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A report on erosion and range condition in the West Kimberley area of Western Australia

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**A REPORT ON EROSION AND RANGE
CONDITION IN THE WEST
KIMBERLEY AREA OF WESTERN
AUSTRALIA**

A REPORT ON EROSION AND RANGE CONDITION IN THE WEST KIMBERLEY AREA OF WESTERN AUSTRALIA

**Commissioned by the Pastoral Appraisal Board,
Perth, Western Australia, 1972, and published under
the authority of the Board**

by A. L. Payne, A. Kubicki, D. G. Wilcox and L. C. Short

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A REPORT ON EROSION AND RANGE CONDITION IN THE WEST KIMBERLEY AREA OF WESTERN AUSTRALIA

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SUMMARY

1. Nearly 30 per cent (26 700 sq. kilometres) of the West Kimberley survey area is in bad range condition. Pastures are degraded to poor or very poor condition and moderate and severe erosion is widespread. Drastic remedial action is required to facilitate rehabilitation.
2. Nearly 51 per cent (45 400 sq. kilometres) of the area is in fair range condition. Careful use is required to prevent further deterioration.
3. Nearly 20 per cent (17 500 sq. kilometres) of the area is in good range condition. This country consists mainly of poorly accessible land systems and systems supporting low quality spinifex pastures.
4. In order to prevent degradation to the point of irreversibility about 6 920 sq. kilometres of bad condition country should be removed from the area currently being grazed. This action should be taken now and be completed within three years.
5. The worst areas of degradation and erosion are on the most valuable pasture lands. These areas are readily accessible, close to permanent water supplies, and support attractive pastures. Continuous, unrestricted, preferential over-use since the early days of settlement is responsible for their present bad condition.
6. Carrying capacity estimations of the pasture lands of the area, at three levels of condition, are presented. These estimations are based on the best available current knowledge of the pasture types. It is suggested that they be adopted for assessing the present and potential productivity of stations. The present system of assessing estimated carrying capacity (ECC) is considered to be inadequate in that, in many cases, it has overestimated the capacity of the land to sustain production.
7. In order to prevent further erosion and pasture decline, and to facilitate recovery of badly degraded areas, co-operative programmes for rehabilitation should be planned by the station lessees and the Department of Lands and Surveys. Based on the present evaluation of rangeland condition this will involve a progressive reduction in cattle numbers from 358 350 to 177 000. Hopefully, recovery during the regeneration programme may obviate the need to reduce numbers to the level indicated above.
8. Maps at 1 : 250 000 scale showing land systems, pasture lands and the severity and location of erosion have been compiled.

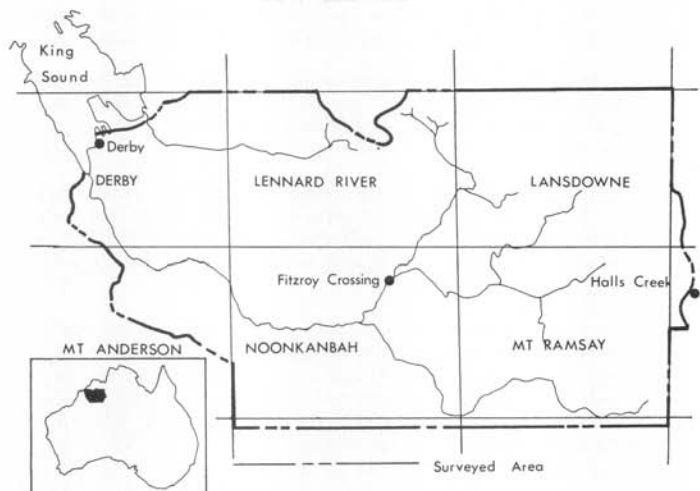


Figure 1—West Kimberley survey area, 1972.

INTRODUCTION

Degradation of native pastures and increasing areas of erosion in the Fitzroy River catchment were recorded as early as 1910 (Bolton, 1951).¹ In 1959, a CSIRO Division of Land Research and Regional Survey field party surveyed the area on a land system and pasture land basis and their findings, including observations on erosion and degradation, were published in 1964.²

Recent reports from field officers of the Departments of Agriculture and Lands and Surveys have indicated that problems of erosion and pasture degradation exist in the area and in 1970, the Pastoral Appraisal Board initiated a survey of the area to be carried out jointly by the Departments of Lands and Surveys and Agriculture. Preliminary aerial photo interpretation work commenced in February 1972, followed by a three week field reconnaissance in April 1972 and a main field survey from June 9 to October 14, 1972.

The major aims of the survey were to:—

- Define the extent, location and severity of erosion and pasture degradation on a land system basis.
- Map the area in terms of land systems and pasture lands at 1 : 250 000 scale.
- Prepare reports on each station describing land systems, pasture lands, erosion, pasture

condition, optimum and recommended carrying capacities and regeneration needs in terms of stock control and range management practices.

- Formulate Range Condition Guides for each land system on a pasture lands basis to define:—
 - (i) the optimum condition in terms of soil and vegetation,
 - (ii) the types of erosion and pasture composition trends likely to be encountered on the various pasture lands at different condition levels, and
 - (iii) the carrying capacity of each pasture land at different condition levels.

The climate, geology, geomorphology and soils of the area have been described in some detail in the previously mentioned CSIRO report. The report should be referred to for the above information and for precise descriptions of the land systems used as a basis for this survey.

The area surveyed covered approximately 89 600 sq. kilometres (24 600 sq. miles) and included most of the catchments of the Fitzroy, Lennard, Meda and May rivers. It included the country between latitude 17° S and 19° 8' S and longitude 123° 30' E and 127° 40' E. All of the Lennard River, Lansdowne, Noonkanbah and Mt Ramsay and parts of the Derby, Mt Anderson, Crossland, Mt Bannerman, Dixon Range and Gordon Downs 1 : 250 000 map sheets were included.

¹ Bolton, G. C., 1954. The Kimberley Pastoral Industry, in Western Australian University Studies in History and Economics. University of Western Australia Press.

² Speck *et al.*, 1964. General Report on the Lands of the West Kimberley Area, W.A. Land Research Series No. 9, CSIRO Melbourne, Australia.

TECHNIQUES OF THE SURVEY

Initial procedure involved drawing up land system boundaries on 1 : 86 150 scale aerial photographs covering the area of interest. This was done using maps provided by CSIRO Division of Land Research and Regional Survey, Canberra, and using land systems as named and described in the CSIRO Land Research Series No. 9, 1964. Forty-four of the 50 land systems described by CSIRO were

encountered within the survey area. For rangeland surveys the land system is a convenient mapping unit and is defined as "an area or group of areas throughout which a recurring pattern of topography, soils and vegetation can be recognised". Land systems were used as a base of this survey as they are repeatable and verifiable units in the field. They permit collation of comparable data

within a station and comparison of data between stations and on the survey area as a whole. Surveying on a land system basis allows the work to progress on a logical and systematic basis thus offering considerable advantages over a survey which uses random sampling techniques.

The preliminary mapping work was followed by three weeks field reconnaissance in April 1972. This visit was to familiarise officers with the land systems and the types of erosion and vegetation found on each land system. The reconnaissance visit also aided the formulation of survey techniques and definitions for erosion and pasture condition to be used in the main survey.

The land systems were the basic units used for mapping but where ground traverse and aerial photograph interpretation indicated, modifications to the CSIRO boundaries were made. During the main survey it was necessary to describe and map two additional land systems Bulka and Landrigan (see Appendix A), to permit better interpretation of the data. Finalised boundaries were transferred to 1 : 86 150 chronoflex compilation sheets for use in the preparation of 1 : 250 000 land system maps.

Field assessments made during the main survey were based on range evaluation site techniques and traverse recordings. The two methods were complementary. Detailed observations on erosion and pasture condition were made at range evaluation sites, but traversing enabled rapid, large scale assessment. Techniques were similar to those used in the Gascoyne Catchment Survey 1970.¹

RANGE EVALUATION SITE METHOD

A series of precise field observations were made at range evaluation sites or "query points" on the various units of each land system. Site selection was based on studies of the aerial photographs and ground inspections. All components of the photo pattern were investigated in order to provide a complete dossier of that pattern for future reference and photographic interpretation.

All sites described were permanently identified on the photographs so that positive re-identification could be made at a future time. The sites were variable in size but usually about 100-200 m in diameter. Each site was photographed to complete the record of range condition at the time of survey.

The method of assessment was a modification of the Deming² "two-phase" system as used by the Soil Conservation Service of the United States Department of Agriculture on some rangelands. It involved evaluations of two basic range resources, the forage stand, and the soil.

The forage stand

At each site a list of all plant species was compiled and recorded under the categories of desirable, intermediate value and undesirable species. The relative desirability of each species was decided primarily on its forage value, but other factors such as durability and position in the ecological succession sequence were taken into account.

The pastures were rated for condition using the compiled lists and comparing the present vegetation status with the site potential. The parameters recorded were—quality (relative proportion of desirable, intermediate and undesirable species), quantity (present as compared to potential production) and vigour and reproduction of the species present.

Six levels of condition, ranging from optimal to extremely poor were used to describe each parameter. Each level was given a numerical value within the range 25-0 as described below.

Quality definitions

From the lists supplied the proportional representation of desirable, intermediate and undesirable forage plants present on the range site was judged as—

- 25 Outstanding predominance of desirable perennial grasses and shrubs. The remainder of the stand composed principally of intermediate value species including annuals with undesirable species virtually absent.³

¹ Wilcox, D. G. and McKinnon, E. A., 1972. A report on the condition of the Gascoyne Catchment. Dept. Agric. W. Aust. pub.

² Deming, M. H. (1957). Two Phase range condition surveys—supplemental instructions for field use. United States Department of the Interior B.L.M. Manual, Vol. IX, Pt. 10: Range Studies.

³ If desirable perennial grasses alone are present but the frequency of desirables is:—

- (a) Slightly below the site potential, downgrade one level, i.e. 20.
- (b) Moderately below site potential, i.e. sparse perennials, downgrade two levels, i.e. 15.
- (c) Considerably below site potential, i.e. extremely sparse perennials, downgrade three levels, i.e. 10.

- 20 Desirable and intermediate value species occupy about equal proportions in the stand. Undesirable species present but only sparsely except on more xeric parts.
- 15 Intermediate value species predominate in the stand. Desirable species and undesirable species occur in equal proportions in the remainder.
- 10 Intermediate and undesirable species predominate; desirable species occur sparsely or in small groups; intermediate and undesirable species make up an increasing proportion of the stand.
- 5 Undesirable species may predominate, intermediate perennial species are rare and annuals may be the dominant plants present. Desirable perennial species virtually absent.
- 0 An extreme situation with bare soil or low annual species only being on the range site.

Quantity definitions

Quantity differs from quality evaluations in as much as it takes into account the potential of the site for production of pasture. Inherently poor sites are never fully covered with perennial vegetation. The converse will apply for sites with high potential. The range site is judged in terms of relative density and degree of occupancy of usable space by desirable and intermediate species.

- 25 There is an optimum cover of desirable species which occupy almost all of the stand. Other intermediate species occur only rarely, but may be more obvious in good seasons.
- 20 There is a good cover of desirable and intermediate value species covering nearly all potentially usable space. Minor amounts of ground are covered with undesirable species.
- 15 There is a moderate cover of desirable and intermediate value species. Undesirable species can occupy as much of the usable space as desirable and intermediate species.
- 10 Desirable and intermediate value species are patchy or thin in occurrence and cover. Undesirable species can be more dense or occupy a major proportion of usable space.

- 5 Desirable and intermediate value species virtually absent. There may sometimes be dense stands of undesirable species.
- 0 There are no desirable or intermediate value species present. Undesirable species only are present, if at all.

Vigour and reproduction definitions

The relative degree of health and thrift of the desirable and intermediate value species in the stand are judged. Crown size and vigour, in mature and young plants, and current tiller production are the factors assessed, then compared with the undesirable species present. The frequency of occurrence of seedlings and of young plants is also used as an indicator of vigour and reproduction.

- 25 Desirable and intermediate value species are robust with well developed and vigorous crowns. There are adequate numbers of seedlings present to provide for maintenance of the stand.
- 20 Desirable and intermediate value species are in good condition with well developed crowns though a small proportion have low vigour. There are small numbers of young or seedling class undesirable species.
- 15 Desirable and intermediate value species are moderately vigorous. Some crowns have become moribund and have died. Some crowns are quite small. Tiller production in the current year is lower than the potential for the rainfall. There are an equal number of young and seedling desirable, intermediate and undesirable species.
- 10 Desirable and intermediate value species have partly moribund crowns or small crowns. Dead crowns are frequent. Growth in the current year is well below optimum for the season. Seedlings and young plants of desirable and intermediate species are rare. Undesirable species if present are robust, well formed and vigorous, and there is adequate reproduction of this group.
- 5 The desirable and intermediate value species are very weak with many dead crowns and extremely poor current growth. There are virtually no seedlings of plants in this group. The undesirable species if present are well grown, robust and have abundant reproduction through seedlings.

