Pasture Lands of the Northern Territory, Australia

By R. A. Perry

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MAP

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By R. A. Perry*

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I. Introduction

At the present time the beef-cattle industry is the main one in the Northern Territory and accounts for slightly more than half its export revenue. Although some of the northern higher-rainfall parts are suitable for the development of arable agriculture, these represent only a small proportion of the total area of the Territory, and vast areas will remain as grazing lands.

Where the mean annual rainfall exceeds 25–30 in. and where soil and topographic conditions are suitable, sown pastures incorporating exotic species are a potential future development, but for the most part the grazing industry will always be dependent on native pastures. In these areas, the cattle industry is likely to remain on a relatively extensive basis, though a gradual intensification can be expected. It is therefore clear that the native pastures of the Northern Territory are one of its most valuable assets and their maintenance in a productive condition is of vital importance to the area.

This paper is a preliminary attempt to define the broad pasture types present in the Northern Territory and to describe some of their characteristics and potentialities. Eight broad groups have been established. These give a general picture and enable comparisons to be made with units of other workers. The main groups have been subdivided and 19 pasture lands or classes of country have been defined. They are delineated on the accompanying map, which is largely a compilation from surveys by the Division of Land Research and Regional Survey, C.S.I.R.O. These include the Katherine–Darwin, Barkly, Ord–Victoria, and Alice Springs surveys. The concepts and techniques used on these surveys have been described by Christian (1952, 1958, 1959*a*), Christian and Stewart (1953), Christian and Perry (1953), and Christian, Stewart, and Perry (1960). In the areas not covered by these surveys boundaries have been extrapolated using photomosaics mainly at a scale of 1 : 250,000.

II. Review of Literature

The definition, description, and mapping of the pasture lands in this paper have been primarily based on information collected during surveys by the C.S.I.R.O. Division of Land Research and Regional Survey. The units used are compared with those used in the descriptions of the individual survey areas in Table 1.

There have been no previous descriptions or maps of the pastures of the Northern Territory alone, and although there are several pasture and vegetation maps of Australia these are on a much smaller scale, are more general, and are

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TABLE 1

COMPARISON OF UNITS USED IN THIS PUBLICATION WITH THOSE USED IN VARIOUS AREAS SURVEYED BY THE C.S.I.R.O. DIVISION OF LAND RESEARCH AND REGIONAL SURVEY

Units used in this Publication		Units used in Various Areas Surveyed by C.S.I.R.O. Division of Land Research and Regional Survey			
Main Pasture Group	Pasture Land	Katherine–Darwin Region (Christian and Stewart 1953)	Barkly Region (Christian and Stewart 1954)	Ord–Victoria Area (Perry and Lazarides, unpublished)	Alice Springs Area (Perry, unpublished)
Mitchell grass country	Barley Mitchell grass		Mitchell grass country; northern Mitchell grass country	Barley Mitchell grass	Mitchell grass plains
	Barley Mitchell grass and other perennial grasses			Barley Mitchell grass and other perennial grasses	
	Inferior Mitchell grass and other perennial grasses	Blue grass pastures	Inferior Mitchell grass country; northern inferior Mitchell grass country; drybog	Sorghum and blue grass	
Short grass–forb country	Short grasses and forbs		Included in southern desert country	Annual pastures	Short grasses and forbs on flat or undulating country
	Short grasses and forbs on flood plains and outwash plains				Mainly short grass–forb pastures and young alluvia
	Short grasses and forbs on lowlands mixed with hilly country				Alternating hills and lowlands

TABLE 1 (*Continued*)

Units used in this Publication		Units used in Various Areas Surveyed by C.S.I.R.O. Division of Land Research and Regional Survey			
Main Pasture Group	Pasture Land	Katherine–Darwin Region (Christian and Stewart 1953)	Barkly Region (Christian and Stewart 1954)	Ord–Victoria Area (Perry and Lazarides, unpublished)	Alice Springs Area (Perry, unpublished)
Chenopod country	Northern bluebush		Bluebush swamps	Bluebush	Included in short grass–forb pastures and young alluvia
	Bladder saltbush and southern bluebush				Saltbush and bluebush country
Spinifex country	Soft spinifex plains		Southern desert country	Desert country	Spinifex sand plains, dune fields, and plains
	Hard spinifex sand plains				
	Spinifex dune fields				
Semi-arid upland country	Three-awned spear grass		Northern desert country		
Higher-rainfall upland country	Kangaroo grass–perennial sorghum	Tall grass pastures of the upland areas		Kangaroo grass	
	Annual sorghum and other tall grasses			Tall grass pasture	
	Kangaroo grass on lowlands mixed with hilly country			Hilly volcanic country	

TABLE 1 (*Continued*)

Units used in this Publication		Units used in Various Areas Surveyed by C.S.I.R.O. Division of Land Research and Regional Survey			
Main Pasture Group	Pasture Land	Katherine–Darwin Region (Christian and Stewart 1953)	Barkly Region (Christian and Stewart 1954)	Ord–Victoria Area (Perry and Lazarides, unpublished)	Alice Springs Area (Perry, unpublished)
Flooded and coastal country	Reeds–wild rice	Pastures of the subcoastal plain		Subcoastal plain; blady grass	
	Kangaroo grass–*Eriachne* spp.	Pastures on "acid" alluvial flats and plains			
	Coastal country		Coastal country	Coastal pastures	
Rugged country	Rugged and otherwise inaccessible country	*Triodia* and *Plectrachne* pastures	Hilly country	Rugged hilly country	Mountains and hills

based on very limited observations. The units used in these previous maps are compared with those used in this paper in Table 2.

Of the previous maps those of McTaggart (1936), Christian and Donald (1950), and Christian, Donald, and Perry (1960) are pasture maps. In none of these has there been any attempt to separate rugged or inaccessible country and some inaccuracies in the boundaries of other types have resulted. The main inaccuracies in McTaggart's map are that the saltbush type is shown too far north and the mallee scrub and *Acacia* scrub areas are too large. He also had to rely on unskilled observers who used only common names and this accounts for some of the errors in his descriptions, e.g. throughout the Territory he has accepted bluebush as *Kochia* spp. whereas the more common bluebush is *Chenopodium auricomum*. Christian and Donald's map is on a much smaller scale and there are fewer units. The main inaccuracy is in the area of mulga scrub, which is too large. The same map has been enlarged as a background to the map of Distribution of Stock in the Atlas of Australian Resources (Department of National Development 1954). The map by Christian, Donald, and Perry is a revision of Christian and Donald's in the light of information available in 1955. The mulga area is too large and the map would have been improved greatly if rugged country had been delineated instead of being included in spinifex country.

Roe (1940) gives very general descriptions of the pastures of northern Australia and divides them into four main groups. Christian (1956) describes and discusses the problems of four main pasture regions in northern Australia. Mair (1940) very briefly discusses the pastures and carrying capacities of what are now the four pastoral districts of the Northern Territory.

The maps of Prescott (1931), Wood (1950), and Williams (Department of National Development 1955) are based on vegetation and are less directly comparable with the present map. The main errors in Prescott are that the *Acacia* semi-desert and shrub steppe area is too large, as is the area of savannah. The map by Wood (1950) is on a very small scale. The main inaccuracies are that the area of mulga scrub is too large and that there is little or no difference between desert sclerophyllous grassland and sclerophyllous grass steppe. This map has been used by Prescott (1952) instead of Prescott's (1931) earlier vegetation map. The units mapped by Williams (Department of National Development 1955) are based on vegetation structure rather than floristics and are less comparable. However, the approximate equivalents are shown in Table 1.

Apart from the general accounts discussed above, in recent years there have been a number of papers (Bateman and Specht 1958; Blake 1953, 1954; Chippendale 1958; Christian and Stewart 1953; Crocker 1946; Perry 1955; Perry and Christian 1954; and Specht 1958) dealing mainly with the vegetation of various parts of the Territory and mostly contributing little on pastures. There are also a number of papers (Beadle 1948; Blake 1938; Burbidge 1945*a*, 1959; Crocker and Skewes 1941; Gardner 1942; Jessup 1951; Osborn 1925; Osborn and Wood 1923; Osborn, Wood, and Paltridge 1932, 1935; Trumble and Woodroffe 1954; Wood 1936, 1937; Woodroffe 1941) on other parts of Australia which include descriptions of country similar to one or more of the types of country in the Territory.

TABLE 2

COMPARISON OF GROUPS USED IN THIS PUBLICATION WITH UNITS OF PREVIOUS AUTHORS

Author	Unit							
Perry (this publication)	Mitchell grass country	Short grass–forb country	Chenopod country	Spinifex country	Semi-arid upland country	Higher-rainfall upland country	Flooded and coastal country	Rugged country
McTaggart (1936)	Open grassland—northern—on limestone and volcanic areas	Acacia scrub area	Saltbush-type areas	Spinifex on desert sandhills, sandstone areas, etc; mallee scrub; *Acacia* scrub	Tropical open forest grazing areas; and open grassland — northern — on sandstone etc. areas			Not recognized
Christian and Donald (1950)	Mitchell–Flinders grass	Mulga scrub	Saltbush steppe	Desert; and spinifex (northern)	Tropical tall grass			
Christian, Donald, and Perry (1960)	Mitchell–Flinders grass	Mulga scrub	Saltbush steppe	Desert; and part of spinifex (northern)	Part of spinifex (northern)	Tropical tall grass		Recognized but included in spinifex (northern)
Prescott (1931)	Savannah and Mitchell grass downs	Acacia semi-desert and shrub steppe		Sandhills with desert grass; mallee and sclerophyll woodland; heath and sclerophyll scrub	Tropical tall grass mixed with savannah and Mitchell grass downs	Tropical tall grass		Not recognized
Wood (1950)	Savannah	Mulga scrub	Desert steppe	Desert sclerophyllous grassland; and sclerophyllous grass steppe	Savannah woodland mixed with savannah	Savannah woodland		

TABLE 2 (*Continued*)

Author	Unit							
Department of National Development (1955)	Semi-arid tussock grassland; tropical tree savannah; semi-arid low tree savannah	Arid scrub; low arid woodland	Shrub steppe	Sclerophyll shrub savannah; sclerophyll low tree savannah; sand-plain desert; sclerophyll hummock grassland	Sclerophyll shrub savannah mixed with low arid woodland	Tropical scrub; tropical layered forest; tropical woodland (mixed); tropical layered woodland; tropical deciduous woodland; tropical tall shrub savannah	Tropical tussock grassland; littoral complex	Not recognized

Most of the above papers are descriptive and there are few published quantitative data on the yield of the pastures or their nutritive status. Limited observations in isolated areas of northern Australia have been published by Christian and Shaw (1951), Beck and Underwood (1938), Snook and Durack (1947), Hely and Hallsworth (1947), and Davies, Scott, and Kennedy (1930). In general their data show that the pastures mostly have only a reasonable protein status for short periods during the early part of the growing season and a low or very low protein status for the remainder of the year.

Poison plant investigations (Barnes 1958; Murnane 1953; Anon. 1934, 1956, 1957) have formed an important part of pasture research in the Territory.

III. Environment

(*a*) *Physiography*

The Northern Territory is an area of gentle to moderate relief, consisting predominantly of plains which rise from sea-level at the north coast to an altitude of about 2300 ft near Alice Springs. Southwards from Alice Springs the plains fall towards Lake Eyre. Several areas of steeply sloping hilly or mountainous country occur, especially in the northern part. The largest of these are the belt of rugged country extending from Arnhem Land south-eastwards into Queensland, and the country contiguous with the Kimberley district of Western Australia. Although these two areas are strongly dissected and of a rugged nature, the overall relief is relatively low and in no place does the altitude exceed 2000 ft. In the southern half of the Territory rugged country occupies a smaller proportion of the total area. The largest mass is the MacDonnell Range system (including the MacDonnell, Ferguson, Krichauff, Strangway, and Harts Ranges), which extends in an east–west direction across about half the width of the Territory between lat. 23°S. and lat. 24°S. Although the highest mountain in the Territory (Mount Ziel, 4935 ft) occurs in these ranges, together with a number of other peaks above 4000 ft, the ranges rise from a plain with a general level of approximately 2000 ft. The range of relief is therefore generally less than 2000 ft.

Nowhere in the Territory are there mountains high enough to exert any appreciable influence on climate, although in some places there is evidence of slight modification. For example, the slightly higher rainfall and less extreme temperatures of Alice Springs (1900 ft) compared with Charlotte Waters (597 ft) are probably due mainly to the difference in altitude.

(*b*) *Climate*

The Northern Territory extends from about lat. 12°S. to lat. 26°S. and thus lies mostly in the tropics.

In such a large area of moderate relief it is not surprising that the climatic pattern is a relatively simple one, becoming progressively more arid with distance from the north coast. Mean annual rainfall decreases from about 60 in. at Darwin on the north coast to about 5 in. at Charlotte Waters on the southern border (Fig. 1).

The climate is dominated by the south-east trade winds which persist almost throughout the year in the southern parts of the area and particularly characterize the overall weather pattern between April and September.

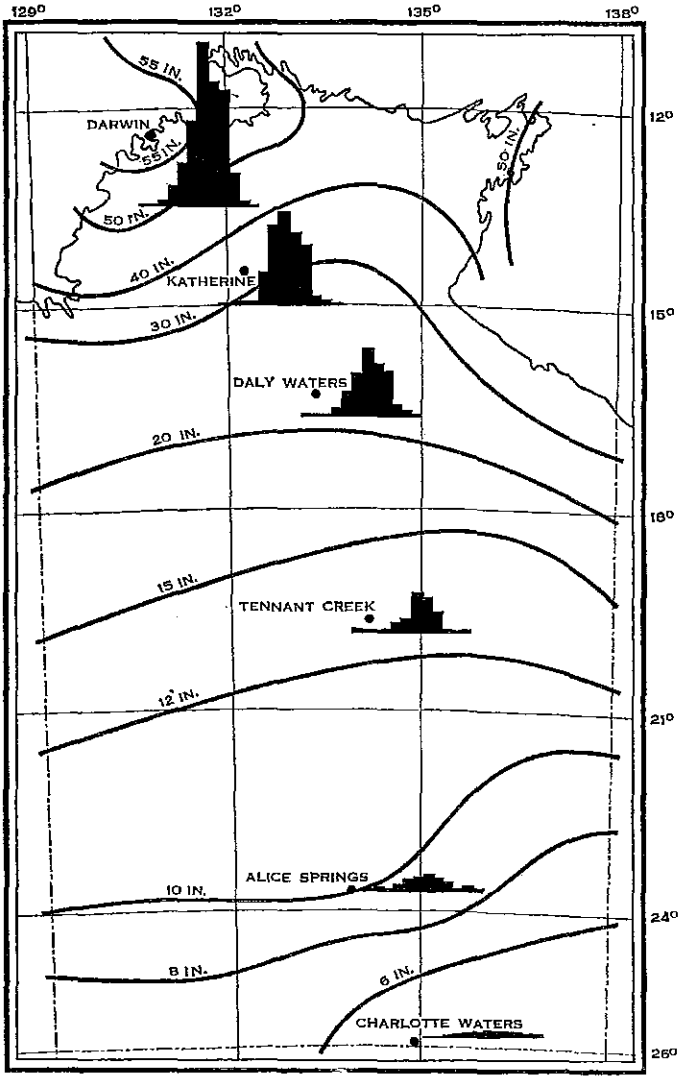

Fig. 1.—Map of the Northern Territory, showing isohyets and histograms of annual rainfall distribution (July to June) for selected localities.

During the summer months the south-easterly situation is interrupted by frequent intrusions of moist tropical air associated with the so-called north-west monsoon. Most of the summer rainfall is received from these sources. This rainfall

is heaviest on the northern coastline (≈60 in.) and although it decreases progressively with distance inland it still provides the bulk of the annual rainfall in the southern regions. Superimposed on this general pattern of summer rainfall, tropical cyclones occasionally occur and, on an average of less than once a year, reach the southern parts of the Territory. Although their incidence is highly sporadic they are extremely important from a land-use viewpoint since widespread and substantial falls of rain are generally received.

