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PASTURE UTILIZATION BY FREE-RANGING CATTLE IN CENTRAL AUSTRALIA : A CASE STUDY

DONALD M. LEYS

UNLESS OTHERWISE ACKNOWLEDGED, THE CONTENT OF THIS REPORT IS THE ORIGINAL RESEARCH OF THE AUTHOR.

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Thank you also Anne for your nimbleness of finger in the typing of this manuscript.

THESIS ABSTRACT

In Central Australia, the need exists for a study of pasture utilization by free-ranging cattle at increasing distances from stock watering points. Two of the most important pasture types, the Mitchell Grass plains and the Open Woodland eco-units were chosen for the study. It was expected that the effects of grazing would be less obvious with increasing distance from watering points, where grazing pressure was assumed to be minimal. Also, by assessing the degree of utilization of the major grasses, the valuable pasture species could be identified.

Sampling to determine basal cover, pasture composition and utilization of pasture species, was carried out at regular and increasing distances from relevant watering points. This involved the implementation of the wheel-point method of botanical survey at ½, 1, 2, 3, 4, 5, 6 km. distance from the focal waters. Analysis was undertaken during July, August, 1977 along 3 radii from Limestone Bore, Amburla Station, in the Mitchell Grass community, and a single radius from Brumby Bone, Milton Park, in the Open Woodland eco-unit. The appropriate site sample size in both pasture types surveyed was based on earlier pilot studies.

Employing the concept of the equivalent fully-grazed-tuft, an index of utilization for pasture species at a site was devised. This was further extended to the development of a "relative use value" which represents the contribution of various plant species to the diet of cattle at any one site. Based upon this index, a species preference rating was derived which relates the amount of forage available to the amount used. This made it possible to identify the valuable or key forage species.

It was evident from an analysis of the Limestone Bore data that the effects of grazing and utilization of pasture species decreased as grazing pressure decreased away from the watering point. Heavy utilization of pastures at the time of survey appeared to be concentrated within a 3 to 4 km. radius of the bore. At 6 km. from the bore there was virtually no grazing effect. The valuable forage species were identified as Mitchell grass (*Astrebla pectinata*) and Oat grass (*Enneapogon avenaceus*).

An analysis of the Brumby Bore data revealed the influence of a highly preferred pasture type on grazing concentrations. A small section of Cottonbush floodplain merged with the single radius sampled at Brumby Bore at approximately the 2 to 3 km. distance from the bore. It was found that intense grazing was not only centred at the watering point, but also around this highly-preferred pasture type. The effects of grazing and utilization of pasture species decreased away from this region. Very little grazing influence was noted at 5 km. distance from the bore. The importance of other foragers, particularly kangaroos, was also observed in this pasture type. The valuable forage species were identified as once again Oat grass, and also Umbrella grass (*Digitaria coenicola*).

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GLOSSARY OF TERMS

ANIMAL UNIT (MATURE AGE ANIMAL UNIT)	- considered to be one mature cow with calf or their equivalent.
BASAL	- pertaining to, situated at, or forming the base.
CONDITION OF CATTLE	- subjective rating scale of state of health/ productivity of cattle. s = store fs = forward-store f = fat.
FLOOD-OVER	- land receiving sheet-flow of run-off water due to excessive amounts of rainfall.
FORAGE (FODDER) n.	- all browse and herbaceous food that is available to livestock or game animals. It may either be used for grazing or harvesting for feed.
GRAZING CAPACITY	- the maximum stocking rate possible without inducing damage to vegetation or related resources.
OVERGRAZING	- continued overuse creating an overgrazed range.
OVERSTOCKING	- placing a number of animals on a given area that will result in overuse at the end of the planned grazing period. Not to be confused with overgrazing because an area may be overstocked for a short period, but the animals may be removed before the area

OVERSTOCKING (Cont'd) - is overutilized. However, continued overstocking will lead to overgrazing.

RANGE - all land producing native forage for animal consumption, and lands that are revegetated naturally or artificially to provide a forage cover that is managed like native vegetation. Generally considered as land that is not cultivated.

RANGE CONDITION - the state and health of the range, based on what that range is naturally capable of producing.

RANGELAND - land that is used as range.

RELICT - as related to climax, fragments of presently existing flora on areas with a historical record of no disturbance and the plant community is assumed to be in near virgin condition.

RUN-ON - area receiving run-off water from an adjacent region, as a result of rainfall.

STOCKING RATE - actual number of animals expressed in either animal units or animal unit months, on a specific area at a specific time.

USE - the proportion of current year's forage production that is consumed or destroyed by grazing animals. syn. Utilization.

WATERED-AREA - theoretically circular area centred at the watering point, where the maximum grazing range of stock defines the radius of the circle.

(Range Term Glossary Committee, 1964)

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SECTION A - INTRODUCTION

CHAPTER 1 - BACKGROUND

Central Australia is at present supporting a grazing industry of some 500,000 head of cattle due to the current depressed state of the beef market, and the series of above average climatic seasons since 1973 (Hyde, 1976). The total area under lease for pastoral purposes is 117,000 square miles. However, due to the unpalatability of some pasture types, 67,000 square miles of this country is regarded as useless (Perry, 1962). According to well experienced pastoralists and agronomists, half a million head of cattle on the remaining area of 50,000 square miles represents a very high stocking intensity for arid pasture lands (synonymous in the Australian context with the term "rangelands"*).

It is the commonly held view of range scientists that this stocking intensity can only be maintained whilst good seasons continue. They fear that when drought occurs, severe deterioration of pasture lands must occur (Ecos, vol.8). If present management patterns do not change, and there is no indication that they will, with drought, vegetation will die before sufficient stock are removed, and pastures will be severely overgrazed. They may never fully recover.

Since there is a distinct threat of massive overstocking, it is desirable that pastoral managers direct their management strategies towards immediate stock number reductions, thereby permitting the

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* See Glossary of Terms.

long-term maintenance of high quality native pastures for the future. This strategy is vital as pasture improvement is not practical in this region due to both low and erratic rainfall, and also to low returns per unit area.

Good quality native pastures can contain a high proportion of productive plant species. According to most range workers, those species that are most preferred by cattle are also the most productive. The main aim of management should therefore be the maintenance of pastures containing those plant species that are highly preferred by cattle.

Particularly at this present time in the central Australian cattle industry, it is important to accurately identify the key forage species, and to detail their responses to different management. Pastoralists believe they have adequate knowledge of what are the valuable plant species of the various pasture types of their holdings, but they have little understanding of the details. In particular, very little is known of the relative importance of the different fodder plants. Even less is known of the contribution of such key species to cattle diet, as stock watering distances increase, or as overall pasture content changes.

Extensive areas of range country in central Australia are low in condition due to previous periods of overstocking (Chippendale, 1963). By eating the palatable species from the pasture, cattle give the less palatable and poisonous species an unfair advantage. In some cases, where grazing pressure has been extreme, destruction of the plant cover has resulted in severe erosion causing further loss of range condition. This is particularly prevalent if a highly preferred pasture type is adjacent to a bore or watering point.