- 0 The desirable and intermediate perennial species exist only as barely surviving relics with no evidence of their reproduction.

Forage Stand Index

The numerical values determined for the three parameters are added to express overall forage condition or aggregate Forage Stand Index as shown in Table 1.

Table 1—Forage Stand Index

Aggregate forage stand index	Pasture classification
75-65	Excellent
60-50	Good
45-35	Fair
30-20	Poor
15-0	Very poor

The soil

The soil condition on any particular site was evaluated in terms of the type and severity of erosion encountered. Six levels of erosion, ranging from nil to extreme, were used and each level given a numerical value within the 25-0 ranges defined below:—

Erosion definitions

The ratings were based on the degree of the soil surface disturbed, or, in extreme cases, on the amount of sub-soil exposed. The levels covered wind and/or water erosion.

25 No erosion

No evidence of soil movement by wind or water. Plant cover or surface strew effective in protecting the soil surface.

20 Slight erosion

Some evidence of soil movement by wind or water but no appreciable area of soil lost. Occasional shallow rills may occur. There may be minor soil or litter build up against obstacles and small, isolated patches of bare ground.

15 Minor erosion

Scattered small scalds with some soil build up at the margins but with much undisturbed country between scalds; or, rilling and a few small gullies, occasional areas of thin sheeting. A surface seal caused by wind or water may be present.

10 Moderate erosion

Frequent large but individual scalds, or numerous small scalds with hummocks at the margins and against obstacles; or, numerous small gullies and thin, discontinuous sheeting on the lower slopes and susceptible areas. Erosion is active and capable of extension onto other parts of the site.

5 Severe erosion

Removal of the soil surface as indicated by very large or continuous scalds, with considerable build up of soil against obstacles (hummocking); or, extensive sheeting or gullying affecting most of the site with redistribution of the transported soil being in a wide front. Exposure of sub-soil or rock may be evident in patches.

0 Extreme erosion

Active stripping by wind leaving extensive bare surfaces. Extensive terracing, severe sheeting and gullying affecting the entire site. Frequent exposure of sub-soil or rock material. In sandy systems major drifting of sand dunes or plains. Plant cover absent or very sparse.

In addition to assessment of erosion, brief notes on land form, soil type, inherent vulnerability, and degree of protective cover afforded by vegetation or surface strew were made at each query site.

Overall range condition at each evaluation site was expressed as a combination rating thus: (50/20), the first figure representing the aggregate Forage Stand Index and the second figure representing the erosion severity level.

Actual examples of field recording sheets are shown with the relevant photographs of the site taken in 1972. They show the data obtained from range sites in good, fair and bad range condition.

A total of 387 range evaluation sites, many with two or more units were made on 46 land systems over the survey area. All sites are shown on the 1 : 250 000 map sheets.

The data collected at range evaluation sites were used in the formulation of Range Condition Guides for pasture lands of the West Kimberley area.⁴

⁴ Payne, A. L., Kubicki, A. and Wilcox, D. G. (1974). Range Condition Guides for the West Kimberley area. Dept. Agric. W. Aust. pub.

WEST KIMBERLEY SURVEY

RANGE CONDITION ANALYSIS:

QUERY NO: 24a PHOTO NO: LR 3/41 DATE 16/6/72

LAND SYSTEM Gogo UNIT Levee back slope

PASTURES:

Desirable

Chrysopogon fallax (butts only)

Intermediate

Eriachne obtusa
Brachyachne convergens
Dactyloctenium radicans
Sporobolus australasicus
Corchorus sp.

Undesirable

Aristida inaequiglumis

TREES AND SHRUBS

Acacia farnesiana

Quality	0000	0000	10
Quantity	0000	0000	0
Vigour	0000	0000	0
Total	0000	0000	10

SOILS

Description: Brown juvenile alluvial clay

Erosion:

Type	0000	0000	0000	0000	0000	0000	0000
Extent	0000	0000	0000	0000	0000	0000	0000
Land form	0000	0000	0000	0000	0000	0000	0000
Inherent vulnerability	0000	0000	0000	0000	0000	0000	0000
Surface cover	0000	0000	0000	0000	0000	0000	0000
Prime causes	0000	0000	0000	0000	0000	0000	0000

EROSION INDEX

Wind

Water

Total—10

Range Site Rating: 10/10



Figure 2—Query No. 24a Land system—Gogo

Unit—Levee back slope.

This range evaluation site was rated by the "two phase" method as 10/10 which indicates very poor pasture condition and moderate erosion. It is in bad range condition.

WEST KIMBERLEY SURVEY

STATION

RANGE CONDITION ANALYSIS:

QUERY NO: 15a PHOTO NO: LR4/31 DATE 13/6/72

LAND SYSTEM Gogo UNIT Levee back slope

PASTURES:

Desirable

Chrysopogon fallax
Dichanthium sp.

Intermediate

Eriachne obtuse
Brachyachne convergens
Enneapogon polyphyllus
Corchorus sp.

Undesirable

Aristida inaequiglumis
Aristida pruinosa
Aristida contorta

TREES AND SHRUBS

Eucalyptus tectifica
Lysiphylum cunninghamii
Carissa lanceolata

	Quality	Quantity	Vigour	Rating
	15
	10
	15
Total	40

SOILS

Description: Brown loamy clay
Erosion:

Type	.....	.....	.....	.....	.....	.....	.....	.....	.....	Minor disturbance of surface crust
Extent	.....	.....	.....	.....	.....	.....	.....	.....	.....	Most of area
Land form	.....	.....	.....	.....	.....	.....	.....	.....	.....	Flat plain
Inherent vulnerability	.....	.....	.....	.....	.....	.....	.....	.....	.....	Moderate
Surface cover	.....	.....	.....	.....	.....	.....	.....	.....	.....	Poor
Prime causes	.....	.....	.....	.....	.....	.....	.....	.....	.....	Overuse

EROSION INDEX

Wind

Water

Total—20

Range Site Rating: 40/20



Figure 3—Query No. 15a Land system—Gogo
Unit—Levee back slope.

This range evaluation site was rated by the "two phase" method as 40/20 which indicates fair pasture condition and slight erosion. It is in fair range condition.

WEST KIMBERLEY SURVEY

RANGE CONDITION ANALYSIS:

QUERY NO: 99a PHOTO NO: D4/02 DATE 12/7/72

LAND SYSTEM Alexander UNIT Cracking clay plain

PASTURES:

Desirable

Chrysopogon fallax
Dichanthium sp.
Panicum decompositum

Intermediate

Eriachne obtuse
Neptunia dimorphantha

Undesirable

Aristida latifolia
Eriachne glauca

TREES AND SHRUBS

Quality	.....	.....	Rating
Quantity	.....	.....	25
Vigour	.....	.....	20
			20
Total	.....	.....	65

SOILS

Description: Dark brown cracking clay

Erosion:

Type	.....	.....	.....	.....	.....	.....	.....	.....	.....	Nil
Extent	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Land form	.....	.....	.....	.....	.....	.....	.....	.....	.....	Flat, cracking clay plain
Inherent vulnerability	.....	.....	.....	.....	.....	.....	.....	.....	.....	Low
Surface cover	.....	.....	.....	.....	.....	.....	.....	.....	.....	Excellent
Prime causes	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

EROSION INDEX

Wind

Water

Total—25

Range Site Rating: 65/25



Figure 4—Query No. 99a Land system—Alexander
Unit—Cracking clay plain.

This range evaluation site was rated by the "two phase" method as 65/25 which indicates excellent pastures and no erosion. It is in good range condition.

TRAVERSE METHOD

In order to give a comprehensive cover of the survey area, traverses were conducted on as many station tracks and roads as possible. The traverse technique involved visual assessment of erosion and pasture condition made from the vehicle while in motion. Traverse speed was about 40 km/h (25 miles per hour). At this speed erosion assessments and species identification could be made with a high degree of confidence.

Ratings were made as each land system was entered and left and at 1.6 km (1 mile) intervals within the land systems. Assessments made were an average of conditions encountered during the preceding 1.6 km traversed. Three parameters of condition, in the order of wind erosion, water erosion and pasture condition, were assessed and recorded. Two assessors were used at all times and agreement was necessary before the values were recorded. Values such as 003, 134, 245 were assigned to each 1.6 km traversed using the following criteria.

Erosion

Wind and water erosion incidence was recorded in the following fashion.

Wind erosion

Severity	Rating	
Nil	0	No erosion.
Minor	1	Litter build up and small scalds. Small isolated scalds, on which the surface showed some degree of polishing. Re-distribution of soil to the margins of the scald, or minor build up of soil material around obstacles.
Moderate	2	Large isolated scalds and hummocks. Stripping of the soil surface and build up against obstacles associated with large but generally discontinuous scalds; or, numerous small scalds scattered throughout the site.
Severe	3	Major deflation of soil surface. Active stripping resulting in large continuous scalds with polished and sealed surfaces. Frequent large hummocks against obstacles. In sandy

systems, major dune drift. Plant cover very sparse to absent.

Water erosion

Severity	Rating	
Nil	0	No erosion.
Minor	1	Rilling. Patchy rilling and small gullies affecting small areas of the site. Much undisturbed ground between these areas.
Minor	2	Thin sheeting. Thin sheeting (1 to 2 cm) and breaking of the surface seal on parts of the site. Some re-distribution of soil and litter down slope.
Moderate	3	Gullies and sheeting on lower slopes. Gullies on the lower slopes or more susceptible parts of the site, these being capable of extension to less susceptible areas. The gullies may be associated with extensive but discontinuous disturbance of the soil surface by sheet erosion and redistribution of soil material.
Severe	4	Terracing or extensive gullies. Severe sheeting or terracing affecting nearly all the site. Re-distribution of soil and exposure of sub-soil or rock material. The sheeting may be associated with or replaced by very extensive gullying over most of the site.

Pasture condition

Using information obtained from the Range Evaluation Sites, reconnaissance trips, prior knowledge of the area and experimental data it was possible to assess pasture condition in the following terms.

Rating

- 1 Excellent pasture condition
Nearly all plants present are desirable species and ground cover is optimum for the site.
- 2 Good pasture condition
Most plants present are desirable with intermediate perennials and annual types increasing in frequency; a few undesirable species may be present.

3 Fair pasture condition

Intermediate value species usually predominate; desirable and undesirable species occupy similar proportions of the available ground space. Small patches of bare ground may be present.

4 Poor pasture condition

Undesirable and intermediate species predominate in the stand; desirable species are very infrequent and may occur only in small patches. The overall stand may be sparse or patchy with frequent small areas of bare ground.

5 Very poor pasture condition

Undesirable species or bare ground predominates; few intermediate species and virtually no desirable species in the stand.

A total of 4 532 traverse recordings on 45 land systems were made during the course of the survey. One land system, Rose, was not traversed on the survey, although it was visited on foot.

ANALYSIS OF THE TRAVERSE DATA

The traverse data were sorted on the Cyber 72 computer at the University of W.A. computing centre. The print-out sheets (unpublished data) showed the number of recordings and percentages in each category of wind erosion (4 levels), water erosion (5 levels) and pasture condition (5 levels) for each land system. In addition expressions for total erosion and range condition were derived from the basic data. Tables were produced showing condition statements for—

- each land system on each station;
- each station as whole;
- each land system within the survey area;
- the survey area as a whole.

Total erosion

Total erosion was derived by combining the wind and water erosion traverse recordings into rational groupings as shown in Table 2.

Table—2 Derivation of total erosion

Wind erosion	+	Water erosion	=	Total erosion	Rating
Nil	+	Nil	=	Nil	0
Nil Minor Minor	+	Minor Nil Minor	}	= Minor	1
Nil Minor Moderate Moderate	+	Moderate Moderate Nil Minor	}	= Moderate	2
Moderate	+	Moderate	=	Severe	3
Nil Minor Moderate Severe Severe Severe Severe	+	Severe Severe Severe Nil Minor Moderate Severe	}	= Severe	3

Total erosion on each land system was expressed as the percentage falling into the nil, minor, moderate and severe categories.