During the winter months the south-easterlies are much more persistent but are periodically interrupted by the passage of a trough associated with a depression well to the south. Most of the winter rain occurs when the passage of a trough coincides with an inflow of moist air. This generally happens only two or three times per winter and seldom causes rain further north than Tennant Creek. Although the amount of rain received from these sources is small compared with that from summer-rainfall influences it is an important component in relation to plant growth. The mean monthly rainfall distribution at various localities between Darwin and Charlotte Waters is given in Table 3.

At Darwin the temperature is relatively uniform, the range in mean maxima from the hottest to coolest months being only 5°F and in mean minima only 10°F (Table 4). The diurnal range is also low. Southwards, temperature conditions become more extreme and both seasonal and diurnal range increase. At Tennant Creek the range in mean maxima from hottest to coldest month is 24°F, and in mean minima 25°F. The corresponding figures at Finke are 32°F and 30°F respectively. The area north of lat. 20°S. is virtually frost-free.

A more comprehensive account of the climatology of various parts of the Territory is given by Slatyer and Christian (1954) and Slatyer (1960), from which most of these data were obtained.

(*c*) *Soils*

Considering the size of the Territory, there are relatively few soil types and their pattern of distribution is fairly simple. A feature common to all is the low, and in some cases very low, phosphate status. Nitrogen level is also generally low.

More detailed information on the characteristics, origin, and distribution of the soils of certain areas in the Territory are available from Christian and Stewart (1953), Stewart (1954, 1956), Jackson (1957*a*, 1957*b*), and Litchfield (1952, 1954).

Excluding the skeletal soils and rock outcrops of the hilly and mountainous areas, the following are the commonest soils:

(i) *Red Sands and Clayey Sands.*—These occupy well over half the area of central Australia and comprise all the sand plains and dune fields. They almost invariably carry hard spinifex (*Triodia basedowii*) with scattered shrubs and low trees.

(ii) *Red Earths.*—As well as being the second most extensive unit in central Australia, these soils extend to the higher-rainfall areas. In the southern region they commonly carry short grass–forb pastures, but under higher-rainfall conditions they are often dominated by kangaroo grass and perennial sorghum.

TABLE 3

MEAN MONTHLY RAINFALL (IN.) AT VARIOUS LOCALITIES

Locality	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Oct.–Mar.	Apr.–Sept.	Annual
Darwin*	16·18	12·37	11·18	3·08	0·33	0·09	0·01	0·02	0·60	1·93	4·32	8·57	54·55	4·13	58·68
Katherine*	9·14	7·07	5·89	0·78	0·27	0·12	0·03	0·01	0·16	1·15	3·02	7·81	34·08	1·37	35·45
Daly Waters*	6·77	5·11	4·24	0·94	0·27	0·14	0·03	0·03	0·12	0·68	2·41	3·98	23·19	1·53	24·72
Newcastle Waters†	5·16	3·57	2·35	0·60	0·21	0·26	0·10	0·02	0·14	0·70	1·58	2·63	16·00	1·32	17·32
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	12·52	1·33	13·85
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	7·54	2·39	9·93
Finke*	0·70	2·12	0·48	0·66	0·42	0·49	0·49	0·36	0·16	0·50	0·34	0·52	4·66	2·58	7·24
Charlotte Waters†	0·78	0·63	0·62	0·46	0·36	0·42	0·21	0·19	0·18	0·32	0·48	0·63	3·46	1·82	5·28

* Data from Annual Report 1955–56, The Northern Territory.

† Data from Commonwealth Bureau of Meteorology publications.

TABLE 4

MEAN MONTHLY MAXIMUM AND MINIMUM TEMPERATURES (°F) AT VARIOUS LOCALITIES*

Locality	Years of Record		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Darwin	14	Maximum	89	88	89	90	89	86	86	88	90	91	91	90	89
		Minimum	77	76	76	74	71	68	67	69	74	77	77	77	73
		Range	12	12	13	16	18	18	19	19	16	14	14	13	16
Katherine	15	Maximum	95	94	95	94	91	86	87	90	96	100	100	98	94
		Minimum	75	74	73	68	62	56	56	59	67	75	76	76	68
		Range	20	20	22	26	29	30	31	31	29	25	24	22	26
Daly Waters	30	Maximum	98	97	95	93	88	84	84	89	96	101	102	101	94
		Minimum	76	74	73	67	61	57	54	56	64	71	75	76	67
		Range	22	23	22	26	27	27	30	33	32	30	27	25	27
Tennant Creek	30	Maximum	99	97	95	89	82	76	76	81	89	95	98	100	90
		Minimum	76	75	72	66	59	53	51	54	61	68	73	76	65
		Range	23	22	23	23	23	23	25	27	28	27	25	24	25
Alice Springs	30	Maximum	95	95	90	81	73	67	67	73	80	88	92	95	83
		Minimum	70	68	63	54	46	41	39	43	49	59	64	68	55
		Range	25	27	27	27	27	26	28	30	31	29	28	27	28
Finke	13	Maximum	99	96	93	82	73	68	67	72	81	87	93	98	84
		Minimum	72	71	66	56	48	43	42	44	51	58	65	70	57
		Range	27	25	27	26	25	25	25	28	30	29	28	28	27

* Data from Annual Report 1955–56, The Northern Territory.

(iii) *Grey and Brown Soils of Heavy Texture.*—These are the heavy clay soils of the Mitchell grass plains, which occur mainly in a crescent-shaped belt stretching across the Territory between about lat. 16°S. and 18°S. on the western side and lat. 19°S. to 21°S. on the eastern side. The belt includes most of the Barkly Tableland and the headwater country of the Victoria River. Where rainfall is less than 20 to 25 in. these areas are characteristically treeless, but under higher rainfall scattered trees are typical.

The poorly drained cracking clays of the subcoastal plains have many affinities with this group. They carry reeds and wild rice.

(iv) *Lateritic Podzols.*—These are extensive only in the northern part of the Territory and typically carry annual sorghum and other tall grasses.

(v) *Texture-contrast and Stony Tableland Soils.*—These soils are mainly restricted to the low-rainfall zone south of lat. 23°S. The most frequent pasture type is chenopodiaceous shrubland, but some areas carry short grasses and forbs.

(vi) *Calcareous Desert Soils.*—There are relatively small areas of these south of the 15-in. isohyet. Short grass–forb pastures are most common, with smaller areas of chenopodiaceous shrublands.

(vii) *Yellow Podzols.*—These are also comparatively small in total extent and only occur where rainfall exceeds about 20 in. Pastorally they are similar to the red earths and mostly carry kangaroo grass and perennial sorghum.

(viii) *Meadow Podzols.*—Only small areas in the far north of the Territory belong to this group. The pastures are typically kangaroo grass and *Eriachne* spp.

(*d*) *Vegetation*

With the exception of areas with heavy clay soil, almost all the communities in that part of the Territory where mean annual rainfall exceeds about 15 in. are woodlands characterized by *Eucalyptus* spp. On the other hand, in the area with less than 15 in. eucalypts are of only minor importance and tend to be restricted to small specialized habitats. Thus vegetationally the Territory can be divided roughly into two halves, the northern half in which eucalypts are the most important trees and the southern half in which they are virtually absent. Areas of treeless grassland which are characteristic of heavy clay soils occur in both parts but are much more extensive in the north.

In the southern, non-eucalypt part vast areas are characterized by various species of *Triodia* or *Plectrachne*, which are sclerophyllous grasses forming large tussocks and collectively called spinifex. These occur on the sand plains and dune fields and on most of the stony hills, and generally have a sparse overstorey of scattered shrubs and low trees, of which *Acacia* spp. are the most important. Of smaller extent, but nevertheless of considerable importance, are areas of low woodland or shrubland characterized mainly by *Acacia* spp. The most extensive and best known of these is the mulga (*Acacia aneura*) community, but gidgee (*A. georginae*), witchetty bush (*A. kempeana*), and myall (*A. calcicola*) communities are also fairly common. In the far south relatively small areas of chenopodiaceous

shrubland occur on texture-contrast and similar soils and to a lesser extent on calcareous desert soils.

A feature of the vegetation is the apparent lack of relationship between tree and ground storeys (Perry 1955). Each upper storey community may have several (in some cases as many as 20–30) ground storey communities associated with it, and *vice versa*. This seems to indicate a lack of influence of one storey over the other. For example, Arndt and Norman (1959) found that in an open forest community at Katherine, composed of various *Eucalyptus* spp. over kangaroo grass and perennial sorghum, clearing the trees made little difference to the floristic composition and dry matter yield of the ground storey over two years. Similarly, destruction of the perennial ground cover by heavy grazing did not appear to have any effect on the tree layers over eight years.

Over the whole of the Territory, the vegetation has to withstand long drought periods. In the north the long dry winter is a regular annual occurrence, while in the south dry periods are less regular but are more frequent and may be of longer duration. There is little doubt that these dry periods have been the main selective influence in the evolution of the vegetation. Species are adapted to persistence through the long dry periods rather than to the full utilization of moisture available during the wet season (Christian and Slatyer 1958). This applies particularly to the ground flora. In many cases the ability to persist through the dry seasons is inversely related to pastoral value, and the most firmly established species are often of little or no use. These same species are also the strongest competitors of better-quality plants which may be introduced.

According to their means of survival through long dry periods the species can be divided into three groups, which are worth considering in detail.

(i) *Perennial Drought-resisting Species.*—The species in which the vegetative parts remain alive and green through dry periods fall into this group. During droughts growth is suspended, but it is resumed under favourable conditions. A characteristic feature of many of these drought-resistant species is the development of a tough ligneous "skeleton" which has obvious influences on their pasture value. The great majority of the species are trees and shrubs, including most of the *Eucalyptus* spp. and all the *Acacia* spp. The most extensive species are sclerophyllous hummock-forming grasses collectively referred to as spinifex (*Triodia* spp. and *Plectrachne* spp.). Other important representatives are saltbush (*Atriplex* spp.) and southern bluebush (*Kochia* spp.), which are semi-succulent chenopodiaceous subshrubs. In the drier areas of the Territory, the group includes a number of useful top-feed or browse species, including mulga, gidgee, the southern ironwood, witchetty bush (all *Acacia* spp.), supplejack (*Ventilago viminalis*), and whitewood (*Atalaya hemiglauca*).

(ii) *Perennial Drought-evading Species.*—This group includes all the perennial species in which the leaves, at least, are dead during drought periods and which thus evade rather than resist dry periods. The species resume growth from vegetative buds. The group includes deciduous trees and shrubs and those perennial herbaceous plants in which the above-ground parts die each season.

Pastorally, the most important species of this group are the perennial grasses of the northern part of the Territory. Here the period of stress is a regular annual winter drought. Rapid growth is made during the wet season, but during the long dry season the fodder consists almost entirely of dry mature pasturage of low nutritive value. Cattle on these pastures exhibit a rhythmic growth curve, gaining weight during the wet season and losing it in the dry season.

Typical species include the Mitchell grasses (*Astrebla* spp.), blue grasses (*Dichanthium* spp. and *Bothriochloa* spp.), kangaroo grass (*Themeda australis*), three-awned spear grass (*Aristida* spp.), perennial sorghum (*Sorghum plumosum*), love grasses (*Eragrostis* spp.), and many others.

(iii) *Ephemeral Drought-evading Species.*—The species of this group have some features in common with those of the previous group, in that the vegetative parts are alive only during favourable conditions and thus they evade, rather than resist, droughts. During droughts the only living parts are seeds from which regeneration occurs under favourable conditions. The group is represented throughout the whole of the Territory but the individual species and their pastoral characteristics and significance vary from place to place. In the far north the commonest members of the group are the rapidly growing, tall (3–12 ft) annual sorghums which for most of the year are unpalatable and of extremely low nutritive value. Many representatives of the group grow in the interspaces between the tussocks of perennial grasses which are characteristic of the grasslands of the heavy clay soil of the Barkly Tableland and Victoria River districts. These representatives, of which the Flinders grasses (*Iseilema* spp.) are the most common, are mostly short and relatively nutritious and provide most of the stock fodder during, and for some time after, the wet season. It is only later in the dry season when they have been consumed that stock are forced to graze the less palatable perennial grasses. In both the far north and the heavy clay soil areas representatives of the group are pioneers on overgrazed areas such as occur near bores. Native couch grass (*Brachyachne convergens*) and button grass (*Dactyloctenium radulans*) are particularly important in this respect.

In the southern half of the Territory most of the stock are carried on pastures characterized by short grasses and forbs belonging to this group. The floristic composition and density of these pastures vary from season to season but, in general, summer rains bring forth mainly nutritious and palatable grasses and winter rains less valuable forbs. The commonest grasses are kerosene grass (*Aristida* spp.) and oat grass (*Enneapogon* spp.) and the commonest forbs are composites and crucifers. Following rains, particularly in the summer, these species provide good pasturage but after they are consumed stock are forced to subsist on the associated drought-resisting top-feed species.

(e) *Fires*

Fires have always been an environmental feature of the vegetation of the Territory, and indeed it is probable that in the north, at least, they have been an important selective feature in the evolution of the present flora.

The aborigines deliberately lit fires to assist their hunting and although such fires were generally small, there was no conscious control and a proportion of them must have covered large areas. Probably of equal importance were fires started by lightning during "dry" thunderstorms, which are common near the end of the dry season. These storms are often accompanied by strong winds and fires started under such conditions sometimes spread widely.

Since white settlement commenced, deliberate periodic burning (Plate 1, Fig. 1) of some pasture types has increased the number of fires. On those types which are deliberately burned the object is generally the same, viz. to destroy the coarse, unpalatable material of low nutritive value with the hope of producing a fresh growth of more nutritious green feed, and the comments of Arndt and Norman (1959) on burning of the kangaroo grass–perennial sorghum are therefore generally applicable. They state, "The first fires are started at the end of the wet season, usually where the pasture includes a proportion of mature annuals to provide tinder. However, pasture on Tippera clay loam composed almost wholly of perennials will not burn until well into the dry season unless carrying the previous season's dead growth. The pasture can be burned every year late in the dry season provided it has not been too heavily thinned by grazing.

"Burning at the end of the wet season is often deliberate, and carried out in the hope of producing a 'green shoot' and prolonging the period of nutritious feed. On Tippera clay loam, although the fresh growth after an end-of-season burn seems attractive, its appearance is deceptive and the dry matter yield is only of the order of 100–200 lb per acre."

"Nothing definite is yet known of the long-term effects of burning upon botanical composition or upon the level of production. As indicated earlier, it is likely that frequent fires have been a feature of the environment for a long period, and the present association may well represent a fire subclimax in relative equilibrium. The withholding of fire for a long period may thus have a greater effect upon species composition than frequent burning."

(*f*) *Animals*

The main animals which have influenced native pastures are marsupials, termites and other insects, and, since white settlement, cattle. Buffaloes have also been introduced but are restricted to coastal, high-rainfall areas in the far north.

Under natural conditions marsupials, although present in large numbers, probably had little effect on the pastures. However, in some parts the additional grazing pressure due to cattle has increased their influence. Termites and other plant-eating insects are abundant but their effect on pastures is not known.

In general the comparatively short period of pastoral occupation has had little effect on most pasture types and over-grazing is limited to small areas. However, gradual intensification of the industry in the future will increase grazing pressure and the condition and trend of the pastures will have to be carefully watched if productivity is to be maintained.

IV. Pastoral Industry

(a) *General*

The pastoral industry of the Northern Territory is administered in four districts which correspond with the statistical divisions and which have some distinctive characteristics. They are the Darwin and Gulf district in the far north, the Victoria River district of the north-west, the Barkly Tableland district in the central eastern part, and the Alice Springs district in the south.