To help to combat the threat of overstocking, the Animal Industry and Agriculture Branch, Dept. of Northern Territory, has undertaken a program of Grazing Capacity Assessment. Its plan is to set "safe" stocking rates for the 90 cattle stations in the Alice Springs grazing district (Hyde, pers.comm.*). To establish these rates effectively, valuable fodder plants must be identified in all the various areas under grazing occupation. The contribution of these species to the cattle diet with increasing distances from watering points must be understood as well. Also, further information is required concerning the distance from a watering point beyond which grazing is not noticeably destructive to the plant cover. A basic grazing management tool lies in the location of watering points. According to the distance cattle graze from waters, a higher or lower density of watering points may allow a more uniform utilization of the plant resource.

It is hoped that this project may provide some insight into both the destructiveness of grazing, and the identification and the utilization of key forage species, with increasing distances from two focal watering points in central Australia.

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* Hyde, K., Senior Agronomist, Animal Industry and Agriculture Branch, Department of Northern Territory, Alice Springs.

CHAPTER 2 - THEORETICAL FRAMEWORK AND LITERATURE REVIEW

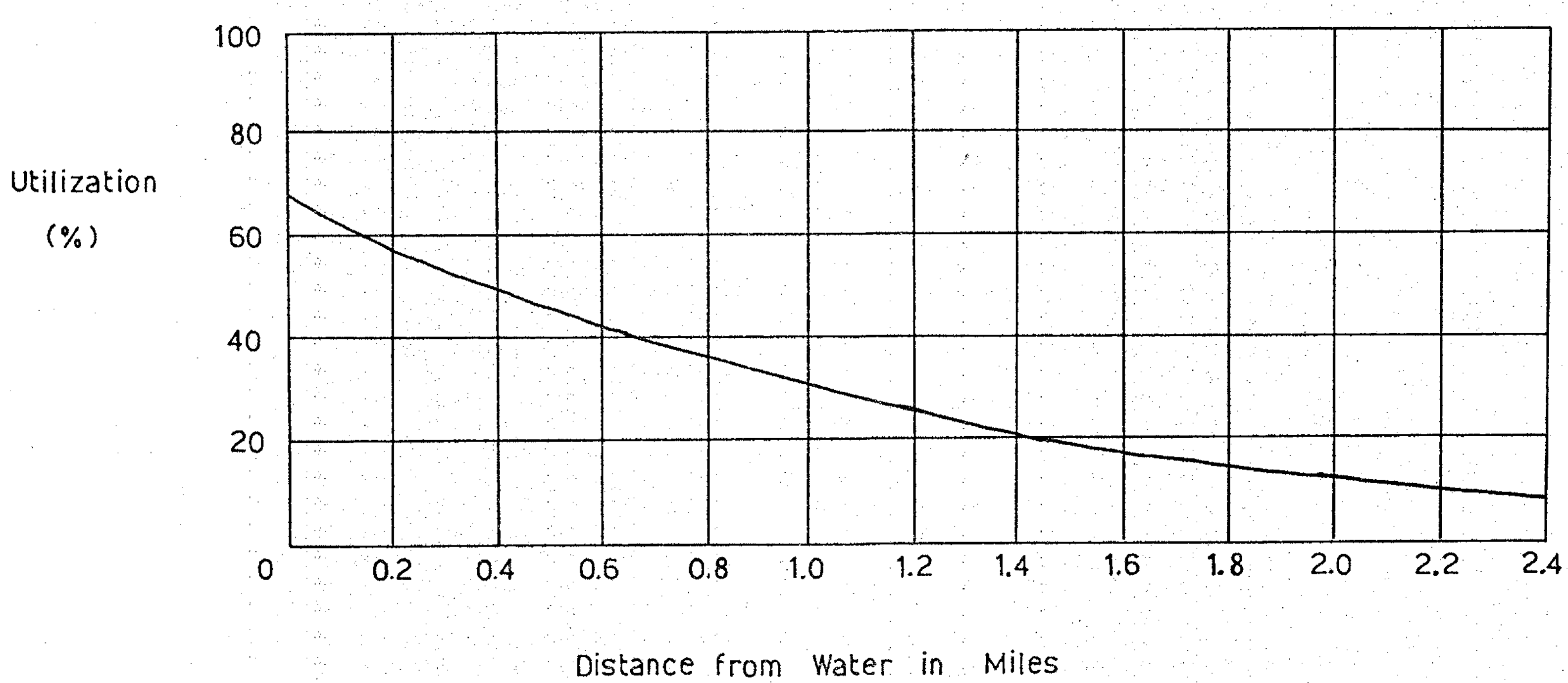
> "In recent years as more attention has been given to the study of range utilization, it has become apparent that even well-watered, level range is not equally used near and away from water. Forage utilization has been found to decrease perceptibly and consistently as distance from water increases."
>
> Valentine, K.A. (1949)

The idea that the watering point in rangelands is a focus of grazing activity is definitely not a new concept. Therefore it is a commonly held view that the area adjacent a watering point is exposed to the greatest impact from stock. Range scientists for many years have recognized a stocking gradient, which simply represents a decrease in grazing intensity or forage utilization as distance from water increases.

Uneven utilization of forage radially away from water was appreciated by Valentine (1949) whilst evaluating the validity of grazing capacity assessments based on range survey techniques. Range country had in many cases been overstocked where grazing capacity was calculated solely on an available forage/average stocking rate basis. This he claimed was due to no allowance having been made for graduated use of forage.

On an experimental New Mexico range, Valentine observed and recorded a definite stocking gradient as shown in Fig 2.1. He recognized that this gradient could vary appreciably with different management practices, such as stocking with a greater number of stock.

Fig. 2.1 UTILIZATION GRADIENT



after Valentine (1949)

At an earlier period, Osborne, Wood and Paltridge (1932) had surveyed sheep grazed Saltbush (*Atriplex vesicarium*) communities in South Australia and found it possible to delineate concentric zones of utilization around central watering points. They distinguished a heavily trampled and overgrazed zone close to water (0-0.25 mile), a moderately heavily grazed zone extending to 1 mile from the water, a lightly grazed zone (1-2 miles), and an unstocked zone at least 4 miles from the watering point.

The importance of the watering point in a grazed range situation was given greater recognition by Lange (1969). On the basis of an analysis of sheep track and dung patterns, Lange defined a distinct ecological system where - "interactions are determined by the existence of the water point and by the capacity of other animals to forage away from the water point." He believed this system was of such significance that he introduced the term "piosphere"* to describe it. The piosphere does not define a finite area, but identifies the attenuating zone of interactions radially away from the watering point. Using the density of sheep dung per unit area as an index of average sheep time per unit area, Lange found it possible to formulate a regression equation describing the stocking gradient in the piosphere.