Wind erosion			Water erosion			Total erosion		
Rating	No. of observations	%	Rating	No. of observations	%	Rating	No. of observations	%
0	68	67.3	0	17	16.8	0	17	16.8
1	26	25.7	1	13	12.9	1	26	25.7
2	7	6.9	2	13	12.9	2	38	37.6
3	0	0	3	43	42.6	3	20	19.8
			4	15	14.9			
101			101			101		

Range condition

Large scale evaluations of any land system can be summarised by adopting a range condition approach. The concept of range condition or "range health", as used in this survey, is based on traverse assessments of the basic range resources, i.e. soils and pastures. It can be considered as a measure of the capability of the range for continued use; or as a measure of the present range situation compared to its optimum or prime situation. Unbalanced use of the range results in pasture degradation and soil erosion. The severity of this degradation can be expressed by range condition statements.

For the purpose of computer analysis, three levels of range condition were selected. These levels were termed good, fair or bad. They were derived by combining total erosion and pasture condition data obtained on traverse into rational groupings as shown in Tables 3, 4 and 5.

Table 3—Derivation of good range condition

Total erosion + Pasture condition = Range condition		
Nil	+ Excellent	} = Good
Nil	+ Good	
Minor	+ Excellent	
Minor	+ Good	

Country in good range condition is in acceptable order and its use for grazing can be continued. To maintain such country in good condition recommended levels of use should be used and sound management methods adopted. Recommendations for each pasture land are outlined in Range Condition Guides for the West Kimberley area (Payne *et al* 1974).

Table 4—Derivation of fair range condition

Total erosion + Pasture condition = Range condition		
Nil	+ Fair	} = Fair
Nil	+ Poor	
Minor	+ Fair	
Minor	+ Poor	
Moderate	+ Excellent*	
Moderate	+ Good*	

* Combinations not encountered in the field. Although theoretically possible they are unlikely to be encountered in the field.

Country in fair range condition may still be used for grazing but as considerable pasture deterioration and some erosion is present, changes in management practices may be necessary to prevent further deterioration.

Table 5—Derivation of bad range condition

Total erosion + Pasture condition = Range condition		
Nil	+ Very poor*	} = Bad
Minor	+ Very poor*	
Moderate	+ Fair	
Moderate	+ Poor	
Moderate	+ Very poor	
Severe	+ Excellent†	
Severe	+ Good†	
Severe	+ Fair†	
Severe	+ Poor	
Severe	+ Very poor	

* Combinations only occasionally encountered in the field.

† Combinations not encountered in the field.

Most country in bad range condition should be removed from use for such time as is necessary for recovery to be effected. Management practices required on pasture lands in bad condition are outlined in Range Condition Guides for the West Kimberley area W.A. (Payne *et al* 1974).

EROSION INDEX FOR EACH LAND SYSTEM

In addition to computer results which showed percentages of total erosion falling into the four erosion categories, a single overall erosion statement or erosion index was required for each land system. This was used to present erosion data for each station. This information is not presented here but the erosion index was obtained from an empirical formula which used the four total erosion percentages derived for each land system.

The erosion index (EI) was defined as the extent of surface affected by any form of erosion (summation of percentages of minor, moderate and severe total erosion) plus a severity index (summation of percentages of nil, minor, moderate and severe total erosion with each erosion category weighted by a ratio based on relative severity). The ratio chosen was 0:1:2:6 which states that any erosion is worse than nil, moderate erosion is twice as bad as minor and severe erosion is six times as bad as minor.

i.e. $EI = (x_0 + x_1 + x_2) + (0x_0 + 1x_1 + 2x_2 + 6x_3)$

where x_0 = % nil total erosion

x_1 = % minor total erosion

x_2 = % moderate total erosion

x_3 = % severe total erosion

Simplifying $EI = 2x_1 + 3x_2 + 7x_3$

The erosion index was expressed as a numerical value. Those systems with extensive erosion had high EI values, those with little erosion had low EI values.

The numerical value was then placed in one of four erosion classes. The limits of each class were determined as falling midway between the values of the 0:1:2:6 ratio multiplied by a hundred because of percentage.

Thus, when $EI < 50$ Nil erosion
 $EI > 50 < \text{or} = 150$ Minor erosion
 $EI > 150 < \text{or} = 400$ Moderate erosion
 $EI > 400$ Severe erosion

e.g. Camelgooda land system

Total erosion				
Rating		No. of observations	%	
0 (nil)	.....	216	83.1	
1 (minor)	.....	39	15.0	
2 (moderate)	.....	4	1.5	
3 (severe)	.....	1	0.4	
Total	.....	260		

$EI = 2(15) + 3(1.5) + 7(0.4)$
 $= 37.3$
 $=$ Nil erosion

e.g. Amy land system—accessible units

Total erosion				
Rating		No. of observations	%	
0 (nil)	.....	0	0.0	
1 (minor)	.....	9	15.8	
2 (moderate)	.....	27	47.4	
3 (severe)	.....	21	36.8	
Total	.....	57		

$EI = 2(15.8) + 3(47.4) + 7(36.8)$
 $= 431.4$
 $=$ Severe erosion

The erosion index indicates the average erosion encountered on each land system over the entire survey area. It was used for mapping purposes and is expressed in the land system summary table presented in this report under the section entitled Range Condition of the Survey Area. It is stressed that these are mean statements for each land system. Erosion present on any particular land system can vary from location to location.

RANGE CONDITION OF THE SURVEY AREA

The concept of range condition or "range health" and its derivation from traverse assessments of erosion and pasture condition has been discussed under the section on Techniques of the Survey. Three levels of range condition, good, fair and bad were recognised.

Country in good range condition is in acceptable order and its use for grazing can be continued provided that sound management practices are adopted.

Country in fair range condition may still be used for grazing, but changes in management practices may be necessary if further deterioration is to be prevented.

Country in bad range condition is in unacceptable order. It is frequently unstable, as pastures are badly degraded and/or moderate to severe erosion is present. In many cases it should be removed from use for such time as is necessary for recovery to be effected.

The overall condition of the survey area can be summarised by bulking all traverse recordings made during the course of the survey. Table 6 shows the breakdown of range condition as sorted from the traverse data by the Cyber 72 programme.

It was not possible to traverse rugged, hilly areas, nor was this necessary as such country is inaccessible or virtually inaccessible to stock

Table 6—Traverse summary, total over all land systems

Wind erosion	%	Water erosion	%	Total erosion	%	Pasture condition	%	Range condition	%
Nil	71.5	Nil	54.7	Nil	47.1	Excellent	4.1	Good	19.5
Minor	17.5	Minor	23.5	Minor	26.5	Good	15.8	Fair	50.7
Moderate	7.9	Moderate	16.6	Moderate	16.5	Fair	37.1	Bad	29.8
Severe	3.1	Severe	5.2	Severe	9.9	Poor	28.9		
						Very poor	14.1		

4 532 recordings were made on 45 land systems. The table was obtained by traversing as many accessible areas as possible.

and its pastoral value is extremely low to useless. Such areas were inspected on foot. The table represents an overall summary of all usable areas of pastoral value.

Over half the area has some form of soil erosion and 10 per cent is severely eroded.

Over 40 per cent of the area has pastures in poor to very poor condition.

Thirty per cent of the area is in bad range condition.

Only 20 per cent of the area is in good range condition. The bulk of the country in good condition consists of low quality pasture land.

In the following discussion, whole land systems and units of land systems in good, fair or bad range condition as found in the survey area are described. These descriptions should be read in conjunction with the maps and the erosion overlays. Together they are intended to give an overall impression of the survey area and the regional occurrence of erosion and degradation. They are not meant to describe the situation on individual stations.

1. GOOD RANGE CONDITION—APPROXIMATELY 20 PER CENT OF THE SURVEY AREA

In general good range condition was encountered only where

- the country was inaccessible or virtually inaccessible to stock;
- the area had not been developed and hence was not stocked;
- the pastures were unacceptable or unattractive to stock, e.g. limestone spinifex (LmSS) and lobed spinifex (LS);
- the soils were inherently resistant to erosion, e.g. stony skeletal soils, some cracking clay plains.

Poorly accessible areas include nearly all of the *Precipice*, *Lubbock*, *Clifton* and *Windjana* land systems. In addition the rocky hill units of the *Amy* (50%), *Burramundi* (70%), *Dockrell* (45%), *Forrest* (60%) and *St George* (60%) land systems are largely inaccessible and are also in good range condition.

The area within the survey that can be classified as virtually inaccessible and of almost negligible use for grazing purposes is 19 580 sq. km or 22 per cent of the total area.

Land systems supporting mixed lobed spinifex (LS) and curly spinifex (CS) pastures are predominantly in good range condition and

include the *Bulka*, *Landrigan* and *Ruby* systems which are restricted to the east and south-east of the survey area. Nearly 40 per cent of the *Gidgia* land system is in good range condition. Topography of these systems is undulating to almost flat; soils are sandy loams, frequently high in laterite gravel and vegetative cover is good. There is generally no erosion. Pastoral value and carrying capacity of these systems is low and, in general, they have not been extensively developed.

Minor parts of the *Camelgooda*, *Wanganut* and *Yeeda* land systems and the sand plain units of the *Luluigui*, *Mamulu*, *Sisters* and *St George* systems are in good range condition. However, the bulk of these systems, as seen during the survey, are in fair range condition. There is usually no erosion at either the good or fair status level. The systems support curly spinifex-ribbon grass (CSRG) pin-dan pastures. Some substantial areas are poorly developed and in these circumstances pasture condition is good to excellent. In developed areas, pasture condition is usually fair. The pastures are moderately acceptable to stock but are of low quality and carrying capacity.

The *Chestnut* land system, which supports soft spinifex (SS) pastures, is relatively stable under grazing and about 30 per cent of the system is in good range condition. The remainder is in fair range condition. The system consists of gently sloping stable alluvial plains with reddish loamy soils. It is found adjacent to better quality pasture lands of the *Djada* and *Gogo* land systems. There is some patchy, minor erosion. The pastures are only moderately attractive to stock but are useful drought reserves.

About 40 per cent of the *Fork* and 27 per cent of the *Tablelands* systems are in good range condition. Some of the large interfluvial units of the *Glenroy* system are in good range condition. These systems are restricted to the north-east of the survey area and support curly spinifex (CS) pastures. Pasture condition is fair to good, ground cover is optimal and, generally, there is no erosion. Pastoral value and carrying capacity is low.

Lobed spinifex (LS) pasture lands, which are found on units of many systems, are usually in good range condition. The rocky hill units and stony lower slopes of the *Dockrell*, *Bohemia*, *Koongie* and *Margaret* systems and the stony outcrop plains of the *Myroodah* system support this pasture type and are in

good condition. Lobed spinifex pastures are of very low quality and carrying capacity and are unattractive to stock. Soils are stony and skeletal. These two factors are responsible for the good condition of the pastures and the usual absence of erosion.

About 36 per cent of the *Egan* land system, which consists of almost flat plains, with yellow, loamy soils supporting ribbon grass (RGa) pastures, is in good range condition. The remainder is in fair condition. Pastures are in fair condition and erosion is nil to minor. The system is well developed on Blina Station and parts of Liveringa, Ellendale and Kimberley Downs stations. Pastoral value is moderate.

Some cracking clay plain land systems, supporting black soil plain (BSP) pastures, are in good range condition. However, the bulk of these land systems, as seen during the survey, are in fair range condition. There are also some extensive areas in bad range condition. Minor parts of the *Duffer*, *Gladstone*, *Oscar*, *Fossil*, *Leopold* and *Alexander* systems fall into the good range condition category. In good range condition there is no erosion. Pastoral value is high.

2. FAIR RANGE CONDITION—APPROXIMATELY 50 PER CENT OF THE SURVEY AREA

Although the bulk of short grass (SGb) pasture lands are in bad condition, some are in fair range condition. Isolated areas in fair condition are found on the restricted lower slopes and drainage floors of the *Bohemia* and *Koongie* systems and alluvial aprons and floors of the *Burramundi* system. Pasture condition is usually fair and erosion minor. Pastoral value is low to moderate. These areas have been subjected to preferential use by stock, as they are usually surrounded by country supporting very poor quality and unattractive lobed spinifex (LS). Continuous, heavy, unrestricted use rapidly results in degradation to the poor condition level.

About 78 per cent of the *Luluigui* land system, which supports curly spinifex-ribbon grass (CSRG) and ribbon grass (RGb) pastures, is in fair range condition. Pasture condition is fair to poor and erosion is minor. *The ribbon grass (RGb) pastures are favoured by stock and a reduction in numbers and wet season spelling is required on some stations.*

The *Calwynyardah* land system is well developed on Blina, Calwynyardah and Noonkanbah stations. About 60 per cent of the

system is in fair range condition. It supports ribbon grass (RGa) pastures which are in fair to poor condition. Erosion is usually minor but moderate erosion, in the form of sheeting and wind scalding, is sometimes found on areas subjected to heavy use.