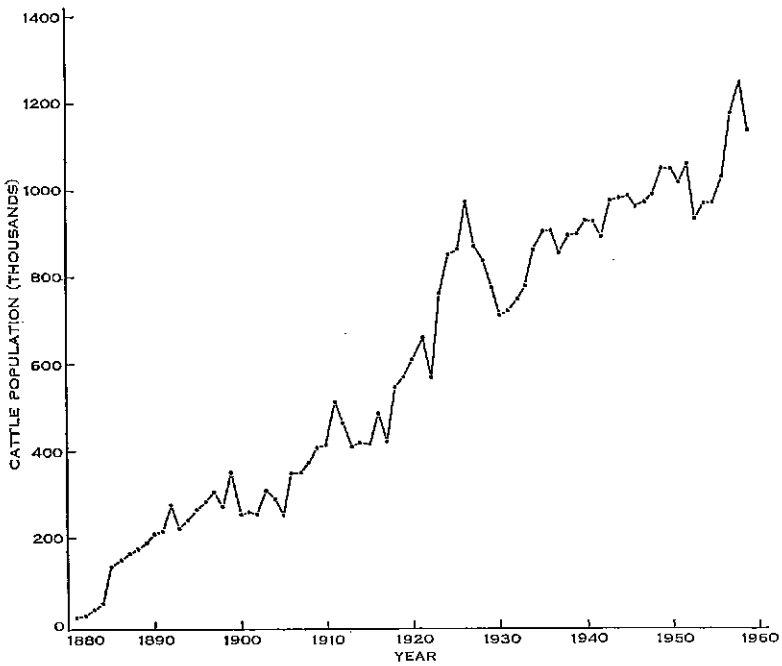

Fig. 2.—Cattle population of the Northern Territory, 1880–1959.

The development of the pastoral industry in the Northern Territory began between 1870 and 1880, and since that time there has been a fairly steady rise in cattle numbers to over 1,100,000 in 1959 (Fig. 2). The fluctuations are primarily due to climatic conditions, especially drought periods, but variations in price have also had some effect.

Most of the present properties were established by 1910. Settlement of the northern part mainly proceeded as a gradual westward movement from Queensland, across the Barkly Tableland, to the Victoria River and Darwin and Gulf districts, though a few of the far north-western properties were settled from Western Australia at the time of the Halls Creek gold rush. The Alice Springs district was mainly settled from South Australia, but made little progress until after 1929, when the railway to Adelaide was completed.

Sheep have been tried in all districts but have been unsuccessful, mainly owing to the difficulty of maintaining flock numbers in a hot climate, on harsh pastures, and against large numbers of dingoes. By 1957 there were only 30,000 sheep and these were restricted to the Alice Springs district. In general most of the Northern Territory is more suited to cattle than sheep, the possible exception being the barley Mitchell grass plains of the Barkly Tableland. Although Christian and Stewart (1954) state that "it is unlikely that there will be any greater expansion of the sheep industry . . . at least not until regional development has reached a more advanced stage", one property (Avon Downs) on this pasture land successfully ran sheep from 1882 until 1919 (Bauer 1959). The sheep were sold in 1919 mainly because of dingoes and increased cost of management. More intensive development will serve to reduce these difficulties and it is possible that some, at least, of the barley Mitchell grass plains may become sheep country. However, one of the observations made by Christian and Stewart (1954) and given as a possible reason for the lack of success with sheep on the Barkly Tableland is the lower proportion of highly nutritive forbs present during the winter period compared with the sheep-carrying Mitchell grass pastures of Queensland. This is probably partly the result of the more strictly defined summer rainfall on the Barkly Tableland.

Buffaloes were introduced to the far northern coastal country before the end of the nineteenth century. There has been no attempt to control them and in the past they have been merely hunted and shot for their hides. However, a more recent development is to tame them for export to the east as draft animals.

(*b*) *Management*

The present cattle industry is conducted on a very extensive system (Kelly and Williams 1953) with large areas (mostly between 1000 and 6000 sq. miles) in each property, few or no fences, and little or no control of cattle movements other than that imposed by distances between watering points (Plate 1, Fig. 2). There is little segregation of stock and in extreme cases stock of all ages and both sexes run together. On better managed properties some classes of stock are separated but rarely is there any attempt to control breeding by segregating males and females.

Under such conditions it is not possible to control ticks and other parasites adequately.

There is also little or no conscious attempt at pasture management, management practices being confined to management of animals according to their condition. Where the industry depends largely on bores for stock water and short-term surface waters are available during and shortly after the wet season, there is, in effect, a form of rotational grazing. During the wet season stock graze near the surface waters and pastures near the bores are spelled. As the surface waters dry, the stock are moved to the bores.

The only other form of pasture management is the periodic, if somewhat haphazard, burning of some pasture types to destroy coarse material and to encourage the production of small amounts of better-quality fodder.

A feature in which the industry differs from that in some overseas countries is that stock are held on a single property throughout the year and there are no distinct seasonal pastures. This is due to the relatively uniform nature of the country, a product of the lack of relief.

The general lack of pasture management, the low and fluctuating level of nutrition, low branding and turn-off percentages, and the low intensity of property improvements are characteristic of the cattle industry.

(c) *Markets and Transport*

The remoteness of the Territory from stable markets has had a retarding influence on the development of the cattle industry. The four districts differ in their accessibility to markets and this is reflected in the standard of development of the industry in each district.

The Darwin and Gulf district has never had a stable outlet for its stock and the industry in that district is the most primitive.

Except for small numbers sent to Wyndham meatworks from nearby areas, stock from the Victoria River and Barkly Tableland districts are sent east to Queensland, whence the original development proceeded. This market is a traditional one and has little relation to the needs of the industry. Stock are walked to the railhead at Dajarra or Mt. Isa and then railed 600 miles to the killing works on the coast. Those from the westernmost properties walk about 1000 miles. They are driven 8 to 10 miles per day along stock routes provided with waters every 16 to 20 miles and which, by the end of the droving season, are severely overgrazed. Under these conditions only stock old enough and strong enough to walk the distance are marketable and although both districts can, and do, produce fats, weight losses on the long journey are heavy and the condition of stock normally deteriorates substantially before they reach the killing works. There has been some slight development of road transport but distances and costs are prohibitive and the real need is for the development of closer markets.

In contrast to the other three districts, the Alice Springs district is served by direct rail link to a stable market at Adelaide and this is reflected in the general efficiency and prosperity of the industry in that district. All the properties are relatively close to the rail trucking centres, which means that cattle of any age can be turned off and weight losses en route to market are relatively low. In recent years road transport from property to railhead has proved economical compared with walking and is rapidly gaining in popularity.

(d) *Potential*

Climatically, the Territory can be divided into two broad zones differing widely in potential and also in the means through which this potential may be achieved.

(i) *High-rainfall Zone.*—This is the northern zone where rainfall exceeds 25–30 in. and is sufficient for arable agriculture or for the growth of introduced pasture legumes. Work at the C.S.I.R.O. Katherine Research Station (Christian, Norman,

and Arndt (in press); Norman 1959; Division of Land Research and Regional Survey 1959) has shown that where soil and topography are suitable, peanuts, grain sorghum, sown pastures, and annual fodder crops can be grown successfully. It can therefore be expected that the cattle industry in these areas will develop ultimately towards intensive fattening, and potential production is vastly greater than present output (Christian 1959*b*).

The intensive development of the high-rainfall zone would be likely to influence the hinterland within a radius of at least 300 miles (almost all the Victoria River district and about a third of the Barkly Tableland district), first, by providing a market for store cattle, and secondly by providing concentrates which could be used as a winter supplement for breeding stock.

(ii) *Low-rainfall Zone.*—This is the southern zone where rainfall is not adequate for growing sown pastures and fodder crops. Although at present this region, by virtue of its accessibility to markets, higher quality of pasture, and relative freedom from ticks, supports a more productive cattle industry than the northern zone, its potential is not so great since improvement is likely to be limited to better utilization and management of native pastures and to improved animal husbandry practices. Development of this zone will be in the nature of a gradual intensification of management in the following stages:

(1) Provision of adequate stock waters for full utilization.

(2) Subdivision by fences for pasture management and breeding control.

(3) Improvement of stock through breeding and selection; better control of parasites and diseases; possibly supplementary feeding.

(4) Development of improved marketing and transport facilities.

All these considerations, of course, apply equally to the northern zone.

V. Description of Pasture Lands

Nineteen pasture lands have been recognized and are described below. They have been classified into eight main pasture groups, the general characteristics of which are summarized in Table 5.

(*a*) *Mitchell Grass Country (48,500 Sq. Miles)*

(i) *Barley Mitchell Grass (Plate 2, Fig. 1)*

(1) *Area.*—24,400 sq. miles.

(2) *Location.*—This country comprises most of the Barkly Tableland and the associated headwaters of the Georgina River, as well as small areas in the headwaters of Sturt Creek and near Alice Springs.

(3) *Environment.*—It is restricted to flat to very gently sloping treeless plains with heavy clay soils developed on Tertiary or Recent alluvia. The mean annual rainfall is mostly 15 to 20 in. but in small areas is as low as 8 in.

(4) *Composition and Structure.*—The perennial component consists of almost pure stands of barley Mitchell grass (*Astrebla pectinata*), which is a drought-evading tussock grass 9 to 18 in. high (inflorescence 18 to 30 in.) and 6 to 12 in. in diameter.

TABLE 5

GENERAL CHARACTERISTICS OF THE MAIN PASTURE GROUPS

Main Pasture Group	Area (sq. miles)	Component Vegetation Types	Soil	Mean Annual Rainfall (in.)	Present Stocking Rate	Pasture Lands
Mitchell grass country	48,500	Perennial drought-evading tussock grasses interspersed with ephemeral drought-evading grasses and forbs	Heavy clays	Mainly 15–30; smaller areas 8–35	8–20	Barley Mitchell grass; barley Mitchell grass and other perennial grasses; inferior Mitchell grass and other perennial grasses
Short grass–forb country	56,400	Ephemeral drought-evading grasses and forbs mostly under perennial drought-resisting top-feed species	Mainly red earths, some calcareous desert and alluvial soils	Mainly 5–12	5–10	Short grasses and forbs; short grasses and forbs on flood plains and outwash plains; short grasses and forbs on low-lands mixed with hilly country
Chenopod country	6,100	Perennial drought-resisting shrubs interspersed with ephemeral drought-evading species in good seasons	Heavy clays	5–30	60–100	Northern bluebush
			Texture-contrast soils; calcareous desert soils	5–10	2–5	Bladder saltbush and southern bluebush
Spinifex country	221,200	Perennial drought-resisting hummock grasses	Red clayey sands and sandy red earths	5–25	0	Soft spinifex plains; hard spinifex sand plains; spinifex dune fields

TABLE 5 (*Continued*)

Main Pasture Group	Area (sq. miles)	Component Vegetation Types	Soil	Mean Annual Rainfall (in.)	Present Stocking Rate	Pasture Lands
Semi-arid upland country	23,700	Perennial drought-evading tussock grasses under eucalypt woodland	Light to medium-textured	17–30	0–4	Three-awned spear grass
Higher-rainfall upland country	60,300	Mainly perennial drought-evading tussock grasses under eucalypt woodland	Light to medium-textured	Mainly 25–60; small areas as low as 15	0–10	Kangaroo grass–perennial sorghum; kangaroo grass on lowlands mixed with hilly country; annual sorghum and other tall grasses
Flooded and coastal country	13,100	Mainly perennial drought-evading species	Cracking heavy clays, meadow podzols, and various saline soils	30–60 seasonally flooded	0–10 including buffaloes	Reeds–wild rice; kangaroo grass–*Eriachne* spp.; coastal country
Rugged country	94,400	Various	Rock outcrop or shallow and skeletal	5–60	0	Rugged and otherwise inaccessible country

The tussocks are generally about 2 ft apart and situated on pedestals 3 to 6 in. high. Other perennial drought-evading tussock grasses of similar size which occur sparsely in those areas where mean annual rainfall exceeds 15 in. are bull Mitchell grass (*Astrebla squarrosa*), weeping Mitchell grass (*A. elymoides*), feathertop (*Aristida latifolia*), and native panics (*Panicum whitei* and *P. decompositum*). Where rainfall is less than 15 in. the associated perennial grasses are limited to feathertop and neverfail (*Eragrostis xerophila*).

The spaces between the perennial grass tussocks are almost bare in adverse seasons, and are usually so at the end of each dry season. During and following favourable wet seasons they are covered with a fairly dense growth of ephemeral drought-evading grasses and forbs generally 6 to 12 in. high. Of these Flinders grasses (*Iseilema* spp.) are the most common. Other grasses include native couch (*Brachyachne convergens*) and button grass (*Dactyloctenium radulans*). Forbs are less common but include sidas (*Sida* spp.), malvastrum (*Malvastrum spicatum*), tar-vine (*Boerhavia diffusa*), and a number of composites and legumes. In wetter-than-average seasons, particularly in the higher-rainfall areas, dense growths, 2 to 3 ft high, of annual sorghum occur.

(5) *Associated Minor Pasture Communities.*—Barley Mitchell grass pastures occur in large relatively uniform tracts and probably occupy 80 per cent. or more of the area mapped as this pasture land. Also included in the area are shallow depressions characterized by weeping Mitchell grass (*Astrebla elymoides*), browntop (*Eulalia fulva*), and blue grasses (*Dichanthium* spp. and *Bothriochloa* spp.), and low gravelly rises or small "deserts" carrying either short grass–forb or three-awned spear grass pastures. In depressions and distributary areas small areas of northern bluebush (*Chenopodium auricomum*) also occur.

(6) *Growth Cycle and Pastoral Value.*—The pasture consists entirely of drought-evading species, some perennial and some ephemeral. At the beginning of the wet season, after adequate rain has fallen, both perennials and ephemerals shoot and grow rapidly, the former from perennating buds and the latter from seeds. Unless the season is unusually dry a fairly dense cover of perennial grasses interspersed with ephemeral grasses and forbs rapidly develops. Dry matter yields are of the order of $\frac{1}{2}$ to $\frac{3}{4}$ ton/acre. This growth is palatable and nutritious and cattle gain weight. By the end of the wet season the perennial grasses have matured to dry, coarse, unpalatable, and nutritionally poor pasturage and cattle selectively graze the ephemerals, which although dry are more palatable and nutritious. This continues until the ephemerals are consumed, after which cattle are forced to graze the perennial pasturage, which does not provide even a maintenance diet and on which they lose weight. At the beginning of the next wet season the cycle starts again.

In unusually poor wet seasons there is little or no growth of either ephemerals or perennials and the pasture continues to deteriorate. In such years the carrying capacity falls to a very low value, often considerably below that of adjacent normally poorer pasture types, and unless stock are moved mortalities occur.

Because of the poor moisture characteristics of the heavy soils, little or no pasture growth occurs with falls of rain less than about $1\frac{1}{2}$ or 2 in. During the dry

season smaller falls may cause considerable damage because the standing dry pasturage "blackens" and becomes virtually useless.

During the dry season, as well as the general low level of nutrition due to the shortage of carbohydrates and proteins, there is evidence of mineral deficiencies in some areas. On the Barkly Tableland Barnes and Jephcott (1955) have demonstrated a phosphate deficiency and on somewhat similar pastures in north Queensland Moule (1948) has show a copper deficiency.

(7) *Stock Waters.*—Most of the area is characterized by widely spaced shallow stream-lines which flow only for short periods after heavy rains and in which there are few permanent water-holes. The streams are mostly unsuitable for dams because of the gentle topography.

Over most of the area ample supplies of water for the pastoral industry can be obtained by sinking bores, generally to a depth of less than 500 ft, to tap subartesian sources (Traves and Stewart 1954). Water rises in the bores and is mostly pumped from less than 300 ft. Most of the bores produce plentiful supplies but quality is variable and only about 50 per cent. yield water suitable for human consumption. About 90 per cent. yield water fit for stock.

Because of the impermeable nature of the soils and the very gentle topography there are large numbers of small ephemeral surface waters after heavy rains. For the same reasons suitable sites for the construction of surface catchment tanks are plentiful. Such tanks could be used to provide stock waters where underground supplies are unsuitable.

(8) *Present Management Practices.*—Other than protection from fires there is no conscious attempt at pasture management. The prevalence of small surface waters after heavy rains provides a form of pasture management in that stock concentrate around them, thus spelling the pastures near bores.

(9) *Present and Potential Productivity.*—On the assumption that cattle can graze within a 5-mile radius of water Christian and Stewart (1954) estimated the present stocking rate of this type of country in the Barkly Tableland district to be between 12 to 15 beasts per sq. mile. These figures probably also apply to the small areas in the Victoria River and Alice Springs districts. However, gradual intensification of watering points to the stage that all pasture is within 3 miles of water would nearly treble this rate. The provision of fences and other improvements would allow the introduction of better pasture management and stock husbandry practices which would greatly increase productivity per beast.