A further important point that Lange discussed was the effect of the stocking gradient on pastures. He claimed that the piosphere effect about watering points involved deterioration of some plant populations, and the stimulation of others in their place. This process which was well documented by Stoddart, Smith and Box (1975) leads

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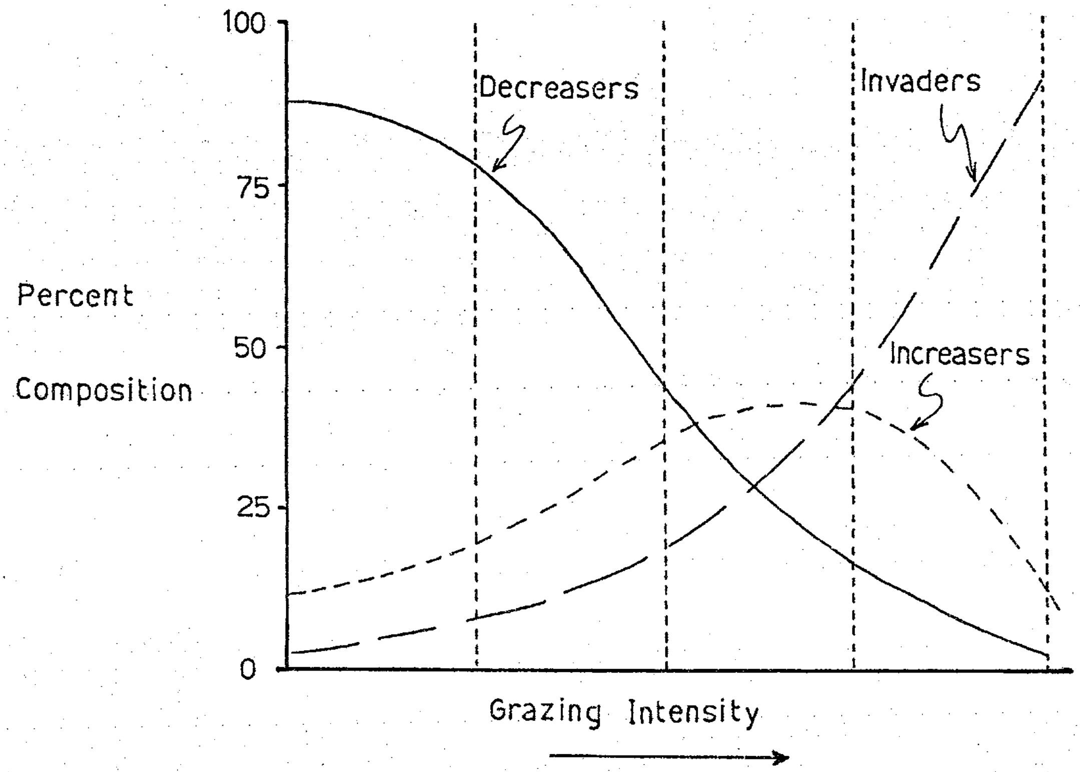
* piosphere - from the Greek word 'pios' - to drink.

to pasture compositional change when the preferred pasture species are replaced by those less preferred by stock. Assuming similar sensitivities to grazing, those plants least preferred will tend to increase in density in the pasture (*increasers*) whilst those plants which are highly selected will tend to decrease (*decreasers*). This situation is particularly prevalent adjacent to watering points. As range condition further declines with greater numbers of increasers and fewer numbers of decreasers, *invaders* (those plants not present in the native vegetation) can form an increasingly larger proportion of the pasture. Figure 2.2 illustrates the effects of increasing grazing intensity.

Lange and Barker in 1969 found distinct changes in the composition of a south Australian black-oak - bluebush pasture, with increasing distance from a watering point. In the heavily grazed area within approximately one mile of the watering point, *Kochia sedifolia* and *Cratystylis conocephala* represented decreaser species whilst *Bassia paradoxa* and *Kochia triptora* were increasers. The situation is depicted in Fig. 2.3. This change was attributed to the stocking gradient or piosphere influence.

Further studies such as Barker (1970), Jensen and Schumacher (1969) confirm the general conclusions that a stocking gradient definitely exists around watering points in range country, and that as a result, there are radially distinct changes in pasture composition away from the waters. Of direct interest to range management is the stocking gradient which is supposedly responsible for the described changes in pasture composition. Range managers continually pose the question - "To what extent can range pastures be utilized before there is a significant change in pasture composition from

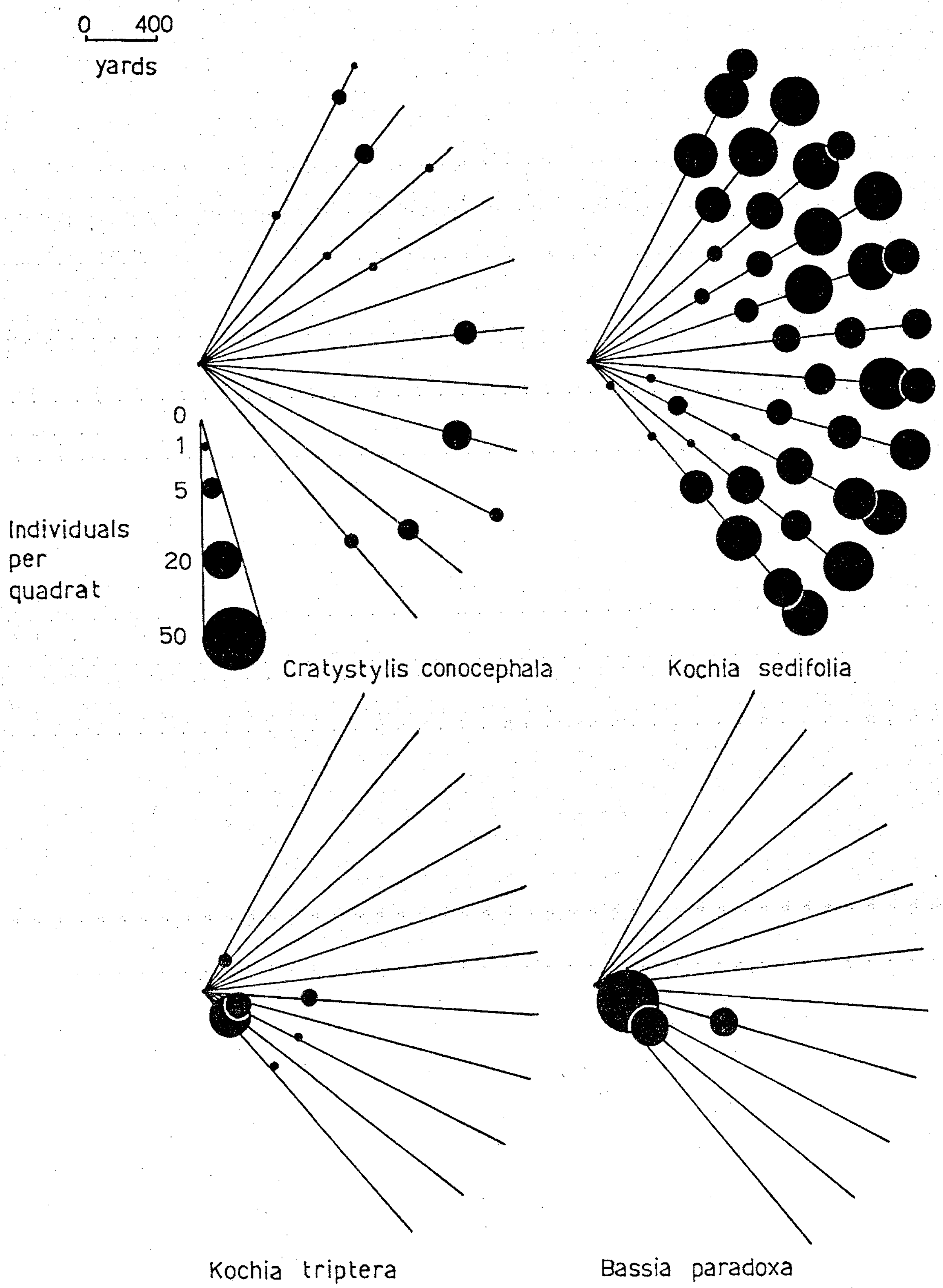
Fig. 2.2 DYNAMICS OF PASTURE COMPOSITION CHANGE



