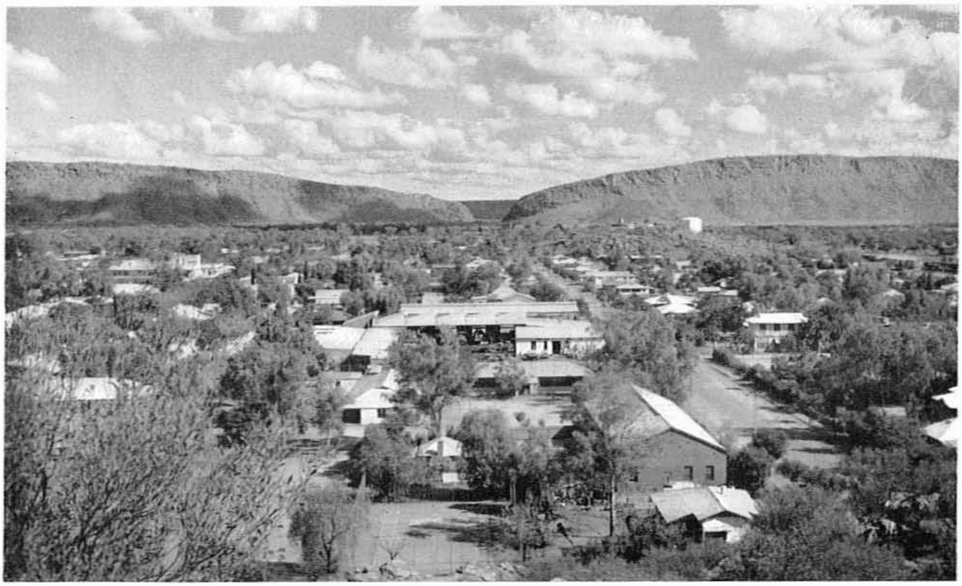


Fig. 2.—Alice Springs is a modern town with a population of about 3500 and is attractively set in a valley in the MacDonnell Ranges. It is the only town in the area and is the centre for the pastoral, mining, and tourist industries. It is the terminus of the railway from Adelaide and of the Stuart highway to Darwin and is an important stop on the Adelaide–Darwin air route. It is the base for Connellan Airways, which serves most of the cattle properties in the Northern Territory.