In about one-third of the area of this country (north-western part of the Barkly Tableland and the small areas in the Victoria River district) achievement of this level of potential productivity is tied to future intensive agricultural and pastoral development of the northern higher-rainfall part of the Territory which could provide a market for its turn-off. Cattle from the other two-thirds would be marketed in the same centres as at present, that is, those from the eastern Barkly would continue to go into Queensland and those from the small areas in central Australia to South Australia.

The large area and comparatively high carrying capacity, both present and potential, of this pasture land make it one of the most important in the Northern Territory.

(10) *Reaction to Grazing.*—On the whole the pasture is remarkably resistant to grazing. Light to medium stocking rates have little or no effect and even under heavy grazing there is only a tendency for a reduction in density of the perennial tussock grasses. Floristically there is a tendency for feathertop (*Aristida latifolia*) to become more common at the expense of barley Mitchell grass (*Astrebla pectinata*). Extremely heavy grazing such as occurs close to waters and on stock routes is necessary to cause appreciable deterioration. In these places the perennial constituents are destroyed and the ground may be bare during the dry season. Annual species such as native couch grass (*Brachyachne convergens*) and button grass (*Dactyloctenium radulans*) are present after rain.

The results of grazing experiments with sheep on Mitchell grass country in south-west Queensland (Roe 1941; Roe and Allen 1945) support these observations.

(ii) *Barley Mitchell Grass and Other Perennial Grasses* (*Plate 2, Fig. 2*)

(1) *Area.*—5000 sq. miles.

(2) *Location.*—This country occurs mostly in the Victoria River district and is associated with the headwaters of the Ord and Victoria Rivers.

(3) *Environment.*—It is associated with gently undulating to undulating country, mainly on Cambrian volcanics with small areas on Mesozoic shales. It is restricted to heavy clay soils, most of which are very stony on the surface, under a mean annual rainfall of about 15 to 25 in. In some parts it occurs as a treeless grassland but more commonly it is a grassland with widely spaced shrubs and low trees, particularly nutwood (*Terminalia arostrata*) and rosewood (*T. volucris*). Less common are bean tree (*Bauhinia cunninghamii*), bloodwood (*Eucalyptus terminalis*), whitewood (*Atalaya hemiglauca*), supplejack (*Ventilago viminalis*), konkerberry (*Carissa lanceolata*), and mimosa (*Acacia farnesiana*).

(4) *Composition and Structure.*—This pasture is generally similar in nature to the previous one but is much more variable from place to place and is characterized by several perennial drought-evading tussock grasses rather than a single one. The commonest of these are barley Mitchell grass (*Astrebla pectinata*), native panic (*Panicum whitei* and *P. decompositum*), blue grasses (*Dichanthium fecundum* and *Bothriochloa intermedia*), feathertop (*Aristida latifolia*), and bull Mitchell grass (*Astrebla squarrosa*). Less common are weeping Mitchell grass (*A. elymoides*), browntop (*Eulalia fulva*), beard grass (*Chrysopogon fallax*), bunch spear grass (*Heteropogon contortus*), and white grass (*Sehima nervosum*). The tussock grasses are mainly 9 to 18 in. high (inflorescence to 36 in.) and 3 to 12 in. in diameter and are somewhat more widely (12 to 36 in. apart) and less regularly spaced than in the previous type.

Normally the spaces between the tussocks have a fairly dense cover of ephemeral drought-evading species of which Flinders grasses (*Iseilema* spp.) are by far the most common but which also include native couch grass (*Brachyachne convergens*),

love grass (*Eragrostis japonica*), barnyard grass (*Echinochloa colonum*), and oat grass (*Enneapogon* spp.). These are all short species (3 to 12 in. high). Forbs are more important, both in variety and density, than in the barley Mitchell grass pastures. Several of these, including camel bush (*Trichodesma zeylanicum*), sesbania pea (*Sesbania benthamiana*), rattlepod (*Crotalaria trifoliastrum*), *Hibiscus ficulneus*, *Aeschynomene indica*, and *Cleome viscosa*, overtop the perennial grasses, but there are also many short (3 to 12 in.) species. These include malvastrum (*Malvastrum spicatum*), yellow daisy (*Flaveria australasica*), sidas (*Sida fibulifera* and *S. spinosa*), sensitive plant (*Neptunia* spp.), indigo (*Indigofera linifolia*), tar-vine (*Boerhavia diffusa*), virbene (*Psoralea cinerea*), stinkweed (*Pterigeron odorus*), roly-poly (*Salsola kali*), and a number of legumes.

(5) *Associated Minor Pasture Communities.*—Unlike the previous type, which occurs in large uniform tracts and occupies 80 per cent. or more of its mapped area, this type occurs only on the flatter parts of a rolling topography and is intimately mixed with several other pasture communities. It occupies about 50 to 70 per cent. of its mapped area, the other 30 to 50 per cent. consisting of:

(*a*) Steep, stony, hill slopes, mainly inaccessible to stock, and in any case carrying a pasture consisting mainly of unpalatable and nutritionally poor annual sorghum. Some hills in the lower-rainfall areas carry spinifex (*Triodia* spp.).

(*b*) Large numbers of small ephemeral drainage channels and their associated small frontages which carry pastures mainly consisting of medium-height (about 3 ft) perennial drought-evading grasses, particularly kangaroo grass (*Themeda australis*) and white grass (*Sehima nervosum*).

(*c*) Gently undulating red soil areas which in the higher-rainfall parts carry pastures similar to the kangaroo grass–perennial sorghum type and in the lower-rainfall parts carry short grass–forb pastures, in most cases under eucalypt woodland.

(6) *Growth Cycle and Pastoral Value.*—The pasture consists mostly of drought-evading species and has a similar growth cycle to the previous type. However, it is nutritively better, has a slightly higher carrying capacity, and produces a higher proportion of fat cattle. Collectively these features are probably due to more fertile soils, greater diversity of pasture species, and the more diverse nature of the country. In addition, the scattered shrubs and low trees, many of which are drought-resistant and green throughout the dry season, provide limited amounts of top feed. Notwithstanding these advantages, cattle lose weight during the dry season.

(7) *Stock Waters.*—In the relatively intense drainage system there are many ephemeral water-holes but the few permanent ones are restricted to the larger channels. Many of the streams are either too steep and narrow or too large for dams suitable for stock waters and much of the volcanic country is too stony for the construction of surface catchment tanks.

Over most of the country supplies of stock water have been obtained by boring. The bores vary tremendously in depth and in the quality and quantity of supplies and there is a greater proportion of failures than on the Barkly Tableland.

The difficulty of obtaining suitable supplies of water has retarded development in some parts. However, with more determined efforts and greater expenditure it should be possible to water adequately all the pasture land either from bores or by constructing tanks or dams.

(8) *Present Management Practices.*—The pasture is protected from fires, but other than this there is no conscious pasture management.

(9) *Present and Potential Productivity.*—The present stocking rate varies from about 10 to 20 cattle per sq. mile. Cattle are walked to Wyndham or else over the much longer distance to markets in Queensland, and therefore are not turned off until they are four or more years old. At this age fat cattle can be produced but by the time they reach Queensland they are in only store condition. As long as these conditions persist financial return will be low and productivity is not likely to be greatly increased. However, the intensive development of higher-rainfall country (which is within 300 miles of most of this pasture) would provide an outlet for both fats and young store cattle and productivity would probably increase rapidly. The provision of enough waters to bring all the pasture within 3 miles of water would increase the stocking rate to 30 to 50 beasts per sq. mile, and the construction of fences and other improvements would greatly increase production per breeder. For example, the present branding percentage of near 30 per cent. could be raised to over 60 per cent. and present turn-off percentage of about 7 per cent. could increase to at least 20 per cent.

(10) *Reaction to Grazing.*—The pasture withstands grazing well. With heavy stocking there is a tendency for the barley Mitchell grass (*Astrebla pectinata*) to be replaced by the less palatable feathertop (*Aristida latifolia*) and blue grass (*Dichanthium fecundum*) and for a greater density of smaller tussocks to be produced. Prolonged heavy stocking causes the destruction of perennial grasses which are replaced by annuals.

(iii) *Inferior Mitchell Grass and Other Perennial Grasses (Plate 3, Fig. 1)*

(1) *Area.*—19,100 sq. miles.

(2) *Location.*—Most of this country is north of lat. 18°S. (approximately Newcastle Waters).

(3) *Environment.*—This pasture is restricted to heavy clay soils developed on Recent or Tertiary alluvia, basic sediments, or volcanics, mostly with a mean annual rainfall greater than about 25 in. The topography is flat to undulating. Some areas occur as treeless grasslands but commonly there are scattered trees, particularly coolibah (*Eucalyptus microtheca*). In some parts bean tree (*Bauhinia cunninghamii*), mimosa (*Acacia bidwillii*), or *Terminalia* spp. occur.

(4) *Composition and Structure.*—The pasture is composed mainly of perennial drought-evading tussock grasses including many of the same species as those of the two previous pasture lands or closely related species but mostly in taller (mostly 3 to 6 ft) and denser stands. In general they produce a greater bulk of less palatable and nutritively poorer material. The common species are bull Mitchell grass (*Astrebla squarrosa*), blue grasses (*Dichanthium fecundum, D. superciliatum, Both-*

riochloa ewartiana, and *B. intermedia*), *Ophiuros exaltatus*, native panics (*Panicum* spp.), beard grass (*Chrysopogon fallax*), feathertop (*Aristida latifolia*), browntop (*Eulalia fulva*), and *Arundinella nepalensis*. In some parts annual sorghums (*Sorghum* spp.) growing to a height of 3 to 15 ft are common. The short ephemeral drought-evading grasses and forbs which provide the more nutritious part of the fodder in the previous pasture type are much less important in this type and those which occur are taller and of a lower nutritive value.

The pasture on those areas in the centre of the Barkly Tableland is shorter and sparser than is general for the type. The common perennial species are native panics (*Panicum whitei* and *P. decompositum*), feathertop (*Aristida latifolia*), and browntop (*Eulalia fulva*).

(5) *Associated Minor Pasture Communities.*—Where the pasture land occurs on alluvium it tends to be in extensive uniform areas with only small areas of creeks and frontage country. On residual country there is an admixture of:

(*a*) Steep, hilly country inaccessible to stock.

(*b*) Red soil country carrying pastures similar to the kangaroo grass–perennial sorghum type.

(*c*) Drainage channels and associated frontage country.

(6) *Growth Cycle and Pastoral Value.*—The component species are all drought-evading species, mostly perennial. They grow rapidly during the wet season and are soon coarse and rank. During the dry season they provide only low-quality pasturage. In some parts, particularly on residual country, top-feed species such as bauhinia (*Bauhinia cunninghamii*), mimosa (*Acacia bidwillii*), nutwood (*Terminalia arostrata*), and rosewood (*T. volucris*) are present. These are mostly deciduous in long drought periods.

(7) *Stock Waters.*—In the northern parts there are many permanent surface waters in the creeks and rivers and in the southern parts suitable supplies are mostly available from underground. In addition the soils and topography are suitable for the construction of surface catchment tanks.

(8) *Present Management Practices.*—In the more northern parts where the pastures are composed of taller and coarser species, periodic burning is practised, but other parts, especially where there is an appreciable content of Mitchell grass, are protected from fires.

(9) *Present and Potential Productivity.*—In those parts near the northern edge of the Barkly Tableland and on the basis of cattle grazing 5 miles from water Christian and Stewart (1954) estimate the carrying capacity at 8 to 10 cattle per sq. mile. Similar stocking rates apply in the Victoria River district and somewhat lower ones further north. Increasing the density of stock waters to bring all the pasture within 3 miles of water would probably proportionately increase the carrying capacity.

In the northern higher-rainfall areas there is scope for sown pastures and fodder crop production, which would considerably increase the potential productivity, at least on the more favourable parts. However, such developments are unlikely

unless they are associated with the development of large-scale arable agriculture and stock markets in the northern part of the Territory.

(10) *Reaction to Grazing.*—The pasture withstands grazing well but under heavy grazing there is a tendency for the more palatable and nutritious species to be replaced by less palatable ones such as *Ophiuros exaltatus* and tall annual sorghums.

(*b*) *Short Grass–Forb Country* (*56,400 Sq. Miles*)

(i) *Short Grasses and Forbs* (*Plate 3, Fig. 2*)

(1) *Area.*—32,100 sq. miles.

(2) *Location.*—This country occurs mainly in central Australia but small areas extend to the southern parts of the Barkly Tableland and Victoria River districts.

(3) *Environment.*—In central Australia the pasture occurs on flat to gently undulating country generally flanking the mountain ranges, over a variety of rock types including granites, metamorphics, and sediments and on alluvium, and on a range of soils including shallow and deep red earths, texture-contrast soils, and calcareous desert soils. It is mostly the ground storey of low woodland communities characterized by various *Acacia* spp. including mulga (*A. aneura*), gidgee (*A. georginae*), southern ironwood (*A. estrophiolata*), myall (*A. calcicola*), and witchetty bush (*A. kempeana*). These are palatable and are an important source of top feed. Near the northern edge of its range it becomes progressively more restricted to calcareous soils developed on limestones and it is the ground storey of a sparse eucalypt woodland.

The mean annual rainfall varies from 5 to 20 in. but is mostly less than 15 in.

(4) *Composition and Structure.*—The pasture is characterized by a variety of short (3 to 12 in.) ephemeral grasses and forbs but the floristic composition, density, and height vary from season to season. There is a tendency for the short grasses, such as kerosene grass (*Aristida arenaria*) and oat grass (*Enneapogon* spp.), to be predominant after summer rain and for short forbs, such as white daisy (*Helipterum floribundum*), yellow daisy (*H. charsleyae*), *Ptilotus helipteroides*, and *Stenopetalum* spp., to follow winter rain. In the far southern parts, and particularly on texture-contrast soils, *Bassia* spp. and other chenopods are more important. In the northern parts, where winter rains are unusual, forbs are less common. Occasional tussocks of the perennial woollybutt grass (*Eragrostis eriopoda*), wallaby grass (*Danthonia bipartita*), and *Eriachne helmsii* occur in some parts.

(5) *Associated Minor Pasture Communities.*—Although the tree communities may vary considerably, most of the area mapped has a ground storey of short grasses and forbs. The most important minor communities are areas characterized by woollybutt grass (*Eragrostis eriopoda*) but others include small creeks and frontages, stony hills, and spinifex (*Triodia basedowii*) sand plains.

(6) *Growth Cycle and Pastoral Value.*—Following rains at any season of the year the short grasses and forbs germinate and grow rapidly. Within a week or so they produce a few flowers and set a few seeds, but if adequate water is available

they continue to grow and to produce more seed. With the onset of moisture stress they die and gradually break up and disappear. The ground is virtually bare during prolonged droughts.

The short grasses which constitute the main production from summer rains are palatable and nutritious and cattle fatten rapidly on them. The winter forbs are less valuable.

In central Australia the pasturage available in this country is composed of representatives of two main groups, firstly the ephemeral drought-evading species which provide good fodder for a variable period immediately following rain, and secondly the palatable perennial drought-resisting shrubs and low tree species (mainly *Acacia* spp.) which provide a maintenance diet for stock during periods when there are no short grasses and forbs. In the more northern areas top feed is scarce but the summer rains are heavier and more reliable and there is a higher yield of short grasses.

(7) *Stock Waters.*—There are very few permanent natural water-holes. Over most of the area stock water supplies are available from underground sources but quantity and quality vary tremendously. In some places where such supplies are not available or are difficult to locate, dams and surface catchment tanks have been constructed. However, much of the soil is too permeable, and to enable all the country to be supplied with stock water some method of mechanically sealing tanks and dams is necessary. The development of some parts has been retarded by the difficulty of providing water but ultimately supplies should be obtainable throughout the whole area, although some may be expensive.

(8) *Present Management Practices.*—Except for protection from fire there is little or no conscious pasture management.