after Stoddart, Smith and Box (1975)

Fig. 2.3 PIOSPHERE INFLUENCE ON PLANT POPULATIONS

after Barker and Lange (1969)



predominantly valuable forage species to weedy, unpalatable types?" This concept is known as "proper-use" of forage.

To maintain high productivity of range, the aim of management should be the proper-use of the valuable fodder species within the pasture. Those plants which are abundant and palatable must not be utilized beyond their limit of tolerance. However, proper-use factors change with different species, with different plant associations, seasons and many other factors. It is therefore difficult to establish values for this extremely important factor in range management. An initial step, particularly in central Australia where at present there is a threat of overstocking, must be the identification of the valuable i.e. key forage species, and the subsequent documentation and analysis of stocking gradients and the effects of stocking in the more valuable pasture types. It is the purpose of this thesis to record and analyse some of this essential information.

CHAPTER 3 - THE PRESENT STUDY

Aims and Scope of Study

It is the broad objective of this thesis to provide information concerning the utilization of pastures and the effects of stocking, with increasing distance from watering points in two of the more valuable pasture types in central Australia.

Specifically, the objectives are to measure:

- species presence and percentage pasture composition of a given area,
- percentage basal cover on a species basis
- percentage utilization of pasture species

  - within a Mitchell Grass*

community and also an Open Woodland* eco-unit, at regular and increasing distances (½, 1, 2, 3, 4, 5, 6 km.) from relevant watering points. As a result of a combined analysis of pasture composition and utilization of pasture species within the pasture types, the key or valuable forage species will become evident.

This study concentrates on the relationships between stocking intensity, and its effects on pastures, primarily by way of pasture utilization. Identification of key forage species using plant-based methods is important, as it is this parameter that is of direct interest to range management. It provides a broad indication of changes in range condition. Therefore, the project also aims to provide information and suggestions which could be of practical benefit to those involved in the determination of range use.

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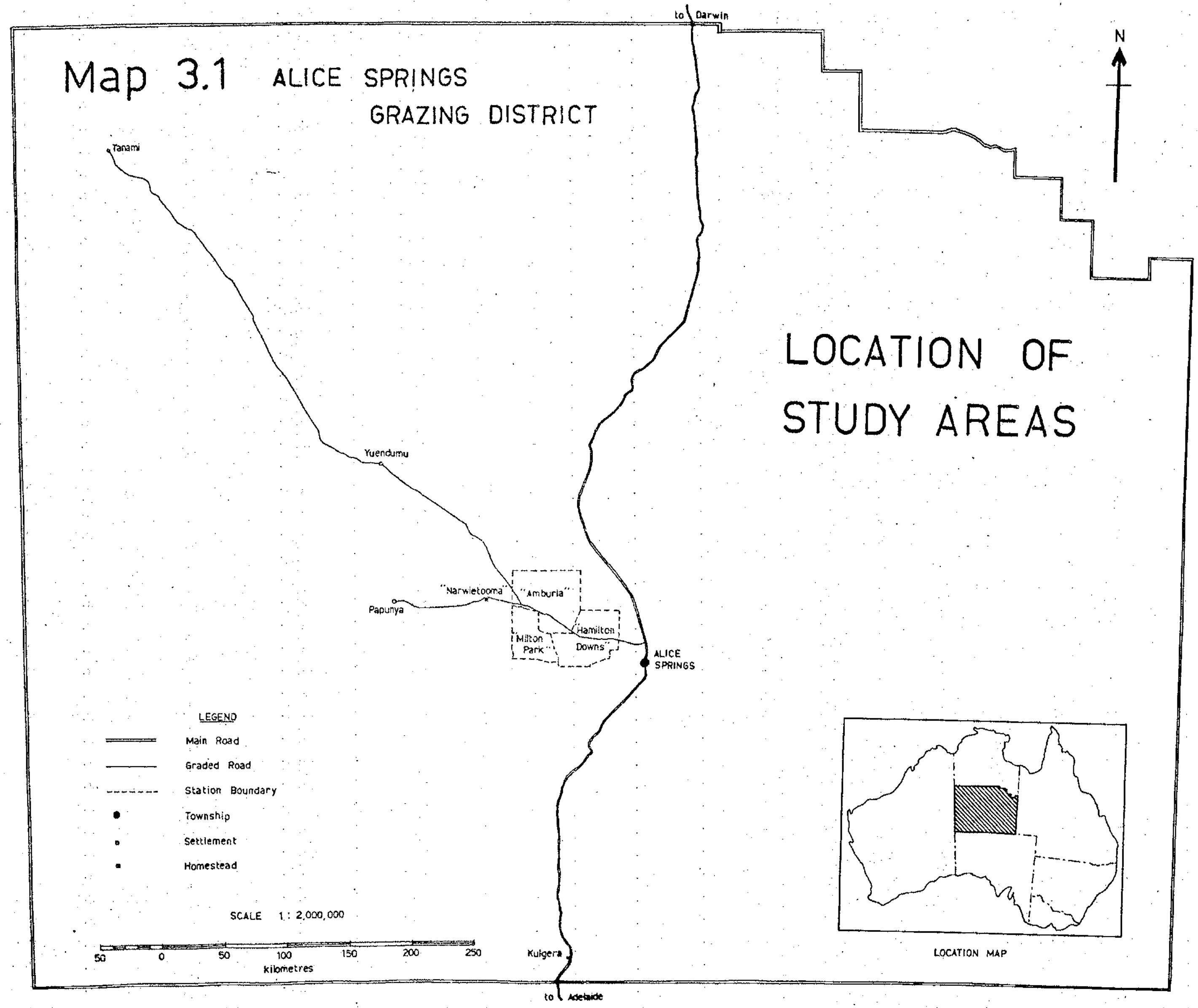
* pasture units defined by Perry (1962).