About 60 per cent of the accessible areas of the basaltic *Looingnin* and *Cowendyne* land systems are in fair range condition. Some extensive areas are in bad condition. Pastures are white grass-bundle bundle (WGBB) and black soil plain (BSP) grasses and their condition is fair to poor. Undesirable species are frequently more common than desirable, and ground cover is patchy. Minor erosion is common. These land systems are best developed on Mt Hart, Mornington, Lansdowne and Bedford Downs stations. Pastoral value is moderate to high. They are nearly always surrounded by hilly, inaccessible country and are subjected to heavy preferential use by stock. *In many cases stock numbers are excessive and should be reduced.*

Most of the *Fossil*, *Leopold* and *Alexander* land systems throughout the survey area can be classified as being in fair range condition. About 75, 68 and 53 per cent respectively of these systems, as seen during the survey, fall into this condition category.

These high pastoral value systems consist of extensive cracking clay plains supporting black soil plain (BSP) pastures. They are well developed in the vicinity of Fitzroy Crossing on such stations as Jubilee Downs, Brookling Springs, Leopold Downs, Fossil Downs and Gogo. They also occur along the Lenard and May Rivers on Meda, Kimberley Downs and Napier Downs stations. Pasture condition is usually fair to poor. Because of the flat topography and inherent resistance of the clay soils, erosion is nil to minor. The systems have been, and still are, subjected to excessive grazing use and, as a result, pastures are degraded. *On many stations, stock numbers should be reduced and periodic wet season spelling implemented.*

Nearly 60 per cent of the limestone derived *Neillabubica* land system is in fair range condition. The remainder is about evenly distributed between good and bad range condition. The system is well developed on Brookling Springs, Fossil Downs and Gogo stations in the Fitzroy Crossing area. It supports limestone spinifex (LmSS), black soil plain (BSP) and some ribbon grass (RGa) pastures.

When in fair range condition, pastures are fair to poor. There is patchy minor erosion. Pastoral value is low to moderate.

Taken overall, the pindan land systems seen during the survey are predominantly in fair range condition. About 70, 86 and 60 per cent respectively of the *Camelgooda*, *Wanganut* and *Yeeda* systems are in this category. Pasture condition is fair and there is usually no erosion. Pastoral value is low.

3. BAD RANGE CONDITION—APPROXIMATELY 30 PER CENT OF THE SURVEY AREA

Many of the high pastoral value pasture lands have been heavily utilised and are in bad range condition. These include—

- Frontage grass (FG) pasture lands of the *Djada*, *Gogo*, *Amy* and *Glenroy* land systems.
- Black soil plain (BSP) pasture lands of parts of the *Alexander* and *Cowendyne* land systems.
- White grass-bundle bundle (WGBB) pasture lands of parts of the *Cowendyne* and *Looingnin* land systems.
- Ribbon grass (RGa and RGb) pasture lands of parts of the *Richenda*, *Coonagoody*, *Myroodah* and *Calwynyardah* land systems.
- Short grass (SGa and SGb) pasture lands of parts of the *O'Donnell*, *Koongie*, *Pigeon* and *Margaret* land systems.

Some of the most severe degradation seen during the survey occurs on the *Djada* and *Gogo* land systems. These high pastoral value systems are derived from alluvium and flank the Fitzroy, Lennard, Meda and Margaret Rivers and Christmas Creek. The black soil plain (BSP) pastures are in poor condition with minor erosion. The frontage grass (FG) pastures are in very poor condition and erosion is usually severe.

Erosion on the levee crests and black slopes is frequently in the form of large wind scalds and sheeting, extending for many kilometres. Wind piling and some root exposure of trees such as coolibah (*Eucalyptus microtheca*) and baubinia (*Lysiphylum cunninghamii*) is fairly common. There are restricted areas of active gullying. The most severely affected areas are found on Kalyeada, Noonkanbah, Cherrabun, Gogo and Christmas Creek stations.

On many areas, perennial grasses are virtually absent and the principal feeds available for stock are annuals such as rice grass

(*Xerochloa* sp.). These annuals produce little dry matter and are grazed out by stock during the early dry season. Therefore, bare ground predominates during most of the year, exposing the unprotected loamy soils of the levee back slopes to wind and water erosion.

Such bad range condition areas require complete withdrawal from grazing for a number of years. In many cases, regeneration by cultural and seeding techniques would be possible. Even if these techniques are adopted, regeneration is likely to be long term (5 to 20 years). *Considerations such as this would impose grazing restrictions upon many stations in the survey area.*

The *Amy* land system is well developed on Napier Downs and Leopold Downs stations and shows extremes of condition. About half of the system consists of inaccessible granite domes and lower slopes (previously mentioned under good range condition) supporting scattered curly spinifex (CS) pastures. The remainder consists of broad alluvial drainage floors supporting useful frontage grass (FG) pastures. These pastures have been subject to heavy preferential use by stock and are now badly degraded. Erosion is severe and range condition is bad.

Soils of the *Amy* drainage floors are derived from granite and are coarse sands or sandy loams overlying loamy clays. They have a low inherent resistance to erosion. When bared by overuse, deep gullying, sheeting and terracing occurs rapidly. Inherently vulnerable soils and overuse, coupled with the high rate of run-off from the surrounding granite hills, have resulted in a highly unstable situation. Virtually all of the accessible and valuable areas have been affected. Thus, for pastoral purposes, all the *Amy* land system must be considered as being in bad range condition. *Many sections, such as on the Napier Downs and Leopold Downs stations, should be withdrawn from use.*

The *Glenroy* land system is well developed on Glenroy and Mt House stations. Over 20 per cent of the system, as seen during the survey, is in bad range condition. The bad condition sections are the alluvial drainage floors, which occur between extensive shaley interfluvies. They support valuable frontage grass (FG) pastures, which are in poor condition. Erosion is usually moderate. *On some areas, stock numbers should be reduced and wet season spelling commenced.*

About 30 per cent of the *Alexander* and *Cowendyne* land systems, supporting black soil plain (BSP) pastures, are in bad range condition. Some stony interfluvies of the *Cowendyne* system, which support white grass-bundle bundle (WGBB) pastures, are also in bad range condition. Pasture condition is very poor and erosion is minor to moderate. The most badly affected areas of the *Alexander* system are found on Alexander Island, between the Fitzroy and Forrester Rivers, on Jubilee Downs station. Badly affected areas of the *Cowendyne* system are found on Lansdowne station. Pastoral value of these systems is potentially high. *Many areas now require reductions in stock numbers and wet season spelling to encourage pasture regeneration.*

The inaccessible lower slopes and narrow drainage floors of the *Richenda* land system are in bad range condition. Condition of the ribbon grass (RGr) pastures is generally poor, and moderate erosion, in the form of gullying and sheeting, is common. Although the soils are generally skeletal and commonly have a stony colluvial mantle, they are still prone to erosion, once bared by overuse.

The *Coonangoody* and *Myroodah* land systems are extensive in the south-western and south-central sections of the survey area. They support large areas of the useful ribbon grass (RGr) pastures. Pastoral value of the *Coonangoody* system is moderate and of the *Myroodah* system is low to moderate.

The *Coonangoody* land system occurs to the south of the Fitzroy River and is well developed in Christmas Creek, Cherrabun and Noonkanbah stations. Nearly half of it is in bad range condition. In many cases, the ribbon grass (RGr) pastures have been subjected to overuse and are in poor or very poor condition. Erosion, taken overall, is moderate. Minor areas are salt affected. *A considerable reduction in stock numbers is generally required and some areas require withdrawal from use.*

About 28 per cent of the *Myroodah* land system, as seen during the survey, is classified as being in bad range condition. The system is well developed on many stations to the south of the Fitzroy River. The soil covered plains of the system are characterised by long linear run-off areas, alternating with run-on strips. The former sites are pebble strewn and support unpalatable lobed spinifex (LS) pastures. The run-on areas support ribbon

grass (RGr) pastures of moderate pastoral value. They have been grazed preferentially by stock and are frequently severely depleted. Long linear scalds, often with small wind hummocks at the margins, frequently occur on these degraded areas. Thin sheeting and rilling is common. *In many cases, stock reductions and wet season spelling is required to encourage recovery of the valuable species.*

About 20 per cent of the *Calwynyardah* land system is in bad range condition. Units affected are lower slopes, scalded tracts and some parts of the alluvial plains. Ribbon grass (RGr) pastures are poor or very poor. Erosion, in the form of extensive thin sheeting and rilling, is moderate. *In many cases, stock numbers should be substantially reduced and areas spelled for several consecutive wet seasons.*

The *Koongie*, *Pigeon* and *O'Donnell* land systems have been derived from granites and gneiss. Substantial parts of these land systems support short grass (SGa and SGr) pastures and are in bad range condition. Pastoral value of the *Koongie* and *Pigeon* systems is low to moderate and of the *O'Donnell* system is moderate.

Koongie land system is well developed on Louisa Downs, Lamboo, Koongie Park and Moola Bulla stations. It has been subjected to heavy continuous overuse. The areas of useful pastures which make up about 40 per cent of the system are in bad range condition. Taken overall, erosion is moderate.

Pigeon land system occurs principally on Leopold Downs, Fossil Downs and Gogo Stations. About 80 per cent is accessible and has proved vulnerable to overuse. Soils of the accessible units are mainly skeletal and readily erode once bared by overuse. Depletion of the pastures is associated with gullying, terracing and sheeting.

The *O'Donnell* land system is restricted to the eastern part of the survey area on Moola Bulla Station. About 60 per cent of it is assessed as being in bad range condition. It consists of extensive undulating interfluvies, low hills and ridges, restricted cracking clay plains and alluvial drainage floors. The present pasture condition is poor to very poor. Erosion, characterised by micro-terracing on the interfluvies and gullies on the lower slopes, is moderate.

Table 7—Summary of land systems—West Kimberley Survey Area

Pastoral value	Land system	Area (sq. km)	% of survey area	Pasture land (p) ³	Pasture condition	Erosion	Range condition	Effective range condition
High	Alexander	976	1.09	BSP	Black soil plain	Min-Mod	Fair-Bad	Fair-Bad
	Cowendyne	1 304	1.46	WGBB BSP	White grass-bundle Black soil plain	Min-Mod Minor	Fair-Bad Fair	Fair-Bad
	Djada ¹	3 981	4.44	FG BSP	Frontage grass Black soil plain	Mod-Severe Minor	Bad Fair	Bad
	Duffer	501	0.56	BSP	Black soil plain	Minor	Fair	Fair
	Fossil	2 128	2.37	BSP	Black soil plain	Minor	Fair	Fair
	Gladstone	124	0.14	RGA BSP	Ribbon grass Black soil plain	Nil	Fair	Fair
Moderate	Gogo ¹	1 847	2.06	FG BSP	Frontage grass Black soil plain	Mod-Severe Minor	Bad Fair	Bad
	Leopold	407	0.45	BSP	Black soil plain	Minor	Fair	Fair
	Sub-total	11 268	12.57					
	Calwinyardah	1 692	1.89	RGA LS	Ribbon grass Lobed spinifex	Min-Mod Nil	Fair-Bad Good	Fair-Bad
Moderate	Carpentaria	530	0.59	Lt	Littoral	Nil-Min	Fair	Fair
	Coonangoody ¹	1 700	1.90	RGB	Ribbon grass	Moderate	Bad	Bad
	Egan	1 609	1.80	RGA	Ribbon grass	Nil	Fair-Good	Fair-Good
	Oscar	305	0.34	BSP LmSS	Black soil plain Limestone spinifex	Nil	Fair-Good Good	Fair-Good
	O'Donnell ¹	1 585	1.77	SGa CS	Short grass Curly spinifex	Moderate Nil	Bad Fair	Bad
	Sub-total	7 421	8.29					

Table 7—(continued)