(9) *Present and Potential Pastoral Productivity.*—Most of the stock in the Alice Springs district are carried on this and the following pasture land, and their present carrying capacity averages about 7 and mostly lies between 5 and 10 cattle per sq. mile. It is better supplied with stock waters than most other types, and in some areas the pastures are all within three miles of water. However, the provision of enough new waters to bring all parts of the pasture land within three miles would probably at least double the present carrying capacity.

In the Alice Springs district the proximity of the properties to the railhead provides the opportunity to market cattle, either fats or stores, at any age at any time of the year, and has been largely responsible for the relatively high efficiency of the industry in the area. Branding percentage is about 60 per cent. and turn-off percentage averages about 20. Improved pasture management and animal husbandry practices could considerably increase the productivity.

The areas of this country in the Barkly Tableland and Victoria River districts are in a more primitive stage of development and their future development is bound up with the provision of closer markets.

The possibility that clearing trees from the central Australian areas would increase the yield of ground storey plants by making more water available for their

growth is being investigated at Alice Springs. Such treatment may also result in greater density of perennial tussock grasses, for example, woollybutt grass (*Eragrostis eriopoda*). However, during prolonged drought periods stock are maintained by top feed, the removal of which may render the stock more susceptible to heavy drought losses. Ultimately there is likely to be a compromise development, with the density of trees being reduced to encourage better growth of the ground flora, but with enough trees left to provide shade and drought fodder.

(10) *Reaction to Grazing.*—Under light to medium stocking and in average or better years cattle gradually consume the ephemerals, which, however, regenerate from seed when there are adequate falls of rain. Under heavy stocking or during prolonged droughts the ground may be bare for long periods and the surface may erode in susceptible areas. Such places remain bare and unproductive and only by special and expensive treatment can new growth be encouraged. Under heavy grazing top-feed species are grazed as high as animals can reach and subsequent growth is not accessible to stock.

Some areas of this type in the headwaters of the Ord River in the Victoria River district have been severely eroded owing to preferential heavy grazing.

(ii) *Short Grasses and Forbs on Flood Plains and Outwash Plains*

(1) *Area.*—10,900 sq. miles.

(2) *Location.*—This country occurs in the southern half of the Territory.

(3) *Environment.*—It is associated with flat to gently sloping areas of alluvium, along larger streams or adjacent to mountain ranges. The soils are variable but are mainly undifferentiated alluvium, or red earths, with small areas of texture-contrast soils. There is little or no water run-off. The more favoured parts receive water run-on from adjacent land types and thus have more moisture available for plant growth than is directly contributed by rainfall. The common vegetation is a sparse woodland characterized by a mixture of low trees including southern iron-wood (*Acacia estrophiolata*), mulga (*A. aneura*), whitewood (*Atalaya hemiglauca*), supplejack (*Ventilago viminalis*), and others.

(4) *Composition and Structure.*—This is similar to the previous type but because of the generally better moisture status, growth tends to be taller and denser.

(5) *Associated Minor Pasture Communities.*—The greater part (probably 70 to 80 per cent.) of the country mapped as this pasture land is characterized by short grasses and forbs. The remainder is very diverse and includes small areas of creeks and frontages with mainly perennial drought-evading tussock grasses, barley Mitchell grass (*Astrebla pectinata*) plains, northern bluebush (*Chenopodium auricomum*) "swamps", old-man saltbush (*Atriplex nummularia*), and spinifex (*Triodia basedowii*) sand plains and low dunes.

(6) *Growth Cycle and Pastoral Value.*—This is also similar to the previous type but with taller and denser growth which seems, however, to have a somewhat lower nutritive value. Also in this type trees are much sparser and there is less top feed available.

(7) *Stock Waters.*—A number of surface waters are available for short periods after rains but there are few permanent ones. In most places adequate supplies of stock waters are available from underground at relatively shallow depth.

(8) *Present Management Practices.*—As with the previous pasture land there is little pasture management except protection from fires.

(9) *Present and Potential Productivity.*—The present stocking rate is similar to that of the previous pasture land, that is about 7 cattle per sq. mile, but the range is somewhat broader and probably extends from 5 to 20. The higher rates apply to only small areas and are due to the presence of minor areas of high carrying types such as northern bluebush "swamps". The carrying capacity could probably be at least doubled by increasing the density of watering points.

Potentially, however, this pasture land is better than the previous one because of the higher proportion of specially favoured areas on which increased yield may be obtained by water spreading or where it is feasible that fodder crops may be produced under irrigation.

(10) *Reaction to Grazing.*—This is generally similar to that of the previous pasture land but, if anything, this country is more susceptible to surface erosion and significant areas are now scalded and unproductive. The small areas of better pastures, e.g. northern bluebush (*Chenopodium auricomum*) and old-man saltbush (*Atriplex nummularia*), tend to be selectively grazed and in some cases have been completely destroyed.

(iii) *Short Grasses and Forbs on Lowlands mixed with Hilly Country* (*Plate 4, Fig. 1*)

(1) *Area.*—13,400 sq. miles.

(2) *Location.*—This country is restricted to central Australia.

(3) *Environment.*—This pasture essentially consists of areas of the two previous pasture lands associated and intermixed with inaccessible hilly country. The topography varies from alternating lowlands and high (up to 1000 ft) linear ridges to rounded rocky rises and valleys. In all instances there is a proportion, varying from 25 to 75 per cent. of hilly country, inaccessible to cattle and therefore useless for grazing, but often providing a source of run-off water which floods on to the adjacent lowlands.

(4) *Composition and Structure.*—On the accessible parts of the topography the pastures are similar to the two previous pasture lands.

(5) *Associated Minor Pasture Communities.*—As well as a proportion of inaccessible hilly country the lowlands are very variable and contain minor areas of creeks and frontages with perennial drought-evading tussock grasses, pastures characterized by woollybutt (*Eragrostis eriopoda*), old-man saltbush (*Atriplex nummularia*), and many others.

(6) *Growth Cycle and Pastoral Value.*—The growth characteristics of the pastures on the accessible parts are similar to those of the two previous pasture lands but if anything, the pastoral value is somewhat higher mainly owing to the greater diversity of country and available fodders.

(7) *Stock Waters.*—Permanent natural waters are limited to a few rock pools, springs, and water-holes in creeks. In many parts, stock water supplies are available from underground sources but the depth, quality, and quantity are very variable. In other areas tanks and dams have been constructed but the soils are generally permeable and some form of mechanical sealing is necessary to make these a successful proposition.

(8) *Present Management Practices.*—These areas are protected from fires but other than this there is little or no attempt at pasture management.

(9) *Present and Potential Productivity.*—The present carrying capacity varies from place to place and depends on the proportion of hilly country and the way in which the hills and lowlands are distributed. It varies from 0 to 10 cattle per sq. mile. The potential productivity is also variable for much the same reason. In many parts the provision of more waters could double or treble the present carrying capacity. In other parts (e.g. where relatively narrow strips of lowland are separated by long linear inaccessible ranges) the provision of stock waters may be uneconomical because each watering point could support too few cattle. In still other areas, small areas of water spreading or irrigation may be developed on the lowlands using run-off from the hills and the productivity greatly increased.

(10) *Reaction to Grazing.*—Some areas, particularly the steeper slopes of the lowlands and a high proportion of the lowlands in limestone country, are very susceptible to erosion. Some of these have been badly scalded through heavy grazing and are now bare and unproductive.

(c) *Chenopod Country (6100 Sq. Miles)*

(i) *Northern Bluebush (Plate 4, Fig. 2)*

(1) *Area.*—1800 sq. miles.

(2) *Location.*—Most of this pasture land occurs within the Mitchell grass plains of the Barkly Tableland, although small areas occur in the Victoria River and Alice Springs districts.

(3) *Environment.*—This pasture is restricted to seasonally flooded "swamps" and all but a few small patches are on heavy clay soils. The mean annual rainfall seems to have little significance, small areas occurring from as low as 5 in. to as high as 30 in. It mostly occurs as a treeless shrubland but in some areas there is an overstorey of coolibah (*Eucalyptus microtheca*).

(4) *Composition and Structure.*—Northern bluebush (*Chenopodium auricomum*) is a shrub generally 2 to 4 ft high and spreading to 2 to 4 ft diameter. Its density is variable but the centres of the shrubs are commonly 4 to 8 ft apart. The associated plants also vary considerably. In some cases, particularly where the mean annual rainfall is less than about 15 in., bluebush forms almost pure stands, but under high-rainfall conditions there are often scattered perennial tussock grasses, including weeping Mitchell grass (*Astrebla elymoides*), bull Mitchell grass (*A. squarrosa*), feathertop (*Aristida latifolia*), blue grass (*Dichanthium* spp.), browntop (*Eulalia fulva*), native panics (*Panicum* spp.), and *Eriachne nervosa*. Annuals are also sparse in lower-rainfall areas but under higher-rainfall conditions there is a dense growth,

particularly as the flood waters recede. The commonest are virbene (*Psoralea cinerea* and *P. patens*) but many other species of both grasses and forbs are represented. These are mostly short (3 to 12 in.) but a few tall species such as sesbania pea (*Sesbania benthamiana*) also occur.

(5) *Associated Minor Pasture Communities.*—Many of the areas are fairly pure tracts of bluebush pastures. Perennial tussock grasses characterize the edges of the swamps and some of the higher parts and the small distributary channels are commonly fringed with lignum (*Muehlenbeckia cunninghamii*).

(6) *Growth Cycle and Pastoral Value.*—Northern bluebush, which provides the bulk of the fodder, is a drought-resisting shrub with semi-succulent leaves and soft stems. It grows rapidly during and after flooding, and provides succulent and palatable feed of high nutritive value for the whole year. Where a dense growth of forbs occurs they provide an important contribution to the fodder.

(7) *Stock Waters.*—For part of the year the flood waters provide adequate stock water but as these recede cattle become dependent on the few permanent water-holes or on underground supplies which are available in most parts.

(8) *Present Management Practices.*—There is little conscious attempt at pasture management. However, the flood waters render the swamps inaccessible for part of the year and in effect provide a form of management. On at least one property in the Alice Springs district small areas have been fenced and are used for topping off marketable stock.

(9) *Present and Potential Productivity.*—In the Barkly Tableland district Christian and Stewart (1954) estimated the present carrying capacity as 60 to 100 cattle per sq. mile. Similar figures probably apply in the Victoria River district but the small areas in the Alice Springs district probably have slightly lower stocking rates. The provision of more stock waters to enable the stock to utilize the pastures after the flood waters have receded may slightly increase these rates.

The pasture is capable of fattening stock but its potential cannot be realized unless closer markets or better transport facilities are developed to enable the fat cattle to be marketed.

(10) *Reaction to Grazing.*—Bluebush withstands grazing well and is capable of regenerating even after the leaves and stems have been grazed almost to the ground. However, because of its high palatability it is selectively grazed in preference to other pasture types and in some cases has been destroyed. This is particularly noticeable in the Alice Springs district where many areas too small to map are associated with large areas of less palatable pastures.

(ii) *Bladder Saltbush and Southern Bluebush* (*Plate 5, Fig. 1*)

(1) *Area.*—4300 sq. miles.

(2) *Location.*—This pasture land is restricted to the far south of the Territory, but is widespread in South Australia (Adamson and Osborn 1922; Jessup 1951; Osborn 1925; Osborn, Wood, and Paltridge 1932; Wood, 1936, 1937; Woodroffe 1941; Trumble and Woodroffe 1954) and New South Wales (Beadle 1948).

(3) *Environment.*—These pastures occur on flat to gently undulating country, low hills, and low tablelands, mainly on texture-contrast (stony tableland) or calcareous desert soils, mostly over shales or limestones. The soils generally, but not invariably, have a high total soluble salt content. The mean annual rainfall is low (5 to 10 in.) and an appreciable part (1 to 2½ in.) falls during the winter.

The country is mostly treeless, though there are small areas where the pastures occur as the understorey to low woodlands characterized by mulga (*Acacia aneura*), gidgee (*A. georginae*), or myall (*A. calcicola*).

(4) *Composition and Structure.*—The characteristic plants, bladder saltbush (*Atriplex vesicaria*) and southern bluebush (*Kochia astrotricha*), are both low (1 to 2 ft high), spreading (1 to 2 ft dia.) shrubs. The spacing varies tremendously from place to place and the community may consist of only scattered shrubs or may be a fairly dense shrubland with bushes at 3 to 4 ft centres. Following favourable rains the interspaces may carry a fairly dense cover of short grasses and forbs, among which *Bassia* spp. are the most common, but for most of the time the interspaces are fairly or completely bare. Perennial tussocks of barley Mitchell grass (*Astrebla pectinata*) and neverfail (*Eragrostis xerophila*) occur in and around gilgais.

(5) *Associated Minor Pasture Communities.*—Probably 80 per cent. of the area mapped as this pasture land is characterized by either southern bluebush or bladder saltbush. The remainder consists of small creeks and frontages with mainly perennial tussock grasses, steeper slopes of the low hills and escarpments of the low tablelands with very scattered short grasses and forbs, bare sometimes saline clay pans and samphire flats, short grass–forb pastures in which *Bassia* spp. are prominent, and sand dunes generally with hard spinifex (*Triodia basedowii*) or cane grass (*Zygochloa paradoxa*).

(6) *Growth Cycle and Pastoral Value.*—Following adequate rains a dense cover of short ephemeral drought-evading grasses and forbs develops between the bushes. However, such rains are infrequent and normally there is only a sparse to medium dense cover and in prolonged droughts the spaces are bare. The short grasses and forbs are highly palatable and nutritious and stock concentrate on them whilst they are present. When there are no short grasses and forbs stock graze the bluebush and saltbush, which are perennial drought-resisting plants with semi-succulent leaves and which remain fairly palatable and nutritious throughout droughts. The growth and reaction to grazing of bluebush and saltbush have been discussed by Osborn, Wood, and Paltridge (1932), Knowles (1951), and Knowles and Condon (1951).

(7) *Stock Waters.*—There are very few permanent natural waters, though for short periods, immediately after rain, surface water is plentiful in clay pans and gilgais. Supplies of underground water are generally available, but in some places at considerable depth (greater than 1000 ft), and in some parts quality is poor. A number of surface catchment tanks have been constructed and there are suitable sites for many more, but because of the low and unreliable rainfall these tanks must be large enough to last for at least two years and are very expensive. Development of this pasture has been retarded by the expense of providing suitable waters.

(8) *Present Management Practices.*—There is no attempt at pasture management. The pastures are not burned.

(9) *Present and Potential Productivity.*—At present the country has a low stocking rate, probably about 2 to 5 cattle per sq. mile. At these rates bluebush and saltbush are scarcely grazed during good seasons, but during protracted droughts higher stocking rates would cause death of many of the bushes. These rates could be increased by the provision of more waters, thus bringing present ungrazed or lightly grazed country into production, but it is uncertain whether such intensification would be economic.

(10) *Reaction to Grazing.*—Heavy grazing, especially during protracted dry periods, causes destruction of some or all of the valuable perennial saltbush and bluebush, which are replaced by less valuable *Bassia* spp. Similar observations on this type but under sheep grazing were made by Jessup (1951). The germination of seeds and the regeneration of overgrazed areas has been studied by Beadle (1952), Burbidge (1945*b*, 1946*a*), and Wood (1936).

(*d*) *Spinifex Country* (*221,200 Sq. Miles*)

(i) *Soft Spinifex Plains* (*Plate 5, Fig. 2*)

(1) *Area.*—73,100 sq. miles.

(2) *Location.*—This pasture land occurs as a belt stretching across the Territory from east to west and mostly between latitude 18°S. and 21°S. (Newcastle Waters to Tennant Creek).

(3) *Environment.*—It occurs in broad expanses of flat to gently undulating plains mostly lateritic but in some places over arenaceous rocks. Low hills occur in some areas. The soils are coarse-textured and are mainly sandy red earths with some red clayey sands.

The mean annual rainfall varies from about 12 to 25 in.

In the drier parts spinifex is the characteristic plant of the vegetation community, which contains scattered shrubs and low trees (mainly *Acacia* spp. and *Eucalyptus* spp.), but further north it is the understorey in a low (10 to 20 ft) woodland characterized by eucalypts, especially snappy gum (*Eucalyptus brevifolia*), bloodwood (*E. dichromophloia*), and silverleaf box (*E. pruinosa*).