The Study Areas

The pasture types chosen for this study were the Mitchell Grass plains bordering Limestone Bore of Amburla Station, and the Open Woodland eco-unit/association of Kunoth Paddock, Hamilton Downs Stn.. Amburla Stn. (owner/manager A. Davis) and Hamilton Downs Stn. (manager T.W. Prior) are located 90 km. and 40 km. north-west of Alice Springs respectively (Map 3.1). The two pasture types are distinctly different, and they have only one major pasture species in common, viz. *Enneapogon avenaceus*. Both regions are considered locally to be extremely important and highly productive grazing land. Because of this fact these two pastures were chosen in preference to those which were less valuable but more aerially extensive. Inferior pasture lands, such as spinifex, being unattractive to stock, are therefore least susceptible to stock damage.

The study commenced at Limestone Bore and upon completion was to be followed by a similar investigation at Kunoth Paddock. However, a closer examination of the Open Woodland eco-unit at Kunoth Paddock revealed that it was unsuitable. This unit formed only a narrow band near Greentree dam - the associated watering point. At every chosen site in this region, vegetation elements from the adjacent gilgaied plain eco-unit were present. Therefore, sampling in this region would have been unrepresentative of true Open Woodland.

It was decided that the Open Woodland eco-unit west of Brumby Bore, Milton Park could prove more suitable for this study. It was representative of Open Woodland according to a classification of central Australian vegetation types (Perry, 1962). Also, it was clearly apparent from an initial field reconnaissance that pastures



Map 3.1 ALICE SPRINGS GRAZING DISTRICT

were heavily grazed and should therefore provide some valuable utilization data.

The Mitchell Grass plains to the south of Limestone Bore are quite extensive locally (Plate 3.1), even though this pasture type constitutes only 0.6% of grazed pasture land in the Alice Springs district (Perry, 1962). The plains are gently sloping to flat with reddish-brown, poorly-drained, heavy cracking clay soils, forming the characteristic gilgaied surface (Plate 3.2). The plains are almost entirely treeless.

Pasture consists dominantly of Mitchell grass (*Astrebla pectinata*) which is a perennial, drought-resisting tussock grass. Other major perennial grasses include Neverfail (*Eragrostis setifolia*), Feathertop threeawn (*Aristida latifolia*), whilst the major annuals include Flinders grass (*Iseilema membranaceum*), Oat grass (*Enneapogon avenaceus*) and Panic grasses (*Panicum decompositum* and *P. whitei*).

Forage was abundant and dry in the Mitchell Grass plains at the time of study. This was partly shown by the low condition of the stock watering at Limestone Bore (Plate 3.3).

The majority of cattle watering at Limestone Bore were of Shorthorn X Santa Gertrudis breeding. There was a broad range in their age and sex structure, from mature age cows and bullocks to heifers with very young calves at foot. Females generally had young calves at the time of study, since a large number of cows conceived following the rains of October, November, 1976 (A. Davis, pers.comm.).

It was noted that bullocks generally watered at the bore at night whilst the majority of the herd (cows and calves) remained at

PLATE 3.1 ELEVATED VIEW OF MITCHELL GRASS PLAINS

View from Valley Bore in the direction of Limestone Bore

PLATE 3.2 GILGAIED SURFACE OF MITCHELL GRASS PLAINS

note: heavy, red cracking clays

PLATE 3.3 STOCK WATERING AT LIMESTONE BORE

note: Mulga shrubland eco-unit

in background

the bore during the heat of the day. Most cattle were in forward-store condition but were rapidly approaching store condition.

The large number of cattle watering at Limestone Bore is also reflected in the rapid loss of stock condition throughout the duration of the study. Over this time, approximately 700 head of cattle* were concentrated on the watering point. According to agronomists (Foran, pers.comm., Bastin, pers.comm.**), such numbers represent a high stocking intensity for Mitchell Grass pasture. The Mitchell Grass plains are not the only pasture type accessible to this water. To the north of the bore there is quite a large area of Mulga shrubland. However, as indicated by recent C.S.I.R.O. observations, the Mitchell Grass eco-unit remains the most preferred grazing land with a current stocking intensity of 30 head per square mile (Table 3.1). This high stocking intensity has been maintained for several years.

An almost complete absence of native grazing animals was observed in this pasture type. One evening only were kangaroos observed in the Mitchell Grass plains during the period of study. Also, there was very little faecal evidence of their activity. Since the forage was very dry, it would not appeal to kangaroos (Newsome, 1965). Most kangaroos, according to local sources, were grazing near the MacDonnell Ranges in flood-over country which receives run-on water.

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* equivalent animal units.

** Foran, B., C.S.I.R.O. Division of Land Resources Management, Alice Springs, Bastin, G., Animal Industry and Agriculture Branch, Alice Springs.

TABLE 3.1 RECENT STOCKING HISTORY : LIMESTONE BORE

Date	Estimated Number of Cattle *	Estimated Stocking Rate in Mitchell Grass Community *	Feed Condition **	Dominant Grazing Direction from Bore	Condition of Cattle ***
2/9/76	700	18	3:1	S.E.	FS
14/12/76	700	22	2:2	S.E. & N.W.	FS/F
4/4/77	565	31	1:1	S	F
15/6/77	679	30	2:1	S	F

* mature age cattle units

** key :

1 = Green	1 = Abundant
2 = Drying off	2 = Moderately Abundant
3 = Dry	3 = Sparse

*** key:

S = store
FS = forward store
F = fat

(see Glossary)

RECENT STOCKING HISTORY : VALLEY BORE

Date	Estimated Number of Cattle *
2/9/76	500
14/12/76	500
4/4/77	794
15/6/77	716

Estimates obtained courtesy R. Hodder, C.S.I.R.O., Alice Springs

Limestone Bore was established in 1948, drilled to a depth of approximately 200 feet, as a Government stock route bore. The stock route has not been used as such for many years, but Limestone Bore remains in operation in association with Valley Bore and Mt. Hay Bore, which were both established in 1950 to depths of approximately 100 feet and 200 feet respectively (A. Davis, R.M. Hodder*, pers.comm.) (Map 3.2). The three bores are within the same paddock. However cattle preferences for a "home-base", and a taste for particular water, as well as the distance between the three watering points, means that there is a large measure of isolation between the cattle "herds" grazing about each bore, i.e. there is minimal watered-area interference, which is desirable for this study. Water quality varies significantly from one bore to the next, and of the three bores, Valley Bore provides the only water fit for human consumption.