Pastoral value	Land system	Area (sq. km)	% of survey area	Pasture land(s) ^a	Pasture condition	Erosion	Range condition	Effective range condition
	Amy ¹	1 362	1.52	CS FG	Curly spinifex, Frontage grass	Good Poor	Nil Mod-Severe	Good Bad
	Glenroy	1 487	1.66	CS FG	Curly spinifex, Frontage grass	Fair-Good Poor	Fair-Good Bad	Fair-Good
	Koongie ¹	3 175	3.54	LS SGB	Lobed spinifex Short grass	Good Poor	Nil Moderate	Good Bad
	Loolingnin	3 686	4.11	WGAS WGBB	White grass-annual sorghum White grass-bundle bundle	Good Poor	Nil Minor	Good Fair
	Luluigui	1 672	1.87	CSRG RGB	Curly spinifex-ribbon grass Ribbon grass	Fair Fair	Nil Nil	Fair Fair
Low to Moderate	Mamulu	565	0.63	CSRG RGB	Curly spinifex-ribbon grass Ribbon grass	Good Good	Nil Nil	Good Good
	Myroodah ¹	5 835	6.51	LS RGB	Lobed spinifex Ribbon grass	Good Poor	Nil-Minor Min-Mod	Good Fair-Bad
	Neillabubica	2 306	2.57	LmSS BSP	Limestone spinifex Black soil plain	Good Fair	Nil-Minor Minor	Good Fair
	Pigeon ¹	2 479	2.77	SGB CS	Short grass Curly spinifex	Poor Fair	Moderate Nil-Minor	Bad Fair
	Sitters	2 295	2.56	CSRG RGa	Curly spinifex-ribbon grass Ribbon grass	Fair-Good Fair	Nil Nil	Fair-Good Fair
	Sub-total	24 862	27.74					

Table 7—(continued)

Pastoral value	Land system	Area (sq. km)	% of survey area	Pasture land(s) ^a	Pasture condition	Erosion	Range condition	Effective range condition
	Bulka	708	0.79	LS CS	Lobed spinifex Curly spinifex	Excellent Good	Nil Nil	Good Good
	Camelgorda	5 961	6.65	CSRG	Curly spinifex-ribbon grass	Fair	Fair	Fair
	Chestnut	433	0.48	SS LS	Soft spinifex Lobed spinifex	Fair-Good Good	Minor Minor	Fair-Good Fair-Good
	Fork	1 272	1.42	CS	Curly spinifex	Fair-Good	Nil	Fair-Good
	Forrest* ¹	1 550	1.73	CS WGAS	Curly spinifex White grass-annual sorghum	Excellent Fair-Poor	Nil Moderate	Good Bad
	Gidgia	296	0.33	CS LS	Curly spinifex Lobed spinifex	Fair-Good Excellent	Nil Nil	Fair-Good Fair-Good
	Landrigan	694	0.77	LS	Lobed spinifex Curly spinifex	Excellent Good	Nil Nil	Good Good
	Richenda* ¹	4 289	4.79	CS RGB	Curly spinifex Ribbon grass	Good Poor	Nil Moderate	Good Bad
	Rose*	491	0.55	CS SGB	Curly spinifex Short grass	Good Fair	Nil Minor	Good Fair
	Ruby	890	0.99	CS LS	Curly spinifex Lobed spinifex	Fair-Good Excellent	Nil Nil	Fair-Good Fair-Good
	Tableland	1 810	2.02	CS	Curly spinifex	Fair	Nil	Fair
	Wanganut	1 832	2.04	CSRG	Curly spinifex-ribbon grass	Fair	Nil	Fair
	Yeeda	4 183	4.67	CSRG RGB	Curly spinifex-ribbon grass Ribbon grass	Fair-Good Fair-Good	Nil Nil	Fair-Good Fair-Good
	Sub-total	24 409	27.23					

Low

Table 7—(continued)

Pastoral value	Land system	Area (sq. km)	% of survey area	Pasture land(s) ²	Pasture condition	Erosion	Range condition	Effective range condition
	Bohemia	2 224	2.48	LS SGB	Lobed spinifex Short grass	Excellent Poor	Nil Minor	Good Fair
	Burramundi ¹	784	0.87	LS SGB	Lobed spinifex Short grass	Excellent Poor	Nil Minor	Good Fair
	Clifton*	633	0.71	CS	Curly spinifex	Excellent	Nil	Good
	Dockrell*	1 989	2.22	LS	Lobed spinifex	Excellent	Nil-Min	Good
	Lubbock*	4 845	5.41	CS LS	Curly spinifex Lobed spinifex	Good Excellent	Nil Nil	Good Good
	Margaret ¹	1 640	1.83	LS SGB	Lobed spinifex Short grass	Good Poor	Minor Moderate	Good Bad
	Precipice*	6 969	7.76	CS	Curly spinifex	Good-Excellent	Nil-Minor	Good
	St. George*	1 205	1.34	LS CSRG	Lobed spinifex Curly spinifex-ribbon grass	Excellent Fair-Good	Nil Nil	Good Fair-Good
	Windjana*	1 386	1.55	LmSS	Limestone spinifex	Good	Nil	Good
	Sub-total	21 665	24.17					
	Total	89 625	100.00					

* Poorly accessible land systems.

¹ Nearly all useful and accessible parts of these land systems are in bad range condition and require drastic remedial treatments.² The major pasture land in the system is listed first.

It appears from the survey records that the carrying capacity of O'Donnell system has been grossly over-estimated in the past. As a result of heavy continuous use this country is now degraded. There is an increase in undesirable species and a decrease in desirable species associated with extensive, patchy bare areas.

The *Koongie*, *Pigeon* and *O'Donnell* systems contain some small, inaccessible units or units supporting worthless pastures. Such areas are in good range condition but are useless for grazing purposes. All the valuable pasture lands are badly degraded. Thus, for pastoral purposes, the whole of each system must be regarded as being in bad range condition. This is the real situation as stock will only use the accessible portions with attractive pastures. *In many cases stock numbers are excessive and should be considerably reduced.* Improvement programmes to facilitate stock control and periodic wet season spelling, are essential. *Some areas should be totally withdrawn from use.*

Table 7 groups the lands systems into pastoral value classes. In addition it shows the component pasture lands of each land system, their present pasture and erosion status, overall range condition and effective range condition. Effective range condition describes the state of the accessible and useful pasture lands. It does not refer to the inaccessible or unacceptable and worthless pasture lands which may be the other components of the land system.

Table 8 lists the land systems and their areas alphabetically.

Table 8—Land system areas—West Kimberley Survey Area

Land system	Area (sq. km)	Percentage of survey area
Alexander	976	1.09
Amy	1 362	1.52
Bohemia	2 224	2.48
Bulka	708	0.79
Burramundi	784	0.87
Calwynyardah*	1 692	1.89
Camelgorda	5 961	6.65
Carpentaria	530	0.59
Chestnut	433	0.48
Clifton	633	0.71
Coonangoody†	1 700	1.90
Cowendyne	1 304	1.46
Djada	3 981	4.44
Dockrell	1 989	2.22
Duffer	501	0.56
Egan	1 609	1.80
Fork	1 272	1.42
Forrest	1 550	1.73
Fossil	2 128	2.37
Gidgia	296	0.33
Gladstone	124	0.14
Glenroy	1 487	1.66
Gogo	1 847	2.06
Koongie	3 175	3.54
Landrigan	694	0.77
Leopold	407	0.45
Looningin	3 686	4.11
Lubbock	4 845	5.41
Luluigui	1 672	1.87
Mamili	565	0.63
Margaret	1 640	1.83
Myroodah	5 835	6.51
Neillabubica	2 306	2.57
Oscar	305	0.34
O'Donnell	1 585	1.77
Pigeon	2 479	2.77
Precipice	6 959	7.76
Richenda	4 289	4.79
Rose	491	0.55
Ruby	890	0.99
St. George	1 205	1.34
Sisters	2 295	2.56
Tableland	1 810	2.02
Wanganut	1 832	2.04
Windjana	1 386	1.55
Yeeda	4 183	4.67
Total	89 625	100.00

* Includes 12 sq. km salt country.

† Includes 31 sq. km salt country.

CARRYING CAPACITY ESTIMATIONS

From the evidence of degradation seen during the survey and from experimental observations on enclosed areas it is obvious that past levels of use have been excessively high. That they have been too high for maintenance of the base pasture resource is also indicated by studying the cattle population trends in West Kimberley since settlement. In 1917 the cattle population reached a peak of

over 400 000 head, and then steadily declined to its lowest point of about 153 000 in 1954. Such a steady decline over an extended period indicates progressive pasture deterioration. The increase in stock numbers since 1954 has been due to factors other than a general improvement in pasture condition. A subsidised boring scheme, for instance, allowed the development of hitherto unused country well

away from natural water supplies. In this period large areas of pindan pasture types were developed for use by cattle.

A number of factors have been taken into consideration in estimating the carrying capacity of the various pasture lands.

- The first consideration is the total dry matter present on a particular site, i.e. the amount of vegetative material on offer. However production figures, taken by themselves, are not sufficient for determining stocking capacities.
- Species composition by weight on a particular pasture land or site must be considered. That is the proportion of total production made up of species highly attractive to stock, species moderately attractive and unattractive species should be considered. Acceptability or palatability of the species on offer is the criterion.

From field observations it is apparent that stock frequently concentrate on small attractive annual grasses and herbage early in the season. There is a gradual change in diet towards palatable perennial species as the annuals become depleted. The change-over may occur earlier or later in the year, depending on seasonal conditions and the percentage composition of the particular pasture. Generally, for at least the last half of the year, stock rely on perennial grasses for their feed requirements. Some perennials such as lobed spinifex (*Triodia intermedia*) and limestone spinifex (*Triodia wiseana*), because of their harsh unpalatable nature, always remain virtually unused. Grazing on these types may be restricted to the seed heads or to times of dire need when other feed is absent.

- Nearly all pasture lands of the West Kimberley consist of tussocky perennial grasses with varying amounts of annual grasses and forbs. Maintenance of the perennials is essential as these provide the base for stability of the range and supply the bulk of feed for stock. Range that is degraded to annuals supplies valuable and nutritious short term feed. However by mid-year its grazing capacity is exhausted, and the soil surface is bare and exposed to the action of wind and water. Management should be aimed at encouraging the return of desirable perennial species.
- Safe levels of use of perennial species must be considered. In general about 40 per cent utilisation by weight can be regarded as safe. With many tussock grasses this level of use is reached when the tussock is grazed down to about 15 cm (6 in.) above ground level. Continual use in excess of this level will result in gradual decline in production.
- Topfeed is not considered in these carrying capacity estimations. Its contribution to total feed is variable but usually small, and is difficult to evaluate. If present, it should be regarded as a reserve to be utilised in poor seasons.

Ribbon grass (RGa) pasture lands as found on the Egan land system, are taken as an example. Seasonal dry matter production is variable depending on rainfall, local topography and soils, but 900 kg/ha (800 lb/ac) can be reasonably expected. Provided that the site is in good condition, species percentage composition by weight will be approximately as indicated below:

Desirable species

1. <i>Chrysopogon fallax</i> —moderate palatability	}	25%	}	50%
2. <i>Sorghum plumosum</i> —high palatability		25%		
3. <i>Sehima nervosum</i> —low palatability				

Intermediate value species

4. <i>Eriachne obtusa</i> —low palatability	}	15%	}	30%
5. <i>Enneapogon polyphyllus</i>				
6. <i>Brachyachne convergens</i>				
7. <i>Dactyloctenium radulans</i>				
8. <i>Gomphrena</i> sp.				
9. <i>Ptilotis</i> sp.				

Undesirable species

10. <i>Aristida inaequiglumis</i>	} unpalatable and useless	20%
11. <i>Aristida hygrometrica</i>		100%

Based on 40 per cent utilisation of 1 and 2, 20 per cent utilisation of 3 and 4, 70 per cent utilisation of 5-9 and nil utilisation of 10 and 11, the total amount of feed available for use per hectare is 257 kg (230 lb/acre). The feed requirements of a cattle unit/annum are about 4 100 kg (9 000 lb) of dry material. About 16 ha of country are required to supply

this. Thus the carrying capacity, on a year long basis, is about 6.3 c.u./sq. km (16/sq. mile).

If the pasture is in fair condition seasonal dry matter production is likely to be about 500 kg/ha (445 lb/acre). Species composition by weight will differ from the composition for good condition and will be approximately as indicated below:

Desirable species

1. <i>Chrysopogon fallax</i> —moderate palatability	14%	} 34%
2. <i>Sorghum plumosum</i> —high palatability	20%	
3. <i>Sehima nervosum</i> —low palatability		

Intermediate value species

4. <i>Eriachne obtusa</i> —low palatability	20%	} 33%
5. <i>Enneapogon polyphyllus</i>		
6. <i>Brachyachne convergens</i>		
7. <i>Dactyloctenium radulans</i>	} high palatability	
8. <i>Gomphrena</i> sp.		
9. <i>Ptilotis</i> sp.		