(4) *Composition and Structure.*—Soft spinifex (*Triodia pungens*) is a perennial drought-resisting grass forming large tussocks or hummocks 1 to 2 ft high and mostly 1 to 3 ft in diameter. In some areas feathertop spinifex (*Plectrachne schinzii*), a similar plant, is associated with the soft spinifex and may even assume dominance. The tussocks occupy 30 to 50 per cent. of the ground area. The interspaces are normally fairly bare but plants of perennial grasses such as three-awned spear grass (*Aristida pruinosa*) and citronella grass (*Cymbopogon bombycinus*) occur, and in good seasons there may be a sparse cover of short grasses and forbs.

Shrubs, 2 to 6 ft high, form a generally sparse but uneven cover. Numerous species are represented but *Acacia* spp. and *Eucalyptus* spp. are the most common.

(5) *Associated Minor Pasture Communities.*—Areas mapped as this pasture land are fairly uniformly covered with soft spinifex pastures. In some parts low hills, also carrying soft spinifex, occupy a small proportion of the landscape. There are also widely spaced shallow drainage channels, along which three-awned spear

grass (*Aristida pruinosa*) is common. Near the southern margin there are areas characterized by other types of spinifex including feathertop spinifex (*Plectrachne schinzii*), buck spinifex (*Triodia longiceps*), and hard spinifex (*T. basedowii*).

(6) *Growth Cycle and Pastoral Value.*—Soft spinifex is a drought-resisting plant and remains green for the whole year. After summer rain it starts to grow at a rapid rate but during the rest of the year, even after rains in winter, the plants are inactive.

The bulk of the plant material is composed of spinifex leaves which are strongly lignified (Burbidge 1945*c*, 1946*b*) and form coarse unattractive fodder of low nutritive value. Many of the associated shrub species are not, or only slightly, palatable, although the few which are grazed form a useful contribution to the diet of the cattle.

The soils are mostly very infertile and in some places stock grazing on the pastures exhibit marked phosphate deficiencies.

A useful feature of the pasture is that, although its pastoral value is always low, it does not appreciably deteriorate during long droughts. It is therefore a useful standby for cattle grazed on adjacent areas of normally better pastures (e.g. Mitchell grass), the pastoral value of which falls to almost nothing during protracted droughts.

(7) *Stock Waters.*—There are very few permanent natural waters and few bores have been sunk. However, supplies of underground water should be generally available.

(8) *Present Management Practices.*—Where this country is used it is burnt as often as it will carry a fire, which is about once every 4 or 5 years. During the first year or so after burning there is a greater proportion of more palatable species and also the young growth of spinifex is softer and more palatable. Within 3 to 5 years competition from spinifex reduces the other species to a sparse cover and the tussocks become large enough and close enough to support another fire. The ecological succession following burning of a soft spinifex pasture in Western Australia has been described by Burbidge (1943).

In areas where stock have access to both this and Mitchell grass pastures they develop a voluntary form of rotational grazing and tend to concentrate on the spinifex areas near the end of the dry season when the Mitchell grass pastures are at their poorest, and also after heavy rain when the Mitchell grass areas are boggy.

On some properties stock waters have been developed in these pastures and reserved for use during long droughts.

In Western Australia on similar pastures that have been stocked with sheep Nunn and Suijdendorp (1954) have shown that "deferred grazing" can improve the carrying capacity of degraded areas. However, in the Territory the better-quality plants favoured by "deferred grazing" are not present in the original pasture.

(9) *Present and Potential Productivity.*—The country is virtually unused except for areas immediately adjacent to better pastures, and even in these parts its stocking

rate is low (2 to 5 cattle per sq. mile). Additional small areas are used during droughts.

Potentially the country is likely to remain unstocked unless the spinifex can be wholly or partly replaced by better-quality fodder plants. The poor soils, relatively low rainfall, and strong competition from spinifex will make such replacement a difficult task. Plants of a drought-resisting type, e.g. palatable shrubs, may be more suitable than drought-evading species such as most perennial grasses. If successful the resultant stocking rate is still likely to be low but the area concerned is so large that the total carrying capacity could be important.

(10) *Reaction to Grazing.*—Because only small areas have been stocked and then generally only intermittently it is difficult to assess the effects of grazing. In areas where stock concentrate, such as near the waters, continuous grazing and trampling can destroy spinifex, at least temporarily.

(ii) *Hard Spinifex Sand Plains (Plate 6, Fig. 1)*

(1) *Area.*—58,400 sq. miles.

(2) *Location.*—This pasture land is restricted to the southern half of the Territory.

(3) *Environment.*—It occurs over vast areas of flat to gently undulating plains, with sandy, infertile soils under a mean annual rainfall which varies from 5 to 13 in. The areas are mostly treeless.

(4) *Composition and Structure.*—Structurally it is similar to the previous type. Hard spinifex (*Triodia basedowii*) is also a perennial drought-resisting grass forming large tussocks generally about 1 ft high and 1 to 3 ft in diameter. In old stands most of the plants are in the form of "rings" which are about 1 ft high and 3 to 20 ft in diameter, and in which only the outer part (about 1 ft wide) consists of living plant material. The vegetative cover due to the spinifex is about 30 per cent. The spaces between the tussocks, and between and within the "rings", is mostly bare with only occasional annual and perennial grasses and forbs. There is normally a sparse to medium dense cover of shrubs 2 to 6 ft high of which *Acacia* spp. and *Eucalyptus* spp. are the most important.

Tussocks of feathertop spinifex (*Plectrachne schinzii*) occur sporadically throughout and in some parts, particularly near the higher-rainfall margins, may be more common than hard spinifex.

A fairly complete list of species on 50 sq. miles of this type situated northwest of Alice Springs is given by Chippendale (1958).

(5) *Associated Minor Pasture Communities.*—This pasture land occurs as large tracts of monotonous, uniform country in which spinifex sand plains comprise over 90 per cent. of the area. Small areas of mulga (*Acacia aneura*) occur but in many cases with a spinifex ground storey. There are also isolated hills, sand dunes, drainage lines, and salt pans.

(6) *Growth Cycle and Pastoral Value.*—Hard spinifex grows rapidly after summer rains but during the rest of the year is inactive, although still green. It provides extremely coarse, unpalatable, and nutritionally poor material and has little or no

pastoral value. Some of the associated shrubs are palatable but provide only small amounts of fodder. In some parts, after heavy rains parakeelya (*Calandrinia* spp.), a succulent and palatable forb, also provides small quantities of useful feed (and water).

(7) *Stock Waters.*—There are very few permanent natural waters but suitable supplies for stock are mostly obtainable underground.

(8) *Reaction to Grazing.*—There are very few areas available on which to base any conclusions but it is known that heavy concentrations of stock even for periods of only a few days will temporarily destroy the spinifex tussocks.

(iii) *Spinifex Dune Fields* (*Plate 6, Fig. 2*).—Areas totalling 89,700 sq. miles of this country occur in the southern half of the Territory. It consists of regular or irregular systems of dunes and swales, all stabilized by spinifex. Hard spinifex (*Triodia basedowii*) is characteristic in the southern parts including the Simpson Desert (Crocker 1946), soft spinifex (*Triodia pungens*) in the northern parts, and feathertop spinifex (*Plectrachne schinzii*) in the intermediate parts.

In its characteristics this country is similar to those of the two previous types, and in the same way, only areas adjacent to better country are grazed. The dune fields are less stable (from wind erosion) than the plains of the previous pasture lands, and will probably always remain in an undeveloped and unstocked condition.

(e) *Semi-arid Upland Country (23,700 Sq. Miles)*

(i) *Three-awned Spear Grass* (*Plate 7, Fig. 1*)

(1) *Area.*—23,700 sq. miles.

(2) *Location.*—This country occurs in the northern part of the Territory mostly between latitude 15°S. and 18°S.

(3) *Environment.*—The topography is flat to undulating and the soils light to medium-textured either on laterite or residual on mainly acid rocks. Many are shallow or gravelly. In these respects this country is similar to the annual sorghum and other tall grasses pasture land but rainfall is lower (17 to 30 in.) and falls during a shorter period. The vegetation is eucalypt woodland with trees mostly 15 to 30 ft high. Bloodwood (*Eucalyptus dichromophloia*) is the commonest species but many others are characteristic in various habitats.

(4) *Composition and Structure.*—These rather sparse pastures are characterized by three-awned spear grass (*Aristida pruinosa*), a perennial tussock grass generally 2 to 3 ft high with tussocks 3 to 6 in. in diameter. Several other perennials, including kangaroo grass (*Themeda australis*), white grass (*Sehima nervosum*), beard grass (*Chrysopogon pallidus*), and citronella grass (*Cymbopogon bombycinus*) occur infrequently. Soft spinifex (*Plectrachne pungens*) occurs at a variable but generally low density. Between the perennial tussocks numerous species of short grasses, particularly *Aristida* spp., and forbs provide a sparse cover. Occasional top-feed species such as supplejack (*Ventilago viminalis*) also occur.

(5) *Associated Minor Pasture Communities.*—A large proportion of the area mapped is covered by three-awned spear grass. The most important associated areas are the lancewood (*Acacia shirleyi*) forest country on which there is a very sparse

grass cover. Other minor communities are restricted to small areas of hills and escarpments, widely-spaced, shallow stream-lines and associated small frontages, and small areas of heavy clay soil with inferior Mitchell grass pastures. Near the drier margin there are also small areas of soft spinifex (*Triodia pungens*) pastures.

(6) *Growth Cycle and Pastoral Value.*—The pastures respond quickly to rain and provide good feed in the early part of the wet season. This is a valuable feature where they occur adjacent to various Mitchell grass pastures which do not respond so rapidly or to such small falls. However, even during the wet season the quality of the fodder is poor and the carrying capacity is low. During the dry season, when both annual and perennial components are mature and dry, the pasturage is of very poor quality.

(7) *Stock Waters.*—There are very few permanent natural waters and little information is available on underground supplies.

(8) *Present Management Practices.*—Although most of the country is not stocked, it is subject to periodic fires. Where this type occurs adjacent to Mitchell grass pastures cattle themselves tend to impose a form of rotational grazing. In the early part of the wet season they concentrate on the spear grass pastures which respond more quickly than the Mitchell grass. Cattle also prefer spear grass areas during very wet periods when the Mitchell grass areas are boggy. At other times they mostly graze on the Mitchell grass pastures. This is not necessarily a desirable form of management.

(9) *Present and Potential Productivity.*—At present the country is mainly unstocked except where it occurs immediately adjacent to better pastures. In these parts, although the carrying capacity is low, the pasture makes a valuable contribution to the diet of the animals for short periods.

The potential productivity is also low. The soils are poor, and in any case the rainfall is inadequate for sown pastures. It may be possible to introduce better-quality exotic species into the native pastures especially in the higher-rainfall parts but this is likely to increase the carrying capacity only slightly (Christian and Stewart 1954).

(10) *Reaction to Grazing.*—Little is known of the effect of grazing. Christian and Stewart (1954) state that "excessive grazing may lead to the dominance of harsh perennial and annual species".

(*f*) *Higher-rainfall Upland Country (60,300 Sq. Miles)*

(i) *Kangaroo Grass–Perennial Sorghum Pastures (Plate 7, Fig. 2)*

(1) *Area.*—9200 sq. miles.

(2) *Location.*—This country occurs in the northern part of the Territory mostly in the Darwin and Gulf district, but with small areas in the northern part of the Victoria River district.

(3) *Environment.*—It occurs on flat to gently undulating country with red earth or yellow podzolic soils, mostly over limestones but with smaller areas on volcanics and alluvium. The mean annual rainfall varies from about 25 to 50 in. The vegetation is a woodland (or low open forest) characterized by eucalypts, 20

to 30 ft high with a canopy cover of 10 to 15 per cent. (Arndt and Norman 1959). At Katherine, on Cambrian limestone, the most common are box (*Eucalyptus tectifica*) and bloodwood (*E. latifolia*). Northern ironwood (*Erythrophleum chlorostachys*) is frequent. On volcanics, silverleaf box (*Eucalyptus pruinosa*), and on alluvia, box (*E. tectifica*) and ghost gum or carbeen (*E. papuana*) are more common. Many of the tree species are deciduous in the dry season.

(4) *Composition and Structure.*—The pasture is characterized by a fairly dense growth (basal area 3·5 per cent.) of perennial drought-evading tussock grasses, mostly about 3 ft high, but with inflorescences as high as 8 ft. The common grasses at Katherine are perennial sorghum (*Sorghum plumosum*), kangaroo grass (*Themeda australis*), and beard grass (*Chrysopogon fallax*). Others include *C. latifolius*, white grass (*Sehima nervosum*), bunch spear grass (*Heteropogon contortus*), and three-awned spear grass (*Aristida pruinosa*). The interspaces are normally bare or have a sparse cover of ephemeral species including native couch grass (*Brachyachne convergens*) and several other short grasses and a number of forbs, particularly legumes.

(5) *Associated Minor Pasture Communities.*—The pasture described above probably occupies 50 per cent. or less of the mapped area. The remainder is occupied by low but inaccessible rocky outcrops carrying tall grasses, creeks and rivers and associated frontages, areas of lateritic soils carrying annual sorghum and other tall grasses, and small areas of heavy clay soils with mainly tall blue grass pastures.

(6) *Growth Cycle and Pastoral Value.*—After effective rains in November or December the perennial grasses grow rapidly. The pastures are generally mature by the end of the wet season and very little growth is made on residual moisture available in the soil at the end of the wet season. Annual dry-weight production averages about 1200 lb/acre but varies from 700 to 1700 lb/acre according to season (Norman and Arndt 1959). During the dry season the pasture consists mostly of dry leaves and stalks with a very low nutritive value (nitrogen content $<0{\cdot}33$ per cent., August to October). Some of the vegetative tillers of perennial sorghum remain green for much of the dry season.

Except for a short period at the beginning of the wet season when most species have a nitrogen level above 1·5 per cent. the nutritive value of the pasture is low or very low. However, for about half the year, from the beginning of the wet season, cattle grazing on this pasture gain weight at a rate of about $\frac{1}{2}$ lb/day, while for the other half they lose weight at a rate of about $\frac{1}{4}$ lb/day. Norman and Arndt (1959) have shown that in the dry season cattle lose approximately 20 per cent. of their peak weight at the end of the previous gain period and that the net annual gain of growing cattle is only 1 cwt/year. As well as the low protein and carbohydrate level, the phosphate level of the pasture is low.

(7) *Stock Waters.*—Except for major streams such as the Katherine and Daly Rivers there are few permanent natural supplies of stock water. In most places underground supplies are available.

(8) *Present Management Practices.*—Most of the pasture is burnt annually, either deliberately or by accident (Arndt and Norman 1959; Norman, unpublished data). Other than burning, no form of pasture management is practised.

(9) *Present and Potential Productivity.*—The present cattle industry is in a primitive state of development and the carrying capacity is light (less than 10 per sq. mile) and productivity low. At Katherine Research Station and with cattle controlled by close subdivision, stocking rates of about 60 and 100 cattle per sq. mile have been maintained for five years without appreciable damage to the pasture although yields were lower under very heavy grazing.

The area occupied by these pastures near Katherine is suitable for arable dry-land agriculture and is capable of growing cash crops as well as sown pastures. With intensive development its potential is far greater than present production and could affect the potential of most of the Victoria River district and the north-western part of the Barkly Tableland (Christian 1959*b*).

(10) *Reaction to Grazing.*—Heavy uncontrolled grazing tends to reduce the perennial cover and annuals such as native couch grass (*Brachyachne convergens*) increase. At Katherine Research Station under heavy grazing with cattle in small paddocks the total yield was reduced but relatively slight floristic changes occurred over five years, although in the last year there was a tendency for a decrease in perennial sorghum (*Sorghum plumosum*) and kangaroo grass (*Themeda australis*) and an increase in beard grass (*Chrysopogon fallax*) and annuals.