The pastures within the Open Woodland eco-unit extending west of Brumby Bore (Map 3.3) are less uniform than the Mitchell Grass pastures bordering Limestone Bore. This eco-unit is situated in the plains flanking the hills to the north of the MacDonnell Ranges. Most of the stock in the Alice Springs district are carried on this pasture type, which forms as much as 12.4% of total grazed pasture lands in the district.

The soils of the Brumby Bore study area are dominantly yellowish-red loams, and the vegetation, a low open woodland characterized by the frequent occurrence of ironwood (*Acacia estrophiolata*) whitewood (*Atalaya hemiglauca*) and corkwood (*Hakea divaricata*) (Plate 3.4). The ground cover consists of low, short-lived grasses and forbs

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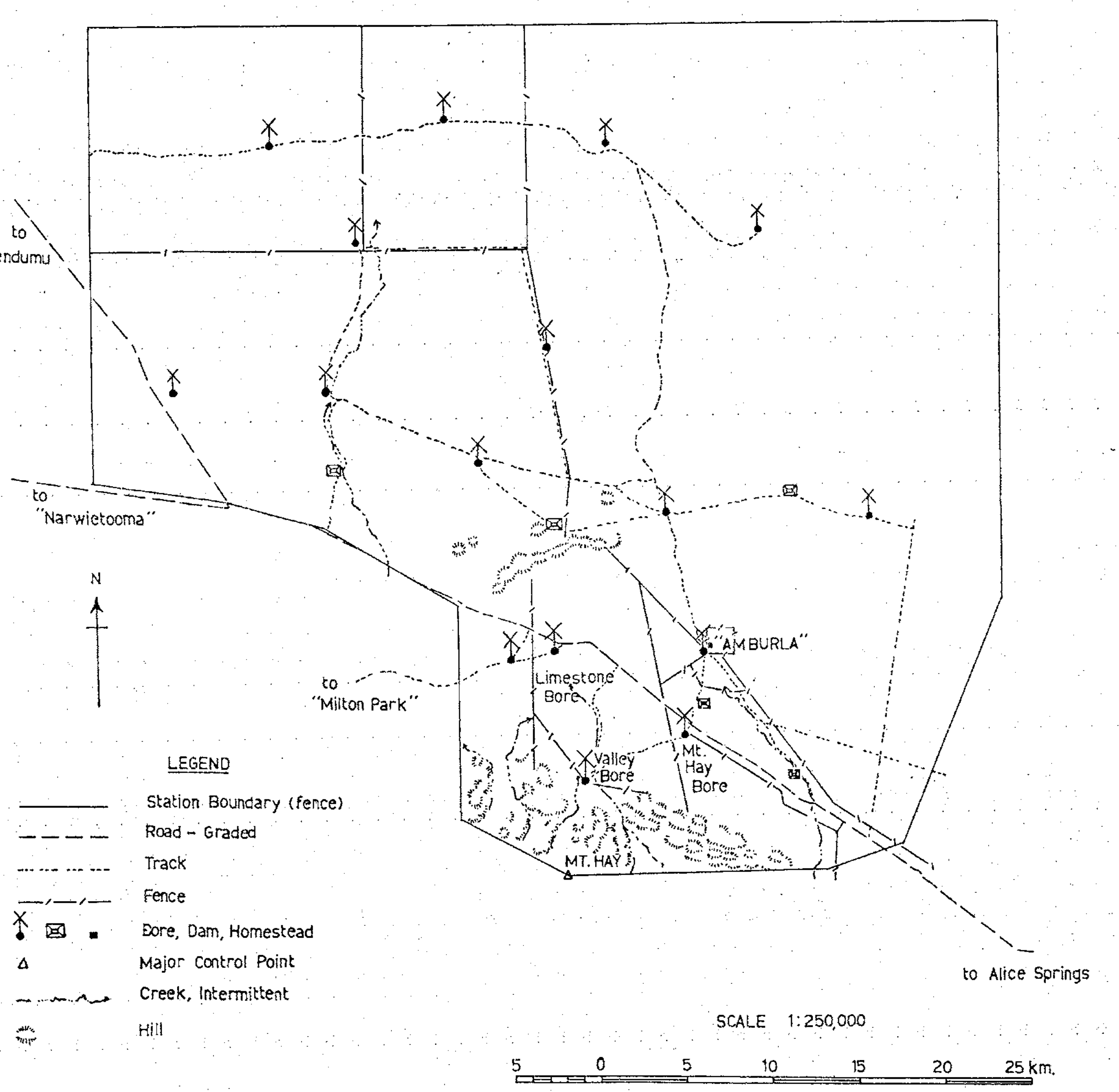
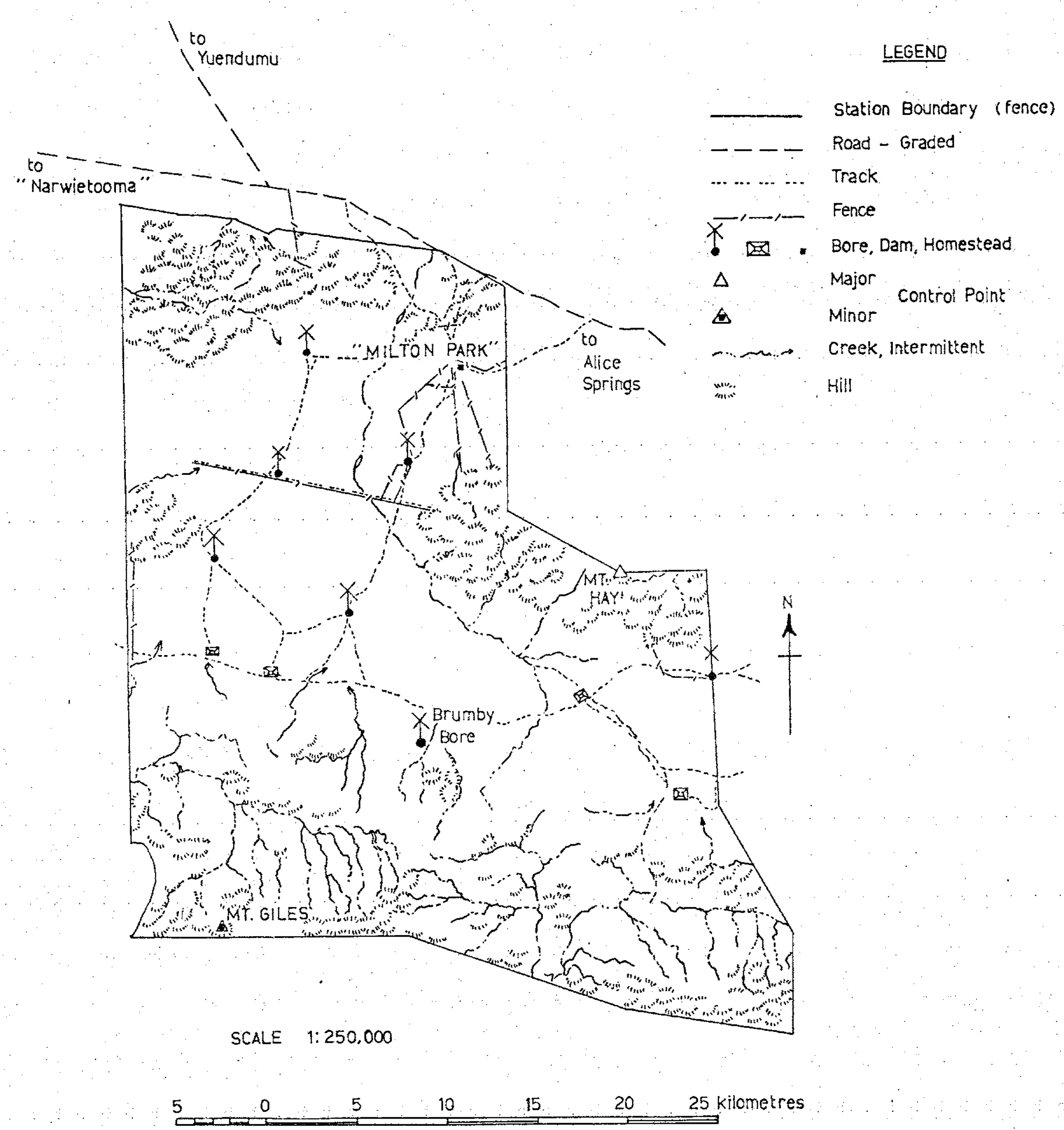
* C.S.I.R.O. Division of Land Res. Mgmt., Alice Springs.