Undesirable species

10. <i>Aristida inaequiglumis</i>	} unpalatable and useless	33%
11. <i>Aristida hygrometrica</i>		
12. <i>Heliotropium</i> sp.		
13. <i>Trichodesma zeylanicum</i>		
14. <i>Pterigeron odoratus</i>		
		100%

Based on the same levels of use as for good condition the total amount of feed available for use per hectare is about 113 kg (100 lb/acre). The carrying capacity, on a yearly basis, is about 2.8 c.u./sq. km (7.2/sq. mile).

If the pasture is in poor condition seasonal dry matter production is likely to be further reduced to about 300 kg/ha (270 lb/acre). In

this situation overall ground cover will be sparse and patchy and there may be fairly extensive areas of surface scalding and thin sheeting. Desirable perennial species will be very sparse and many individual plants will show poor vigour and production. Intermediate value species and undesirable species will dominate in the stand. Species composition by weight will be approximately as below:

Desirable species

1. <i>Chrysopogon fallax</i> —moderate palatability	5%	} 20%
2. <i>Sorghum plumosum</i> —high palatability	15%	
3. <i>Sehima nervosum</i> —low palatability		

Intermediate value species

4. <i>Eriachne obtusa</i> —low palatability	15%	} 30%
5. <i>Enneapogon polyphyllus</i>		
6. <i>Brachyachne convergens</i>		
7. <i>Dactyloctenium radulans</i>	} high palatability	
8. <i>Gomphrena</i> sp.		
9. <i>Ptilotis</i> sp.		

Undesirable species

10. <i>Aristida inaequiglumis</i>	} unpalatable and useless	50%
11. <i>Aristida hygrometrica</i>		
12. <i>Heliotropium</i> sp.		
13. <i>Trichodesma zeylanicum</i>		
14. <i>Pterigeron odoratus</i>		
15. <i>Solanum</i> sp.		
16. <i>Cassia notabilis</i>		
		100%

Levels of use on the highly palatable intermediate value annual species 5-9 can be assumed to be 70 per cent as for fair and good condition. Because of the low vigour of desirables 1 and 2, 20 per cent utilization would be regarded as a safe level of use. At the same time some 10 per cent utilization of the low palatability species 3 and 4 could be expected. Based on these levels the amount of feed available for use per hectare is about 43 kg (38 lb/acre). Carrying capacity, on a year long basis, is about 1 c.u./sq. km (2.5/sq. mile).

In the Range Condition Guides (Payne *et al* 1974) the level of use for ribbon grass (RGa) pasture lands in bad condition is given as 0-1.0 c.u./sq. km. This is to indicate that, in the extreme situation, where pastures are severely depleted and associated with moderate erosion, they should be totally withdrawn from use. In any event ribbon grass pastures in bad range condition should not be grazed on a year long basis. They should be spelled for a number of consecutive wet seasons to allow recovery of desirable species. Grazing should be restricted to the eight months dry season at levels not in excess of about 1.5 c.u./sq. km (3.8/sq. mile). This is equivalent to 1 c.u./sq. km on a year long basis.

The carrying capacities of other pasture lands have been calculated using similar techniques to those described. For the purpose of determining carrying capacities, the standard of cattle units (c.u.) has been used. This is defined as "a dry cow or steer in excess of 2 years of age". The feed requirement for a

cattle unit is about 4 100 kg/year (9 000 lb/year). This enables comparisons to be made against other animals as summarised in Table 9.

From figures derived by Westerman,¹ Ritson and Norman,² the average stock composition by age on Kimberley stations is summarised in Table 10.

Table 10—Kimberley cattle ages

Age	Male	Female
Less than 1 year	12	11
1 to 2 years	10	12
2 to 4 years	16	22
Older than 4 years	3	14

A value of 0.85 was calculated from Table 10 as the conversion factor from total herd numbers to cattle units. For example, an estimated present stock number of 10 000 is considered as 8 500 cattle units.

In preparing individual station reports (not presented here) cattle units were used for expressing present stock numbers and recommended and optimum stocking capacities.

Horses were not included in the estimated present stock number, as these figures were not available for all stations. However, it is considered that horse numbers should be quoted and that they be regarded as one cattle unit for calculating grazing pressures and for the stations overall carrying capacity. Eight dry ewes, or wethers, are considered to be equivalent to one cattle unit.

A summary of land systems, their component pasture lands and safe stocking rates for each condition level is presented in Table 11.

Table 9—Cattle unit equivalents

Animal class or type	Cattle units
Calf	0.4
1 to 2 year old heifer or steer	0.7
Adult steer, dry cow	1.0
Pregnant cow	1.2
Adult horse	1.0
Adult dry ewe or wether	0.125
8 dry ewes or 8 wethers	1.0

¹ Westerman, P. A. "The Kimberley Beef Cattle Industry" *Quart. Review of Agric. Econ.*, Bureau of Agric. Econ., October 1966.

² Ritson, J. B., Norman, M. J. T. "A Sample Census of Cattle in East Kimberley Region", *J. Aust. Inst. Agric. Sci.* 27, March 1961.

Table 11—Pasture land and land system carrying capacities

Land system	Pasture Land(s)		% of land system	E.C.C. (Cattle Units/sq. km) for range condition			Remarks
	BSP	Black soil plain		Good	Fair	Bad	
Alexander	BS	Black soil plain	100	11.0	5.0	0.1-0	
Amy	CS	Curly spinifex	60	1.2	0.8	0.4	Inaccessible hills
	FG	Frontage grass	40	8.0	3.0	0.1-0	
Bohemia	LS	Lobed spinifex	85	1.2	0.8	0.4	0.0-0.5
	SGb	Short grass	15	4.0	1.5	0.1-0	
Bulka	LS	Lobed spinifex	70	1.2	0.8	0.4	0.5
	CS	Curly spinifex	30	2.4	1.5	0.8	
Burramundi	LS	Lobed spinifex	70	0.6	0.4	0.2	Useless hills
	SGb	Short grass	30	4.0	1.5	0.1-0	
Calwinyardah	RGa	Ribbon grass	88	6.5	3.0	0.1-0	0.0-0.9
	LS	Lobed spinifex	12	1.2	0.8	0.4	
Camelgooda	CSRG	Curly spinifex-ribbon grass	100	2.5	1.5	1.0	
Carpentaria	Lt	Littoral	31	5.0	2.0	0.1-0	69% saline mud
Chestnut	SS	Soft spinifex	88	2.4	1.5	0.8	0.0-0.7
	LS	Lobed spinifex	12	1.2	0.8	0.4	
Clifton	CS	Curly spinifex	100	1.2	0.8	0.4	Poorly accessible
Coonagoody	RGB	Ribbon grass	100	5.5	2.8	0.1-0	
Cowendyne	WG88	White grass-bundle	51	5.5	2.5	0.1-0	0.1-0
	BSP	Black soil plain	49	11.0	5.0	0.1-0	
Djada	FG	Frontage grass	52	10.0	4.0	0.1-0	0.1-0
	BSP	Black soil plain	48	11.0	5.0	0.1-0	
Dockrell	LS	Lobed spinifex	100	1.2	0.8	0.4	Poorly accessible
Duffer	BSP	Black soil plain	100	11.0	5.0	0.1-0	
Egan	RGa	Ribbon grass	100	6.5	3.0	0.1-0	
Fork	CS	Curly spinifex	100	2.4	1.5	0.8	

Table 11—(continued)

Land system	Pasture land(s)		% of land system	E.C.C. (Cattle Units/sq. km) for range condition			Remarks
				Good	Fair	Bad	
Forrest	CS	Curly spinifex	59	1.2	0.8	0.4	Inaccessible ridges
	WGAS	White grass-annual sorghum	41	2.0	1.5	1.0	
Fossil	BSP	Black soil plain	100	11.0	5.0	0.1-0	
Gidgia	CS	Curly spinifex	85	2.4	1.5	0.8	0.0-0.7
	LS	Lobed spinifex	15	1.2	0.8	0.4	
Gladstone	RGA	Ribbon grass	60	6.5	3.0	0.1-0	0.1-0
	BSP	Black soil plain	40	11.0	3.8	0.1-0	
Glenroy	CS	Curly spinifex	64	2.4	1.5	0.8	0.0-0.9
	FG	Frontage grass	36	8.0	3.0	0.1-0	
Gogo	FG	Frontage grass	86	10.0	4.0	0.1-0	0.1-0
	BSP	Black soil plain	14	11.0	5.0	0.1-0	
Koongie	LS	Lobed spinifex	56	1.2	0.8	1.1	0.0-0.7
	SGb	Short grass	44	4.0	1.5	0.1-0	
Landrigan	LS	Lobed spinifex	59	1.2	0.8	1.1	0.0-0.6
	CS	Curly spinifex	41	2.4	1.5	0.0-0.8	
Leopold	BSP	Black soil plain	100	11.0	5.0	0.1-0	
Looningin	WGAS	White grass-annual sorghum	67	2.0	1.5	1.0	Poorly accessible hills
	WGGB	White grass-bundle	33	5.5	2.5	0.1-0	
Lubbock	LS	Lobed spinifex	100	0.6	0.4	0.2	Rainfall < 500 mm Rainfall > 500 mm Poorly accessible
	CS	Curly spinifex	100	1.2	0.8	0.4	
Luluigui	GSRG	Curly spinifex-ribbon grass	70	2.5	1.5	1.9	0.1-0
	RGB	Ribbon grass	30	5.5	2.8	0.1-0	
Mamili	GSRG	Curly spinifex	56	2.5	1.5	2.1	0.1-0
	RGB	Ribbon grass	44	5.5	2.8	0.1-0	
Margaret	LS	Lobed spinifex	90	1.2	0.8	0.9	Some inaccessible hills
	SGb	Short grass	10	4.0	1.5	0.1-0	

Table 11—(continued)

Land system	Pasture Land(s)	% of land system	E.C.C. (Cattle Units/sq. km) for range condition			Remarks
			Good	Fair	Bad	
Myroodah	LS Rb	62 38	1-2 5-5	0-8 2-8	1-6 0-4 0-1-0	0-0-6
Neillabubla	LmSS BSP	66 34	1-2 11-0	0-8 4-5	2-2 0-4 0-1-0	0-0-6
Oscar	BSP LmSS	55 45	11-0 1-2	5-0 6-6	3-1 0-1-0 0-0-7	
O'Donnell	SGa CS	84 16	6-0 2-4	2-5 5-4	2-3 0-1-0 0-0-9	
Pigeon	SGb CS	71 29	5-0 2-4	2-0 4-3	1-9 0-1-0 0-0-9	Some inaccessible hills
Precipice	CS	100	1-2	0-8	0-4	Inaccessible ranges
Richenda	CS Rb	70 30	1-2 5-5	0-8 2-8	1-4 0-4 0-1-0	Poorly accessible hills
Rose	CS SGb	68 32	1-2 4-0	2-1 0-8	1-0 0-4 0-0-6	Poorly accessible hills
Ruby	CS LS	70 30	2-4 1-2	2-0 0-8	1-5 0-0-8 0-0-7	
St. George	LS CSRG	60 40	0-6 2-5	1-4 0-4	0-8 0-2 0-0-5	Inaccessible hills
Sisters	CSRG RGa	64 36	2-5 6-5	3-9 3-0	2-0 0-1-0 0-1-0	
Tableland	CS	100	2-4	1-5	0-0-8	
Wanganut	CSRG	100	2-5	1-5	0-1-0	
Windjana	LmSS	100	0-6	0-4	0-2	Poorly accessible
Yeeda	CSRG Rb	86 14	2-5 5-5	2-9 2-8	1-5 0-1-0 0-1-0	

CONCLUSIONS AND RECOMMENDATIONS

1. DEGRADATION

The most extensive areas of eroded and bad condition range are found on the most valuable and accessible pasture lands.

The most badly affected pasture lands are:—

- Frontage grass (FG) and black soil plain (BSP) pastures closely associated with the major rivers.
- Frontage grass and ribbon grass (RGa and RGb) pastures of drainage floors, plains and valleys throughout the survey area.
- White grass-bundle bundle (WGBB) pastures of valleys with basaltic red earth soils in the east and north east of the survey area.
- Short grass (SGa and SGb) pastures of undulating interfluvies and alluvial drainage floors situated in the central and eastern parts of the survey area.

A further decline of these lands is unacceptable and is inconsistent with the long term stability of the pastoral industry.