(ii) *Kangaroo Grass and Other Perennial Grasses on Lowlands intermixed with Inaccessible Hills (Plate 8, Fig. 1)*

(1) *Area.*—6900 sq. miles.

(2) *Location.*—This pasture land is mostly confined to the Victoria River district.

(3) *Environment.*—This is essentially hilly, volcanic country with stony, inaccessible hills occupying well over half the area, but with significant areas of undulating lowland with mainly red soils of variable depth carrying kangaroo grass and other perennial grasses. The mean annual rainfall varies from about 15 to 30 in. and the vegetation of the lowland is a low woodland characterized by silverleaf box (*Eucalyptus pruinosa*) or bloodwood (*E. terminalis*).

(4) *Composition and Structure.*—On the lowland the pasture, although similar to the previous pasture land, is generally shorter (2 to 3 ft) and the species are somewhat different. Kangaroo grass (*Themeda australis*) is common and other perennial grasses include blue grasses (*Dichanthium* spp. and *Bothriochloa* spp.), beard grasses (*Chrysopogon* spp.), and white grass (*Sehima nervosum*). Short annual species are normally sparse unless the perennial cover has been reduced by adverse seasons or very heavy grazing. Native couch grass (*Brachyachne convergens*) is the commonest short grass and there are a number of short forbs among which legumes are common.

(5) *Associated Minor Pasture Communities.*—Apart from the large areas of stony and inaccessible hills, mostly carrying annual sorghum, there are minor areas of heavy clay soils carrying inferior Mitchell grass pasture, and also of creeks and rivers and associated frontages. In the drier parts there are some areas of annual grasses mainly on red or calcareous desert soils.

(6) *Growth Cycle and Pastoral Value.*—This is generally similar to that of the previous pasture land but the soils are somewhat more fertile and therefore the pastures probably have slightly higher nutritive value.

(7) *Stock Waters.*—A few permanent natural water-holes occur in the creeks and rivers. There is plenty of surface water during and for a short period after the wet season. In most parts stock waters are available underground but the water is mostly stored in cracks and joints of the volcanic rocks and may be difficult to locate. The country is generally too stony for tanks and dams.

A high proportion of the country is too steep and inaccessible for cattle and it will only be economical to provide water where sufficient accessible country is within range of it.

(8) *Present Management Practices.*—The industry is generally in a very primitive state, it is difficult to muster stock and many of them are very wild. The pastures are frequently burned for the same reasons as in the previous type.

(9) *Present and Potential Productivity.*—The present stocking rate averages about 4 cattle per sq. mile and probably ranges from about 0 to about 10. The provision of more waters on the accessible country would probably raise these rates but the high proportion of unusable country will always retard development. However, if and when intensive development takes place on the high-rainfall country to the immediate north, this pasture land will be close to a market for its stock and there would be a greater incentive for development.

(10) *Reaction to Grazing.*—In the limited observations on the pasture there have been no areas greatly affected by grazing and it is probably capable of supporting heavy stocking rates without appreciable damage. By analogy with the previous type there would probably be a tendency for the more palatable perennials such as kangaroo grass (*Themeda australis*) to decrease, and for white grass (*Sehima nervosum*) and annuals to increase.

(iii) *Annual Sorghum and Other Tall Grasses* (*Plate 8, Fig. 2*)

(1) *Area.*—44,200 sq. miles.

(2) *Location.*—This pasture land is restricted to the northern part of the Territory.

(3) *Environment.*—This country occurs on flat to undulating topography (not flooded) with light-textured soils, either lateritic or developed over mostly acid rocks. The mean annual rainfall is usually greater than 30 in. Vegetation is mostly tall (30 to 70 ft) open forest characterized by numerous *Eucalyptus* spp. of which stringybark (*E. tetrodonta*) and woollybutt (*E. miniata*) are most common. There is a lower (10 to 30 ft) tree storey which is extremely variable in composition and density but of which palm and deciduous broad-leaved species form a conspicuous part.

(4) *Composition and Structure.*—The most common plants are tall (5 to 10 ft) annual sorghum (*Sorghum intrans* and *S. stipoideum*), but numerous tall perennial species occur throughout and may assume dominance in some areas. These include giant spear grass (*Heteropogon triticeus*), perennial sorghum (*Sorghum plumosum*), beard grass (*Chrysopogon latifolius*), and *Coelorhachis rottboellioides*. The density of

these tall species varies considerably and although normally high may be quite sparse in some parts. Numerous shorter grass species, both perennial and annual, occur but are generally sparse, especially where the tall species are dense. Of medium height (2 to 5 ft) are bunch spear grass (*Heteropogon contortus*), three-awned spear grass (*Aristida pruinosa*), kerosene grass (*A. browniana*), cockatoo grass (*Alloteropsis semialata*), citronella grasses (*Cymbopogon* spp.), native panics (*Panicum* spp.), soft spinifex (*Plectrachne pungens*), *Eriachne* spp., and *Eragrostis* spp. There are also numerous short annual grasses and forbs which, however, form only a small part of the vegetation.

On light sandy soils and particularly near the lower-rainfall margin of the pasture land soft spinifex (*Plectrachne pungens*) is more common and may become the characteristic plant in some areas.

(5) *Associated Minor Pasture Communities.*—Annual sorghum and other tall grasses occupy most (probably 80 per cent.) of the mapped area. The remainder is divided between creeks, rivers, lagoons, and billabongs, seasonally flooded flats with kangaroo grass–*Eriachne* spp. or wild rice–reed pastures, and steep rocky hills and escarpments.

(6) *Growth Cycle and Nutritive Value.*—The main bulk of the fodder in this pasture is contributed by drought-evading species, both annual and perennial, which grow very rapidly from the beginning of the wet season. During the first few weeks they have a reasonable nutritive status but subsequently they rapidly become coarse and unpalatable. By the end of the wet season they have matured and from then until the next wet season provide only very poor-quality pasturage on which stock lose weight. The perennial drought-resisting soft spinifex (*Plectrachne pungens*) provides some fodder during the dry season and is a poor but useful standby (Christian and Stewart 1953), but areas where this is common are usually poorly supplied with stock water.

(7) *Stock Waters.*—During the wet season and for 2 to 3 months after it, natural water supplies are abundant, but towards the end of the dry season surface supplies are limited in many parts. However, underground supplies are available if required.

(8) *Present Management Practices.*—Most of the pastures are regularly burned. Efforts are made to burn at the end of the wet season as soon as the bulky growth is dry enough to carry a fire and while there is sufficient soil moisture to provide new growth. As well as ensuring shorter and probably more nutritious food, burning aids mustering because stock congregate on the burnt areas, and it also helps to control ticks.

(9) *Present and Potential Productivity.*—At present the cattle industry on this pasture is in a primitive state, partly because of the lack of markets and partly because the abundant surface waters and tall pastures make control of cattle very difficult. In addition, ticks are plentiful and the effect of these combined with a very poor diet causes severe live-weight losses during the dry season. The average stocking rate is less than 4 cattle per sq. mile, branding percentage is unknown but very low, and many properties have a zero turn-off percentage (Beattie 1956).

Potentially, this country is capable of greatly increased productivity but its development will be in conjunction with the development of an agricultural industry on adjacent country, as it is only through such development that suitable markets will be available.

Stable nearby markets could provide a financial return sufficient to warrant the construction of fences for the control of stock movements and breeding, and dips to control ticks. The mean annual rainfall is high, and although the soils are poor the replacement of native species with better pasture species such as Townsville lucerne (*Stylosanthes sundaica*) would raise the nutritive level of the pastures. The provision of small amounts of high-quality protein concentrate to supplement the bulky but poor-quality pasture during the dry season would improve the efficiency and productivity of the industry.

(10) *Reaction to Grazing.*—The present grazing rates are too low to show any effect on the pastures.

(*g*) *Flooded and Coastal Country* (*13,100 Sq. Miles*)

(i) *Reeds–Wild Rice* (*Plate 9, Fig. 1*)

(1) *Area.*—4500 sq. miles.

(2) *Location.*—This country is restricted to the far north of the Territory.

(3) *Environment.*—It occurs on the subcoastal plains which have heavy-textured or peaty soils developed on alluvium. The mean annual rainfall is 45 to 60 in. and the areas are flooded deeply for 6 to 8 months each wet season. During the dry season the heavy clay soils dry and crack severely but the peaty soils remain swampy. The country is mostly treeless.

(4) *Composition and Structure.*—This pasture consists of a dense growth of tall (3 to 6 ft) perennial tussock grasses and reeds. The tussocks are mostly small but their density is very high. The commonest reeds are various species of *Eleocharis* and the commonest grass species is wild rice (*Oryza sativa* var. *fatua*). Other common plants are rice grass (*Leersia hexandra*), *Hymenachne amplexicaulis*, swamp panic (*Panicum paludosum*), and water couch grass (*Pseudoraphis spinescens*). In low swampy areas the tall reed (*Phragmites karka*) and *Scleria poaeformis* are common and drier parts carry *Ischaemum arundinaceum* and blady grass (*Imperata cylindrica* var. *major*), sometimes with rice grass (*Xerochloa imberbis*) and blue grass (*Bothriochloa intermedia*) (Christian and Stewart 1953).

(5) *Minor and Associated Pasture Communities.*—The plains are traversed by meandering tidal streams, in some places fringed by mangroves. Small areas carry tall paperbark (*Melaleuca* spp.) forests.

(6) *Growth Cycle and Pastoral Value.*—The grasses and reeds grow rapidly during the wet season when the plains are flooded and inaccessible to cattle. When the waters recede, the grasses and reeds provide excellent succulent grazing for several months into the dry season and, in the wetter parts, right through the dry season unless they are over-grazed. In the drier zones plants mature to coarse unpalatable material with a very low nutritive value.

(7) *Stock Waters.*—There is no shortage of stock water during the wet season and during the dry season lagoons and distributaries of the major rivers provide adequate supplies, although some nearer the coast may be brackish.

(8) *Present Management Practices.*—The fringe of the plain, which mostly carries blady grass (*Imperata cylindrica* var. *major*) and *Ischaemum arundinaceum*, is regularly burned as the waters recede to provide a fresh "green shoot". With the long period of flooding there is little scope for the application of any better management practices.

(9) *Present and Potential Productivity.*—Christian and Stewart (1953) state that this country carries about 10,000 cattle, i.e. the average stocking rate is less than 5 cattle per sq. mile. However, much of it is not stocked, or occupied only by buffaloes, which are better adapted to the swampy conditions and can better utilize the available wet-season feed. In the past, production from buffaloes has been limited to hides, but more recently taming for export to the east has developed. Small areas where the introduced para grass (*Brachiaria purpurescens*) has persisted were observed by Christian and Stewart and it could possibly be spread further. However, because of flooding, fences are difficult to construct and in the absence of stock control it is doubtful if this development is worth while.

The potential of this country appears to lie more in intensive agricultural development for the mechanized production of rice under controlled natural flooding than in cattle-grazing.

(10) *Reaction to Grazing.*—No overgrazed areas have been observed.

(ii) *Kangaroo Grass*–Eriachne *spp. Pastures* (*Plate 9, Fig. 2*)

(1) *Area.*—2400 sq. miles.

(2) *Location.*—This pasture land is restricted to the far north of the Territory.

(3) *Environment.*—It occurs on flat to gently sloping plains on alluvium in the middle and upper sections of the Adelaide, Margaret, McKinlay, Mary, Finnis, and South Alligator Rivers. The mean annual rainfall is 50 to 60 in. and the plains are liable to flooding each wet season for periods of 3 to 4 months during which they are inaccessible to cattle. The soils are meadow podzols. The plains are mostly treeless although in some places there is a low parkland characterized by eucalypts and low *Melaleuca* spp.

(4) *Composition and Structure.*—The bulk of the pasture is composed of perennial drought-evading tussock grasses generally 2 to 5 ft high. Of these kangaroo grass (*Themeda australis*) and *Eriachne burkittii* are the commonest, but there are a number of others, including cockatoo grass (*Alloteropsis semialata*), perennial sorghum (*Sorghum plumosum*), giant spear grass (*Heteropogon triticeus*), and *Coelorhachis rottboellioides*. Some shorter perennials including *Ectrosia leporina* and *Eriachne avenacea* also occur. Among annual species the most common is the tall *Sorghum intrans* but various shorter ones are also present in small quantities. Throughout the type there are small areas characterized by wild rice (*Oryza sativa* var. *fatua*) and *Ischaemum arundinaceum*, both of which are tall perennial tussock grasses.

(5) *Associated Minor Pasture Communities.*—The generally level plains are intersected by large mature watercourses (with low levees) and there are small areas of low gravelly or stony rises and isolated hills and ridges. The low rises and hilly country carry annual sorghum and other tall grasses.

(6) *Growth Cycle and Pastoral Value.*—At the beginning of the wet season the perennial grasses make rapid growth but the plains are flooded and inaccessible to cattle for 3 to 4 months. By the time the waters recede the grasses are already near maturity and from then on the plains and most of the flats dry rapidly and the pastures quickly deteriorate. Some small flats remain damp and produce sparse short ground feed for part of the dry season if burned early enough (Christian and Stewart 1953). During the dry season the coarse perennial drought-evading species have a very low nutritive value and cattle lose weight.

(7) *Stock Waters.*—Permanent natural supplies of stock water are plentiful.

(8) *Present Management Practices.*—Grazing is uncontrolled and there appears to be little scope for pasture management. Some attempts are made to burn areas shortly after the waters recede in the hope of producing a short "green shoot".

(9) *Present and Potential Productivity.*—Christian and Stewart (1953) state that in 1946 the area carried about 10,000 head of cattle. However, most of these were on one property and the other parts carried very few cattle. In some areas there are large numbers of buffaloes which appear to be able to contend with the flooded conditions and the coarse pastures better than cattle.

As with the previous pasture land the potential of this country lies more in intensive development for rice-growing.

(10) *Reaction to Grazing.*—Stocking rates have been too low to have any significant effect on pastures.

(iii) *Coastal Country* (*Plate 10, Fig. 1*).—Areas totalling 6200 sq. miles of this pasture land occur in an interrupted strip along the coast. It mostly consists of useless salt flats, samphire flats, and dunes. In some parts there are saline meadows characterized by rice grass (*Xerochloa imberbis*) or salt couch grass (*Sporobolus virginicus*) which produce useful fodder, but because of the inaccessibility of the areas and, in many cases, the lack of fresh water, they are mainly undeveloped.

(*h*) *Rugged Country* (*94,400 Sq. Miles*)

(i) *Rugged and Otherwise Inaccessible Country* (*Plate 10, Fig. 2*).—Large areas extending throughout the whole of the Territory have been mapped in this country. They are extremely variable but have one feature in common, viz. they are all inaccessible to stock and therefore generally useless for pastoral purposes except that they provide catchment areas for water which may be used to benefit the industry on adjacent areas.

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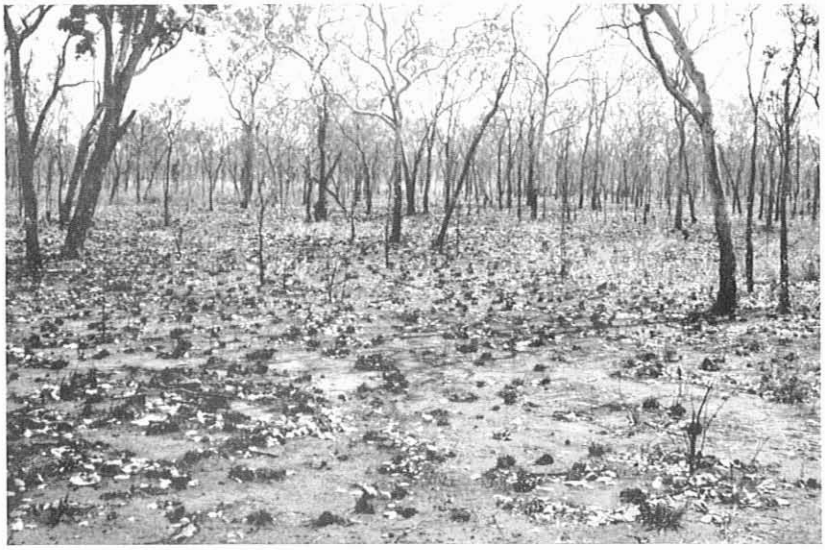

Fig. 1.—The pastures of the higher-rainfall areas are periodically burned to destroy the accumulations of coarse, dry material and encourage the growth of a fresh "green shoot". This photograph of recently burned kangaroo grass (*Themeda australis*)–perennial sorghum (*Sorghum plumosum*) pasture illustrates the low basal area of the perennial tussock grasses.