Map 3.2 AMBURLA STATION



Source: HERMANNSBURG 1:250,000 Sheet, SF 53-13 Ed.1, Series R502, 1969.

Map 3.3 MILTON PARK STATION



Source: HERMANNSBURG 1:250,000 Sheet, SF 53-13 Ed.1, Series R 502, 1969

PLATE 3.4 ELEVATED VIEW OF OPEN WOODLAND

Brumby Bore in distant background.

with isolated scatterings of perennial grasses. The dominant annuals include Oat grass and Mulga grass (*Aristida contorta*). Forage of this pasture type was in general abundant and dry.

Despite apparent heavy utilization of pastures, the Shorthorn cattle watering at Brumby Bore were generally in forward-store/fat condition (Plate 3.5). The structure of the herd watering at the bore was once again quite complex, ranging from mature age bullocks to cows with young calves. Brahman bloodlines from registered stud bulls have been infused into the herd in recent years.

During the period of study, there were approximately 400 head of cattle* watering at Brumby Bore; an equivalent therefore of 11 head per square mile in both the Mulga shrubland and Open Woodland eco-units over which the bore commands. This lower level of stocking, as shown in Table 3.2, has only recently been recorded, as 9 months ago the number of stock grazing in the open Woodland unit alone was approaching 400 head (18 beasts per square mile). This decrease in stock numbers in the Open Woodland is due to both sales of stock, and a net movement of cattle from the woodland to the Mulga shrubland. Stock movement could be attributed to lack of sufficient winter rainfall, causing cattle to forage in the less preferred pasture type.

Brumby Bore was established in 1948, drilled to a depth of approximately 100 feet (Hodder, pers.comm.). The bore water is of fair to good quality (A. Davis, pers.comm.), and the pasture lands of the local Open Woodland eco-units are considered by pastoralists as "very sweet country". Perhaps this may explain the abundance of

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* equivalent animal units.

PLATE 3.5 STOCK WATERING AT BRUMBY BORE

note: scarcity of cover; particularly adjacent cattle pad in foreground

TABLE 3.2 RECENT STOCKING HISTORY : BRUMBY BORE

	Estimated Number of Cattle *	Estimated Stocking Rate in Open Woodland Eco-unit *	Feed Condition **	Dominant Grazing Direction from Bore	Condition of Cattle ***
30/6/76	500	15	3:1	N	FS/F
22/9/76	500	12	3:1	N	FS/F
8/12/76	700	18	3:2	N.W. & E.	FS/F
15/2/77	900	15	3:2	N	FS/F
14/4/77	500	16	2:1	N.W.	FS/F
8/6/77	400	11	2:1	N.E.	FS/F

* mature age cattle units

** key : 1 = green; 2 = drying off; 3 = dry — 1 = abundant; 2 = moderately abundant; 3 = sparse

*** key : S = store; FS = forward store; F = fat

Estimates courtesy R. Hodder, C.S.I.R.O., Alice Springs native forage animals, particularly kangaroos, in the Brumby Bore area. At both dawn and dusk large numbers of kangaroos were observed feeding in the Open Woodland, particularly in depressions that would receive run-on water from rainfall.

Fire-induced vegetation changes are not applicable in this study, as neither the Open Woodland nor the Mitchell Grass transect lines have been burnt in recent times (Hodder, pers.comm.). The history of burning on these regions prior to 1960 could not be determined, however, so there could be residual effects not apparent today.

It is important to note that the study areas were observed following a series of above average rainfall seasons. This is evident in Table 3.3. High rainfall result in an abundant growth of all vegetation, including many annuals and forbs. However, this fact does not lessen the value of the findings from the study, since vegetation assessments have been made in relative, not absolute terms. Vegetation measurements were compared against other contemporary recordings, and not against previously recorded averages or absolute values.

TABLE 3.3 MEAN MONTHLY RAINFALL : MILTON PARK HOMESTEAD.
(mm)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1959		7.8	14.8		34.8					14.0	8.3	16.0	95.5
1960	61.0	18.0		3.0	28.3				20.3	25.3		23.3	179.0
1961	18.0			45.3									63.3
1962	86.6	1.0	143.3	5.5		13.5	11.8	24.0		54.8	13.3		353.8
1963	13.8		20.0	2.0	27.5	5.5				12.5	2.8	4.0	88.1
1964	4.0			3.8	29.5	12.8			34.0		12.8	32.0	128.8
1965			27.8			1.5		10.0			15.3	32.0	86.5
1966	88.0				13.5	58.0		47.3		16.3	10.5	10.3	243.5
1967	32.5	210.0	39.8		4.8						1.5	9.0	297.5
1968	45.8	42.3	25.5	43.5	76.3	8.3	37.0	3.8	22.5	26.0	36.3	15.0	382.0
1969	42.3	84.3	40.5		2.5	6.0	28.8					14.0	219.0
1970		6.3	9.5	62.5	6.0				5.0	11.3	17.8	18.5	136.8
1971	4.0		20.0	4.3		8.0	10.0	4.3			59.0	44.0	153.5
1972	10.8	7.0	252.8	1.5			2.5	7.0	9.3		12.3	3.5	306.5
1973	37.0	65.5		13.3	10.5	88.3	17.5	83.5	12.8	20.0	203.5	49.3	601.0
1974	491.4	9.50	19.2	65.0	60.0			43.8	96.8	72.3	57.6	31.2	1032.3
1975	15.2	31.0	63.0			0.2	23.1	31.4	51.0	22.0	43.4	134.2	414.5
1976	85.8	78.7	85.3							44.7	6.4	9.0	309.9
1977		214.0	45.0										

SECTION B - EXPERIMENTAL PROCEDURE

General Considerations

The sampling method to be used in this study had to meet proper statistical and sampling requirements. It was decided that the data to be collected would need to be such that would yield valid estimates of basal cover, pasture composition and degree of species utilization. These three vegetation factors were seen from reconnaissance to be those most likely to meaningfully portray grazing use of range.