2. AREAS TO BE WITHDRAWN FROM USE

6 924 sq. km (2 670 sq. miles) or about 7.7 per cent of the survey area is recommended to be totally withdrawn from use for such time as is necessary for recovery to be effected. Such action should be completed within three years. Additional areas in bad range condition will require large reductions in stock numbers and periodic spelling. Both these proposals will involve changes in management practices particularly in respect of fencing for the control of stock numbers.

3. STOCK REDUCTIONS

Based on the current evaluation of range-land condition a reduction of cattle numbers from 358 000 to 177 000 is recommended for the area within the survey. This represents a reduction of 50 per cent on present numbers. Programmes for the reduction of stock numbers should be developed by the station lessees in co-operation with the Department of Lands and Surveys. These will involve additional fencing and water supplies to control stock numbers and their distribution. Specific fencing requirements planned on a land system and pasture land basis are outlined in the individual station reports. Properly implemented

rehabilitation plans will, hopefully, promote regeneration within the short term and thus obviate the need to reduce numbers to those specified above.

4. RECOMMENDED PRESENT CARRYING CAPACITY

Virtually no high or medium value pasture lands (apart from some areas remote from waters) are in optimum condition. *Carrying capacity estimates commensurate with present condition, have been made for each pasture land.*

The total number of cattle units advocated for a station, allowing for present condition, is termed the *Recommended Cattle Unit Capacity (C.U.C.)*. In this context a cattle unit (c.u.) is defined as a dry cow or a male animal over the age of two years.

Recommended C.U.C.'s have been calculated using a standardised approach and data not previously available. They include such considerations as the proportion of desirable, intermediate value and undesirable species, dry matter production, palatability, and safe levels of use for each pasture land. In many cases the recommended C.U.C. figures are lower than the present estimated carrying capacity (E.C.C.) figures assessed by the Department of Lands and Surveys. The greatest disparities occur in estimations of the carrying capacities of poorly accessible country and low quality pasture lands.

It is recommended that the permitted stock numbers for each lease be amended to the recommended C.U.C. derived as a result of this survey.

It is recommended that stations with stock numbers in excess of their recommended C.U.C. progressively reduce numbers to the recommended level. The number of cattle units on a station is calculated by multiplying the estimated total stock number, as declared annually by statutory declaration, by 0.85. The derivation of this factor is outlined in the section on carrying capacity estimations.

Some latitude of numbers above the recommended C.U.C. is acceptable. *It is suggested that a maximum of 15 per cent latitude above the recommended C.U.C. be permitted. Any station exceeding this should be immediately advised as a matter of course, to reduce to the recommended level.*

5. TIME PERIOD FOR IMPLEMENTATION

The most severely degraded areas (6 924 sq. km) should be withdrawn from use within three years. This action should be initiated as soon as possible. Detailed recommendations for specific areas and stations are presented in the individual station reports. Station management plans drawn up by the lessees and the Department of Lands and Surveys should aim at achieving rehabilitation within an acceptable time span. Ten years is suggested for most properties, though this could be varied dependent upon the requirements on each station and the urgency of the situation.

6. OPTIMUM CARRYING CAPACITY

Carrying capacity estimates for optimum condition status have been made for each pasture land.

The total cattle units that could be run on a lease if all its country was in good range condition is termed the *Optimum Cattle Unit Capacity*. The optimum C.U.C.'s for each station are considered to be more realistic expressions of potential than the current capability E.C.C.'s used for rental purposes.

It is recommended that the capability E.C.C. for each station be amended to the optimum C.U.C. derived as a result of this survey. This change would demand an alteration to the present pricing structure for land lease rental.

7. REGENERATION

Responsibility for regeneration of badly degraded areas should rest with the lessee. In some cases cultural and seeding techniques are feasible and would effect faster recovery. On some of the worst country lessees should be required to undertake some form of regeneration work as well as destocking. Technical assistance and demonstrations of regeneration methods could be provided as part of the extension services of the Department of Agriculture.

8. STATION PLANS

Station plans showing land system boundaries, areas requiring withdrawal from use, degraded areas requiring reductions in stock numbers and suggested fencing should be supplied to each lessee.

9. SUPERVISION

Programmes for rehabilitation developed by the lessee, in co-operation with officers of the Department of Lands and Surveys, should

provide for steady improvement in range condition in most instances. In some cases, however, additional supervision and inspection may be necessary if the recommendations of this report are to be implemented successfully. During the implementation period it is suggested that station inspections be made every two years. These inspections would be to ascertain the progress of fencing and destocking programmes required of the lessee, rather than to reassess condition.

10. STATUTORY DECLARATIONS

To aid supervision it is recommended that stations be required annually to declare branding figures and turnoff figures for each class of stock. This is in addition to the presently required estimated stock numbers. They should also be required to declare horse numbers. These should be included in calculating the number of cattle units present on a station in any one year. One adult horse can be regarded as equivalent to one cattle unit.

11. REASSESSMENT

It is recommended that stations be reassessed for condition, by the Pastoral Appraisal Board, at intervals after the commencement of the rehabilitation programme. A monitoring programme based on sites already established precisely on this survey could be used to determine trend in range condition. This would determine the extent of recovery, and when, and at what levels, areas previously withdrawn from use could be brought back into production. Recommended C.U.C.'s for individual stations should be then adjusted to be commensurate with the condition status found at the time of reassessment.

Further monitoring sites will also be required. As areas of a lease are progressively destocked to promote regeneration, rangeland monitoring sites should be established in partnership with the lessee. Evaluations made at intervals at these sites will measure the rate of progress of regeneration and will serve as guides to future stocking of these areas in respect of numbers of cattle and season of use.

12. NON-VIABLE STATIONS—OPTIMUM CONDITION

The concept of viability is a constantly fluctuating one dependent upon returns for cattle, operating costs, debt structure and personal demands. It is difficult therefore to establish a figure below which a property may become non-viable.

However, there are a number of leases in the area which can support only very few cattle. These must be regarded as being non-viable. Stations in this category may be too small or may have a high proportion of inaccessible or very low value country. Such leases should be eventually reallocated to one of the adjoining properties. In effect this has occurred as in some cases these small properties are already run as outstations of larger units.

13. NON-VIABLE STATIONS—PRESENT CONDITION

Stations in this category are potentially viable at an improved level of condition. They are currently of suspect viability because the severely degraded condition of their useful pasture lands demands significant stock reductions. For these properties the destocking recommendations may appear drastic. However, the decreased carrying capacity is directly attributable to past and present overuse by stock. It is not attributable to seasonal conditions. These stations have been viable in the past but, *as the existing erosion and degradation clearly indicates, only at the expense of the base resource.*

14. VERMIN

On some stations along the Fitzroy valley, e.g. Myroodah, Liveringa and Noonkanbah, heavy populations of sandy wallabies (*Macropus agilis*) have contributed to pasture decline.

Large populations are restricted to narrow frontage lands to the west of Fitzroy Crossing. Populations are not accurately known, but have been estimated at many hundred thousands by Agriculture Protection Board officers. As a guideline, 20 adult wallabies can be regarded as a cattle unit.

In some cases the density of population is sufficient to prevent the recovery of severely depleted pastures even if stock were reduced or totally removed. Wallabies could also negate the effect of cultural and seeding operations.

There is a need for research into the preparation of baits using locally available materials such as grain sorghum, and bait distribution methods.

On some properties to the south of the Fitzroy River and north of the Leopold Ranges, donkeys are numerous. They compete with stock for grazing and contribute to pasture decline.

Vermin control is the responsibility of the lessee, with technical assistance and policing the responsibility of the Agriculture Protection Board. *Vermin control programmes, particularly on areas recommended for stock exclusion, should be implemented and enforced by local Vermin Boards.*

15. RECOMMENDATIONS FOR FUTURE SURVEYS

It is recommended that for future similar surveys the survey area be delineated by station boundaries rather than by exact catchment boundaries. All recommendations can be then made on a whole station basis.

ACKNOWLEDGMENTS

The land system breakdown of the area made by the Division of Land Research and Regional Survey of CSIRO was used in this survey of range condition. Grateful acknowledgment is made to the then Chief of the Division, Mr G. A. Stewart, for permission to use the 1:250 000 scale maps of the area prepared by his officers. The preliminary photo interpretation was aided considerably through this assistance.

Grateful acknowledgment is made to the Royal Flying Doctor Service for providing ef-

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Many station managers supplied details of local tracks and conditions and helped the survey team in other ways during the field work and this co-operation is gratefully acknowledged.

Miss H. Nicol of the Biometrics Section of the Department of Agriculture prepared the programme for the Cyber 72 computer which sorted the great mass of data obtained from traverse recordings.

APPENDIX A

LAND SYSTEMS BULKA AND LANDRIGAN

BULKA LAND SYSTEM

Area: 708 sq. km (273 sq. miles)

Q 350 Mt B 1/36

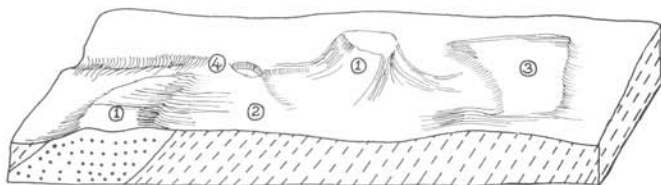
Gently undulating plains with low scattered hills, lobed spinifex grass land.

Geology¹

Weathered siltstones, mudstones and minor amounts of sandstones, mostly of Upper Proterozoic age with some Quaternary aeolian sand deposits.

Geomorphology

Formed by dissection of the Kimberley surface.



Siltstone



Sandstone

BULKA LAND SYSTEM

	Approx. Unit area (%)	Land forms	Soils	Vegetation
1	10	Hills and low rises up to 15 m (50 ft) high; flat or gently sloping rocky crests up to 0.8 km (½ mile) wide.	Mainly outcrop of siltstones and minor amounts of sandstone.	<i>Triodia intermedia</i> grassland.
2	60	Undulating plains with lateritized shale strew and occasional outcrop of laterite.	Brown loam to clay loam soil with variable amounts of lateritized shale fragments.	Open grassland of <i>Triodia intermedia</i> and patches of <i>Triodia pungens</i> and <i>Eucalyptus pruinosa</i> .
3	25	Sand plain islands up to 1.6 km (1 mile) wide.	Deep red sands with patches of thin laterite strew.	Open grassy shrubland of <i>Plectrachne pungens</i> , <i>Acacia tumida</i> and <i>Grevillea wickhamii</i> .
4	5	Pans and drainage depressions less than 0.8 km (½ mile) wide with tough clays; depressions less than a foot deep with sandy loam soil.	Grey tough alluvial clays and depressions of sandy loam soils.	Probably low fringing woodlands and grassland of <i>Plectrachne pungens</i> , <i>Triodia pungens</i> and <i>Eucalyptus pruinosa</i> .

¹ Mount Bannerman Geological Sheet.

LANDIGRAN LAND SYSTEM

Area: 694 sq. km (268 sq. miles)

Q 339 Mt R 7/59

Q 349 Mt B 1/40

Q 351 Mt R 8/79

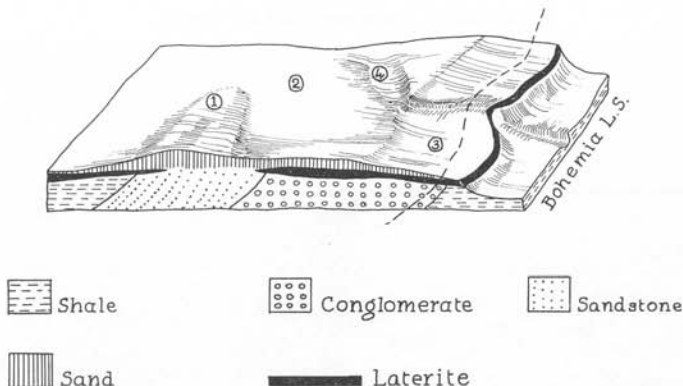
Undulating plains and sand-plains, brown sandy soil over laterite, spinifex grassland and very open shrubland.

Geology¹

Lateritized gently dipping sandstone, conglomerate and shale of Permian and Jurassic age. Quaternary aeolian sandplain islands.

Geomorphology

Part of the Kimberley surface. Gently sloping plains up to 10 kilometres (6 miles) in extent. Surface drainage absent except for shallow drainage depressions.