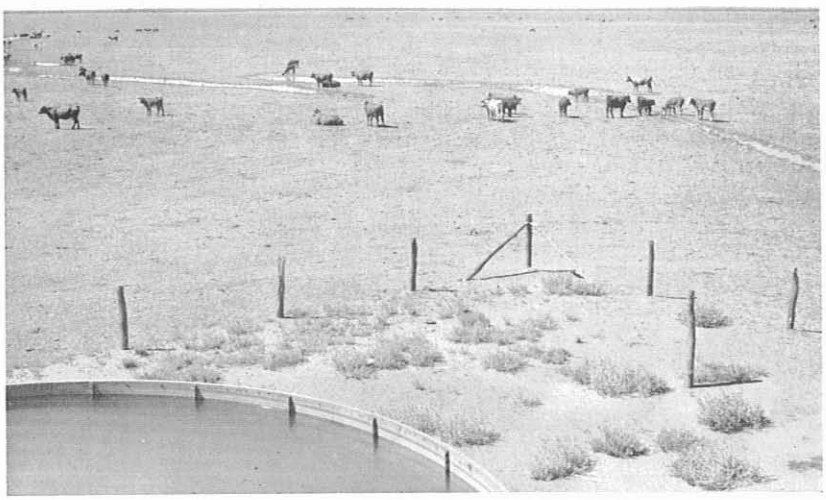

Fig. 2.—The Northern Territory cattle industry is conducted on an extensive scale with large properties and few fences. The main control of cattle movements is by widely spaced watering points. The large number of cattle on each water results in overgrazing near the watering point but beyond two to three miles there is little or no effect.

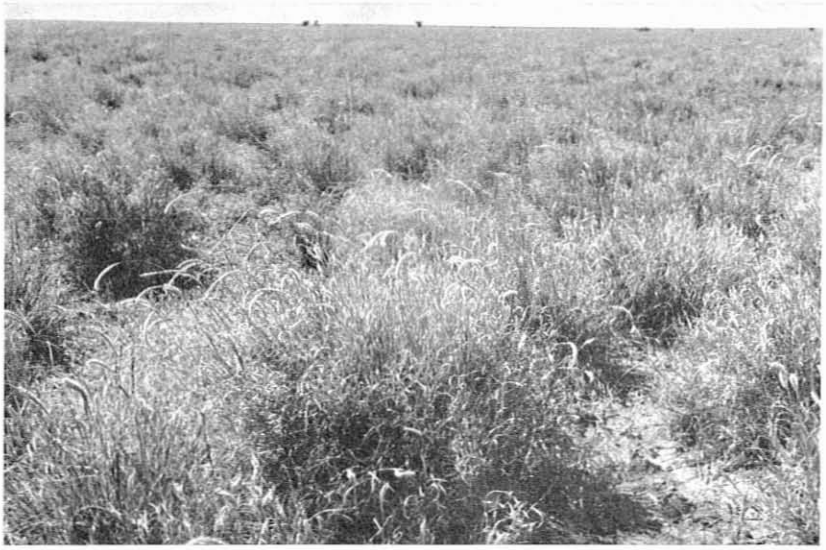

Fig. 1.—Barley Mitchell grass (*Astrebla pectinata*) pastures occur on plains with heavy clay soils developed on Tertiary or Recent alluvia. After rain the spaces between the tussocks are covered with short ephemeral grasses and forbs but in the late dry season are almost bare.

Fig. 2.—The barley Mitchell grass and other perennial grasses pasture land occurs mainly on stony heavy clay soils on gently undulating country on basic volcanics. It is more variable than the barley Mitchell grass pastures on alluvium and in many places has a sparse cover of shrubs and low trees.

Fig. 1.—Compared with the other Mitchell grass pasture lands the inferior Mitchell grass pasture land is characterized by taller and coarser perennial grasses and a smaller proportion of ephemeral species. Low trees such as bean tree (*Bauhinia cunninghamii*) are a common feature.

Fig. 2.—In the more arid parts of the Territory most of the cattle are carried on short grass–forb pastures growing in association with low woodlands characterized by various *Acacia* spp. of which mulga (*A. aneura*) is the most important. The tree species are a valuable source of top feed during long dry periods when short grasses and forbs are absent.

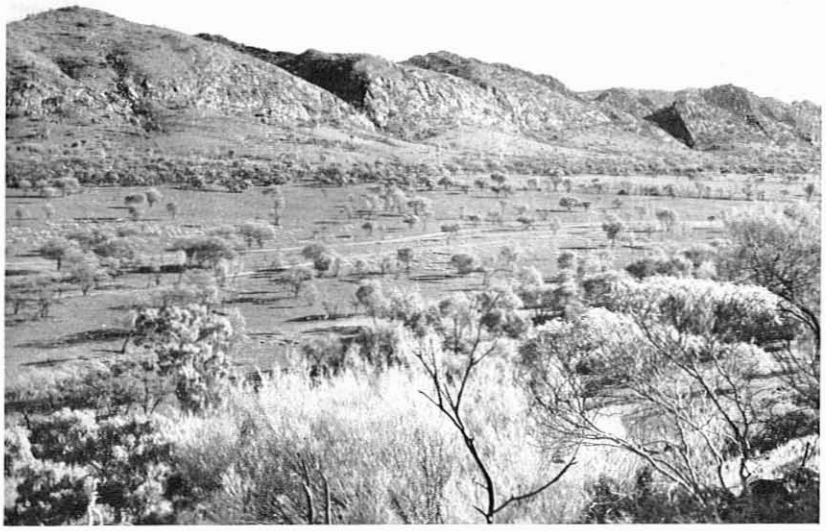

Fig. 1.—Areas where inaccessible hills alternate with lowlands carrying short grass–forb pastures occur in central Australia. They are suitable for grazing where areas of the lowlands are large enough to justify the provision of water supplies.

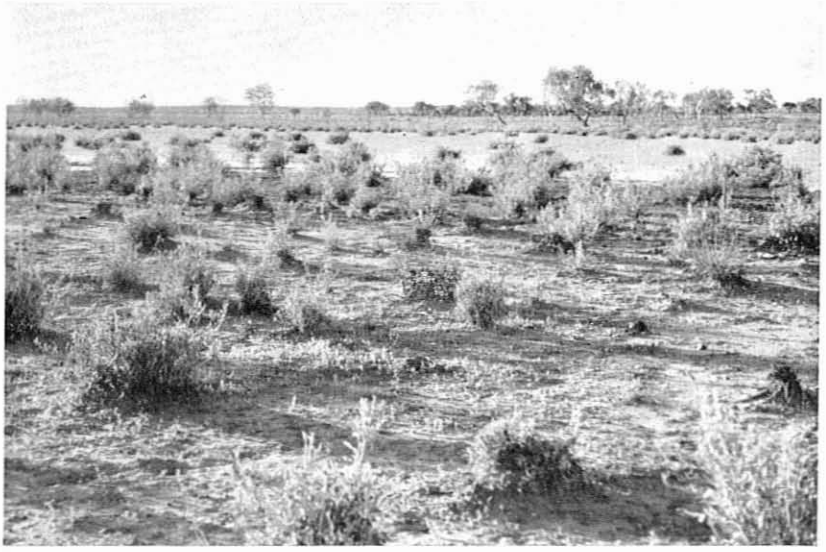

Fig. 2.—Northern bluebush (*Chenopodium auricomum*) pastures occur on seasonally flooded country, mostly with heavy clay soils. Northern bluebush itself is palatable and nutritious and with the ephemerals produced as the flood waters recede it provides fattening pasturage.

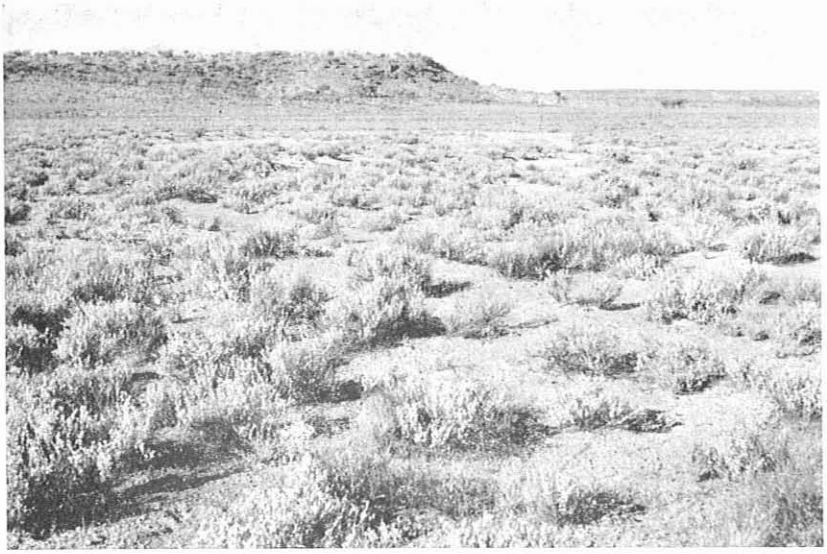

Fig. 1.—Bladder saltbush (*Atriplex vesicaria*) and southern bluebush (*Kochia astrotricha*) are restricted to the far southern parts of the Northern Territory. They have a low stocking rate but are mostly developed with stock water supplies.

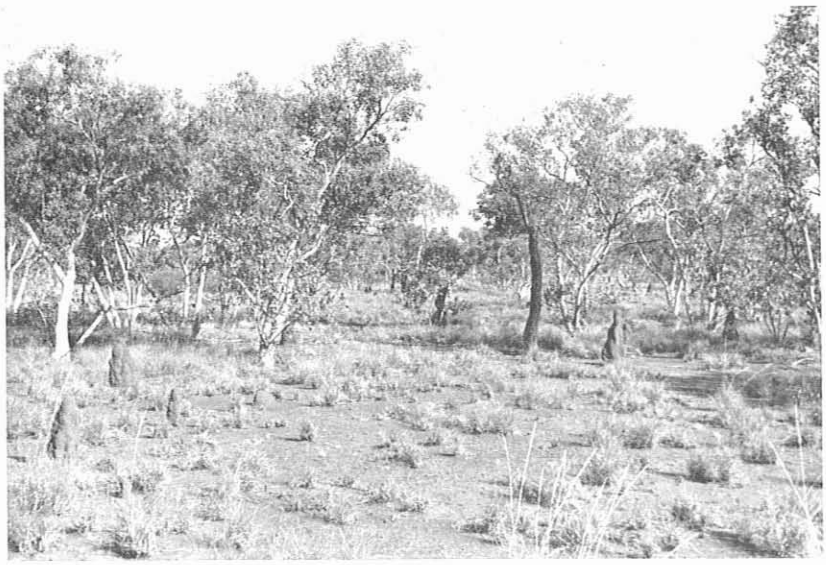

Fig. 2.—Soft spinifex (*Triodia pungens*) pastures are commonest in a belt stretching across the Territory between about the 12 and 25 in. mean annual rainfall isohyets. They occur on sandy or lateritic soils, in the northern parts under a low eucalypt woodland but with only scattered shrubs further south.

Fig. 1.—Hard spinifex (*Triodia basedowii*) pastures occupy large areas of sand plain in central Australia and generally have a sparse to medium dense shrub layer associated with them. "Ring" formation is characteristic of mature stands.

Fig. 2.—Hard spinifex (*Triodia basedowii*) is also the characteristic plant of most of the dune fields.

Fig. 1.—Where the mean annual rainfall is between about 17 and 30 in., and on sandy or lateritic soils, three-awned spear grasses (*Aristida* spp.) are characteristic of the pastures. They occur as the ground storey of a low eucalypt woodland.

Fig. 2.—Kangaroo grass (*Themeda australis*)–perennial sorghum (*Sorghum plumosum*) pastures are the ground storey of a low eucalypt woodland growing on red earth soils under a mean annual rainfall of 25 to 50 in. Some of this country is suitable for arable agriculture. The kangaroo-grass-dominant ground storey illustrated is a drier phase of the pastures.

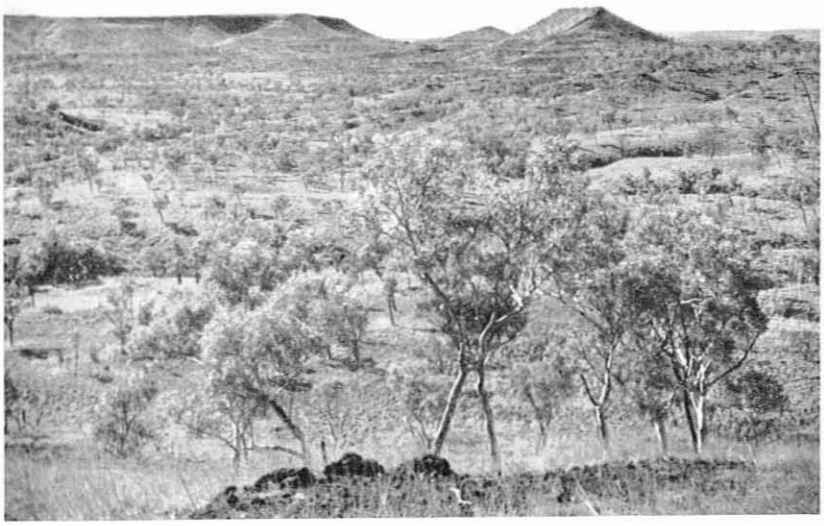

Fig. 1.—On hilly parts of the Cambrian volcanics the gentler parts of the topography carry kangaroo grass–perennial sorghum pastures. The steeper parts are inaccessible to stock.

Fig. 2.—Annual sorghum and other tall grasses are the typical ground storey of the tall open forest country on light-textured soils under high rainfall.

Fig. 1.—The subcoastal plains are flooded for long periods each year and mainly carry reeds (*Eleocharis* spp.). Potentially they are more suitable for rice production than cattle-grazing.

Fig. 2.—Kangaroo grass (*Themeda australis*) and *Eriachne* spp. are characteristic of meadow podzolic soils in the far north of the Territory. They are flooded during the wet season and their potential lies more in development for rice production than in the cattle industry.

Fig. 1.—Salt flats and salt meadows occur along some parts of the coast-line. Their inaccessibility and general lack of fresh water supplies have retarded development even where useful fodder is produced.

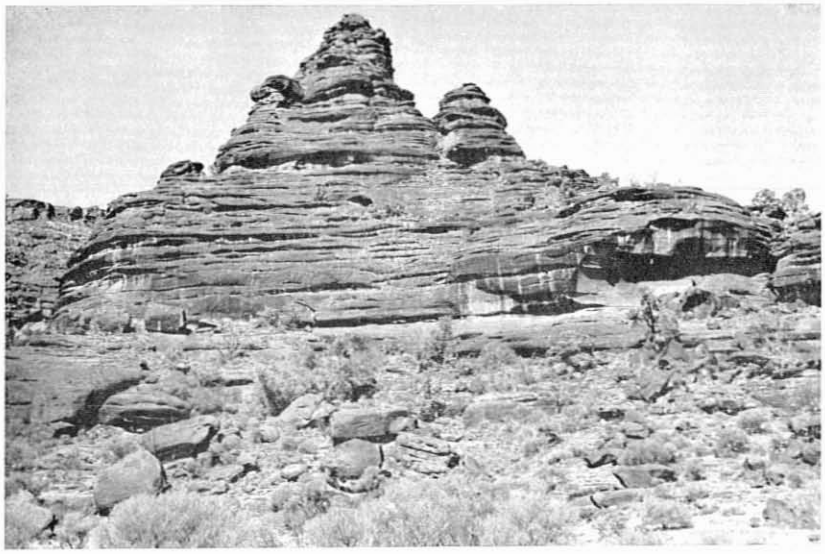

Fig. 2.—Areas of rugged country are useless for grazing.