LANDIGRAN LAND SYSTEM

Unit	Approx. area (%)	Land forms	Soils	Vegetation
1	11	<i>Sand plain islands</i> up to 4.8 km (3 miles) in extent; flat.	Deep red sands, commonly with some laterite.	Spinifex grassland and very open shrub land of <i>Plectrachne pungens</i> , <i>Triodia pungens</i> and <i>Acacia</i> spp.
2	54	<i>Plains</i> up to 9.6 km (6 miles) in extent, sandy surface, sparsely strewn with laterite gravel, slopes less than 1%.	Shallow skeletal sands over laterite, patches of sandy loams over laterite.	Spinifex grassland and very open shrubland of <i>Triodia intermedia</i> , <i>Plectrachne pungens</i> and <i>Acacia</i> spp.
3	32	<i>Stripped margins</i> up to 3.2 km (2 miles) wide, stony slopes with frequent exposure of laterite.	Shallow red or brown loamy sands over laterite. Frequent laterite exposure.	Open shrubland of <i>Acacia</i> spp. and <i>Triodia intermedia</i> .
4	3	<i>Shallow depressions</i> up to 0.4 km (¼ mile) wide and 3.2 km (2 miles) long.	Mostly firmed sandy surface over brown sandy loam.	Grassland of <i>Triodia pungens</i> and <i>Plectrachne pungens</i> .

¹ CSIRO Land Research Series No. 9.

APPENDIX B

PLATES

A series of photographic plates (1-27) showing the pasture lands described in this Report at different condition levels.

BLACK SOIL PLAIN (BSP) PASTURE LANDS



Plate 1—Black soil plain pastures of such land systems as Alexander, Fossil, Leopold and Cowendyne constitute some of the most valuable grazing lands in the area. This site is in fair to good condition. Mitchell grass (*Astrebla* spp.) tussocks have been moderately utilised. There is no erosion. Fossil land system, Leopold Downs Station. Q.280.

BLACK SOIL PLAIN (BSP) PASTURE LANDS



Plate 2—Black soil plain pastures in very poor condition. Note heavy over-utilisation of the sparse perennial grasses. There is no erosion on this site. Alexander land system, Jubilee Downs Station. Q.242.



Plate 3—Due to their usually flat topography and the inherent resistance of the heavy soils, black soil plain pastures are not usually eroded. However, the sloping margins of clay plains, once bared of vegetation, are susceptible to gully erosion. Cowendyne land system, Lansdowne Station. Near Q.309.

FRONTAGE GRASS (FG) PASTURE LANDS



Plate 4—The valuable frontage grass pasture lands are moderately to severely degraded throughout the survey area. This site on the Djada land system is in bad range condition. Perennial grasses are absent and erosion in the form of surface sheeting over extensive areas is severe. Note root exposure of coolibah (*Eucalyptus microtheca*) trees. The area should be totally withdrawn from use. Gogo Station. Q.276.



Plate 5—Frontage grass pasture lands, Djada land system. Bad range condition. The area should be withdrawn from use. Noonkanbah Station. Q.237a.

FRONTAGE GRASS (FG) PASTURE LANDS



Plate 6—Surface sheeting is the most common form of erosion encountered on frontage grass pasture lands. However, areas of active gullying are encountered on some properties. Djada land system, Christmas Creek Station. Near Q.319.

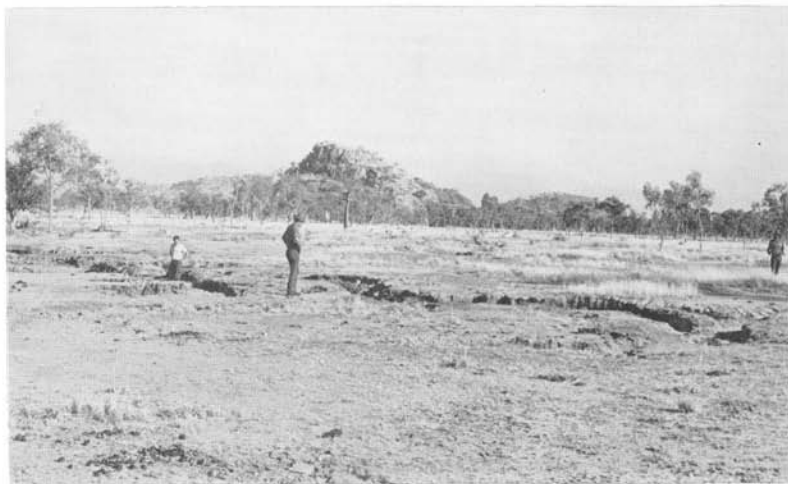


Plate 7—Degraded frontage grass pastures and erosion on broad drainage floors of the Army land system. Bad range condition. Granite hill in the background. Napier Downs Station. Q.40a.

RIBBON GRASS (RGa and RGb) PASTURE LANDS



Plate 8—Ribbon grass (RGa) pasture lands of such land systems as Calwinyardah and Egan are generally in fair condition. This site on an alluvial plain of the Calwinyardah system is in good range condition. Liveringa Station. Q.232.



Plate 9—Ribbon grass (RGb) pasture lands of such land systems as Coonangoody, Luluigui, Mamilu and Myroodah are in variable condition. This site on a stable plain of the Mamilu system is in good range condition. Noonkanbah Station. Q.236.

RIBBON GRASS (RGa and RGb) PASTURE LANDS



Plate 10—Ribbon grass (RGb) pastures in very poor condition. Ribbon grass has been subjected to severe over use and butts are now mostly dead. There is thin surface sheeting and minor wind hummocking over the whole site. Bad range condition. Myroodah land system, Cherrabun Station. Q.322b.

SHORT GRASS (SGa and SGb) PASTURE LANDS



Plate 11—Short grass (SGa) pasture lands are mostly in poor condition. This site on an interfluvium of the O'Donnell land systems, is in bad range condition. Perennial grasses are almost completely absent. Production is very considerably below potential. Many trees are dead. Moola Bulla Station. Q.375.



Plate 12—This site within a small paddock shows the potential of short grass (SGa) pasture lands. There is a good mixture of annual and perennial grasses. Vigour and production is good. Good range condition. Interfluvium on the O'Donnell land system, Moola Bulla Station. Q.376.

SHORT GRASS (SGa and SGb) PASTURE LANDS

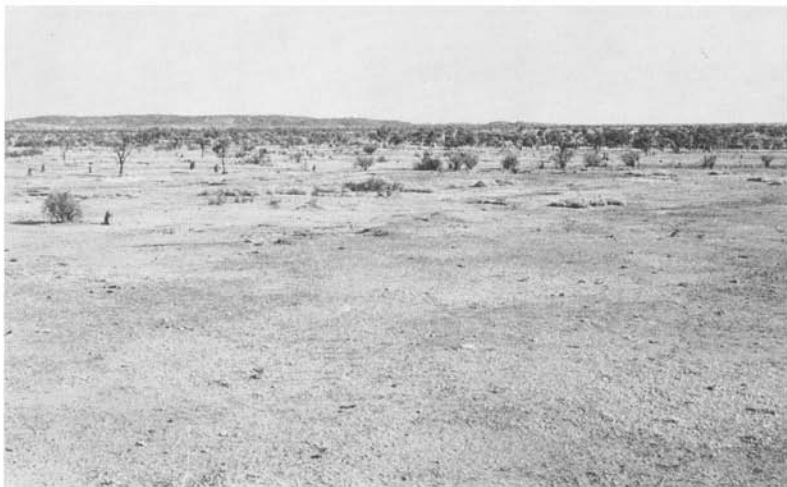


Plate 13—Short grass (SGb) pasture lands as found on the drainage floors of the Bohemia, Koongie, Margaret, Pigeon and Richenda land systems are mostly in bad condition. This site on a drainage floor of the Koongie land system is in bad range condition. Erosion is active. The area should be destocked. Lamboo Station. Q.370.



Plate 14—Severely degraded and eroded short grass (SGb) pasture land on a drainage floor of the Margaret land system. Lobed spinifex (LS) pastures on a stony rise in the foreground. Louisa Downs Station.

WHITE GRASS-BUNDLE BUNDLE (WGBB) PASTURE LANDS



Plate 15—White grass-bundle bundle pasture lands are mostly in fair or poor condition. This site on the lower slopes of the Looingnin land system is in fair range condition. Mt. Hart Station. Q.44.



Plate 16—White grass-bundle bundle pastures of an interfluvium of the Cowendyne land system in bad range condition. Desirable perennial grasses are virtually absent and ground cover is sparse. There is minor erosion in the form of shallow rilling. Lansdowne Station. Q.303.

CURLY SPINIFEX-RIBBONGRASS (CSRG) PASTURE LANDS



Plate 17—Curly spinifex-ribbon grass pindan pasture lands of the extensive sandy land systems Camelgooda, Yeeda and Wanganut are usually in fair to good condition. Pastoral value is low. This site on a swale of the Camelgooda system is in good range condition. Meda Station. Q.112b.

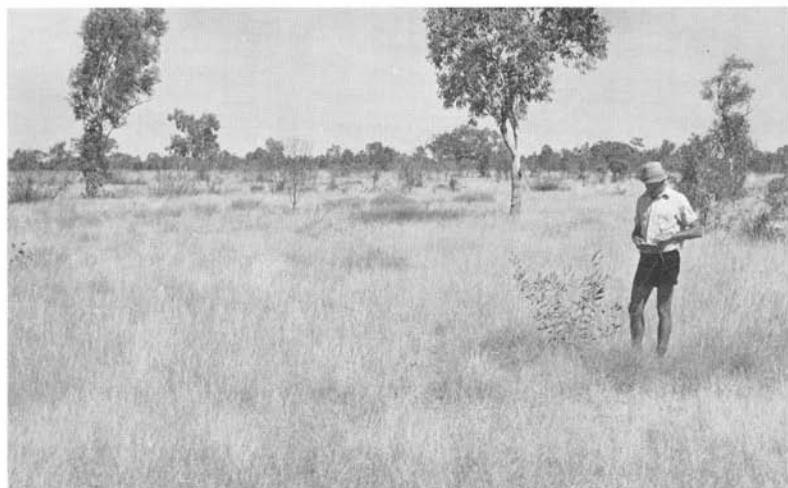


Plate 18—Sand plain of the Camelgooda land system with curly spinifex-ribbon grass pastures in very poor condition. The dense ground cover consists almost exclusively of the worthless annual corkscrew grass (*Aristida hygrometrica*). This species is promoted by excessive firing and/or continuous overuse. There is no erosion. Luluigui Station. Q.190a.

CURLY SPINIFEX (CS) PASTURE LANDS



Plate 19—Curly spinifex pasture lands are usually in good range condition. Pastoral value is low. They are found on many land systems including poorly accessible systems such as Clifton, Lubbock, Precipice, Richenda and St. George. This site, on an interfluvium of the Pigeon system is in good range condition. Fossil Downs Station. Q.297.



Plate 20—Curly spinifex pastures in good condition on the lower slopes of the Precipice land system. Much of this system is extremely rugged and poorly accessible to stock. Pastoral value is very low. Mornington Station. Q.70.

SOFT SPINIFEX (SS) PASTURE LANDS



Plate 21—Soft spinifex pasture lands are found as minor components of many land systems but are dominant on only the Chestnut system. Pastoral value is low but they are useful reserves for light seasons. They are relatively stable under grazing. This site, on a plain of the Chestnut system, is in good range condition. Cherrabun Station. Q.170.

WHITE GRASS-ANNUAL SORGHUM (WGAS) PASTURE LANDS



Plate 22—White grass-annual sorghum pastures are found on basaltic hills, ridges and some lower slopes of various land systems. Accessibility is often poor and pastoral value is low. Condition, as this photo shows, is usually good. Looingnin land system, Mt. Hart Station. Q.46.

LOBED SPINIFEX (LS) PASTURE LANDS



Plate 23—Lobed spinifex pasture lands are found extensively on many land systems. They are harsh and unpalatable to stock and pastoral value is extremely low. Condition is usually good or excellent. This site is on a stony surface of the Myroodah land system, Liveringa Station. Q.162.



Plate 24—Lobed spinifex pastures on characteristic rounded hills of the Burramundi land system, Fossil Downs Station. Q.312.

LIMESTONE SPINIFEX (LmSS) PASTURE LANDS



Plate 25—Limestone spinifex pastures are found mostly on the Neillabublica, Oscar and Windjana land systems. They are unpalatable to stock and pastoral value is extremely low. Range condition is nearly always good. Lower slopes, Windjana system, Brooking Springs Station. Q.210a.

INACCESSIBLE COUNTRY



Plate 26—Many land systems within the survey area are rugged and very poorly accessible. Pastoral value is extremely low to negligible. Pasture condition is nearly always good. St. George land system, Mt. Anderson Station. Q.148.



Plate 27—View from top of a steep basalt hill. Lower slopes, small plains and drainage floors below are mostly in bad range condition. Looingnin land system, Lansdowne Station. Near Q.304.