The method used also had to be one that would be appropriate to the very large and diverse rangeland. Any area sampled had therefore to be of sufficient size to effectively eliminate possible distortion introduced by such internal variation. However many sites would have to be sampled in a limited period of time, so the method had to be one capable of being performed rapidly. These are simply some of the requirements of the sampling method.

CHAPTER 4 - SAMPLING PROCEDURE

Wheel-Point Method of Botanical Survey

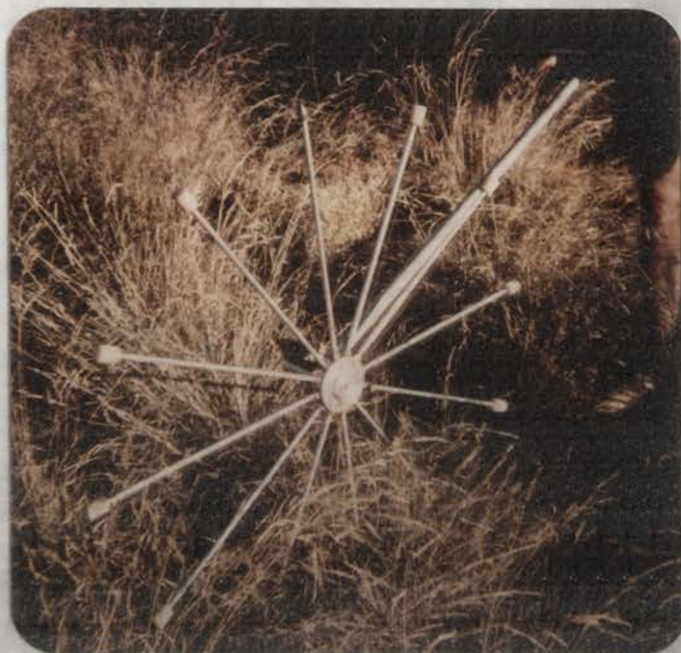
After initial experimentation it was concluded that the wheel-point method of botanical survey (after Tidmarsh and Havenga, 1955) would provide an appropriate means of sampling in both the Mitchell Grass plains and the Open Woodland eco-units. It clearly fulfilled the major requirements of the sampling method, and a wheel-point apparatus was readily available for use (Plate 4.1). The method permitted rapid sampling of large areas, particularly in the Mitchell grasslands. However, in the Open Woodland sampling proved more difficult due to the regular, although scattered occurrence of trees. A description of the wheel-point apparatus is given in Appendix I.

The wheel-point apparatus basically measures one factor: basal strike or no strike. So its simplest application is for the determination of basal cover. However, if an observer records not only direct species strikes, but also the "nearest plant" in the case of a no strike, then pasture composition can be quickly estimated. Composition by this method is a measure of frequency of species occurrence, and not a measure of vegetation biomass. Other observations relating to the individual sample point plants, such as degree of utilization, can also be recorded.

Establishment of Sample Size

In both the Mitchell Grass plains and Open Woodland, the sample size was determined following a pilot study. One thousand points were sampled in each pasture type at ½km. from the respective

PLATE 4.1 WHEEL-POINT METHOD OF BOTANICAL SURVEY



The Wheel-Point

The Wheel-Point in use in the Mitchell Grass plains.

bores. Frequency of occurrence of several of the most regularly recurring pasture species was in each case taken as the basic measure for analysis, and a running means statistical test (Kershaw, 1964) (Greig-Smith, 1957) was applied to these values. The running means, standard deviations, and co-efficients of variation were then calculated and it was found in both pasture types that 500 points would provide sufficient sample size to achieve a co-efficient of variation of approximately 10% (Appendix II). For botanical sampling in areas of semi-arid and arid country, this is regarded as an acceptable amount of variance (Foran*, pers.comm.).

Determination of Levels of Forage Utilization

A means of accurately recording the levels of utilization of plant species in the area sample was devised. The method used involved a combination and modification of two range utilization recording techniques in use today. The field observations were recorded on data sheets (Appendix III) according to a modification of the percentage utilization rating scale devised by Anderson and Walker**(1974). These authors grouped their observations into 8 ranks of forage utilization. In the present study, the 8 classes were reduced to 6 classes, viz.

Rank	Class Interval (% utilization)
0	0
1	1-25
2	26-50
3	51-75
4	76-99
5	100

* B.D. Foran - C.S.I.R.O. Div. Land Res. Mgmt., Alice Springs.

** Anderson and Walker (1974) in Walker (1976).

This modification was made as a consequence of the initial field trial, when it was clear that estimating utilization using 8 classes would require lengthy periods of practice before sufficient accuracy could be obtained.

The designation of percentage utilization classes to individual sample species was carried out with the aid of photographic utilization guides. Known as the grazed-class method of estimating forage utilization, the technique followed was that devised by Schmutz, Holt and Michaels (1963). A normal mature sized un-utilized plant was over-dried, weighed, clipped and photographed at successive stages of forage removal. This allowed the preparation of a photographic guide for the field determination of percentage forage utilization (Appendix IV).

Field Measurements

The initial step in both pasture types was to establish the study transect(s) radially away from the relevant bore. Transect length was based on the widely held assumption that the usual maximum grazing range of cattle from a watering point is about 6 km. (Perry, 1962), and that beyond this distance there is little grazing effect. In both pasture types, by taking 6 km. as the grazing limit, the transects appeared to avoid undesired grazing interference from stock on adjacent watering points. Possible line transects were established from aerial photography, and their more precise position was then fixed in the field.

Sampling areas were examined along chosen line transects at regular and increasing distances from the bore. At each site, 10 runs of 50 points per run were made. This surveyed an area equivalent of approximately ½ h.a. since sampling occurred every 3 m., with successive runs spaced at 3m. intervals. The long dimension of each sampling area was perpendicular to the transect line. At each of the sample sites, representative soil samples and site photographs were taken. The results of an analysis of soil samples can be found in Appendices V, VI, and similarly sequences of site photographs are shown in Appendices VII and VIII.

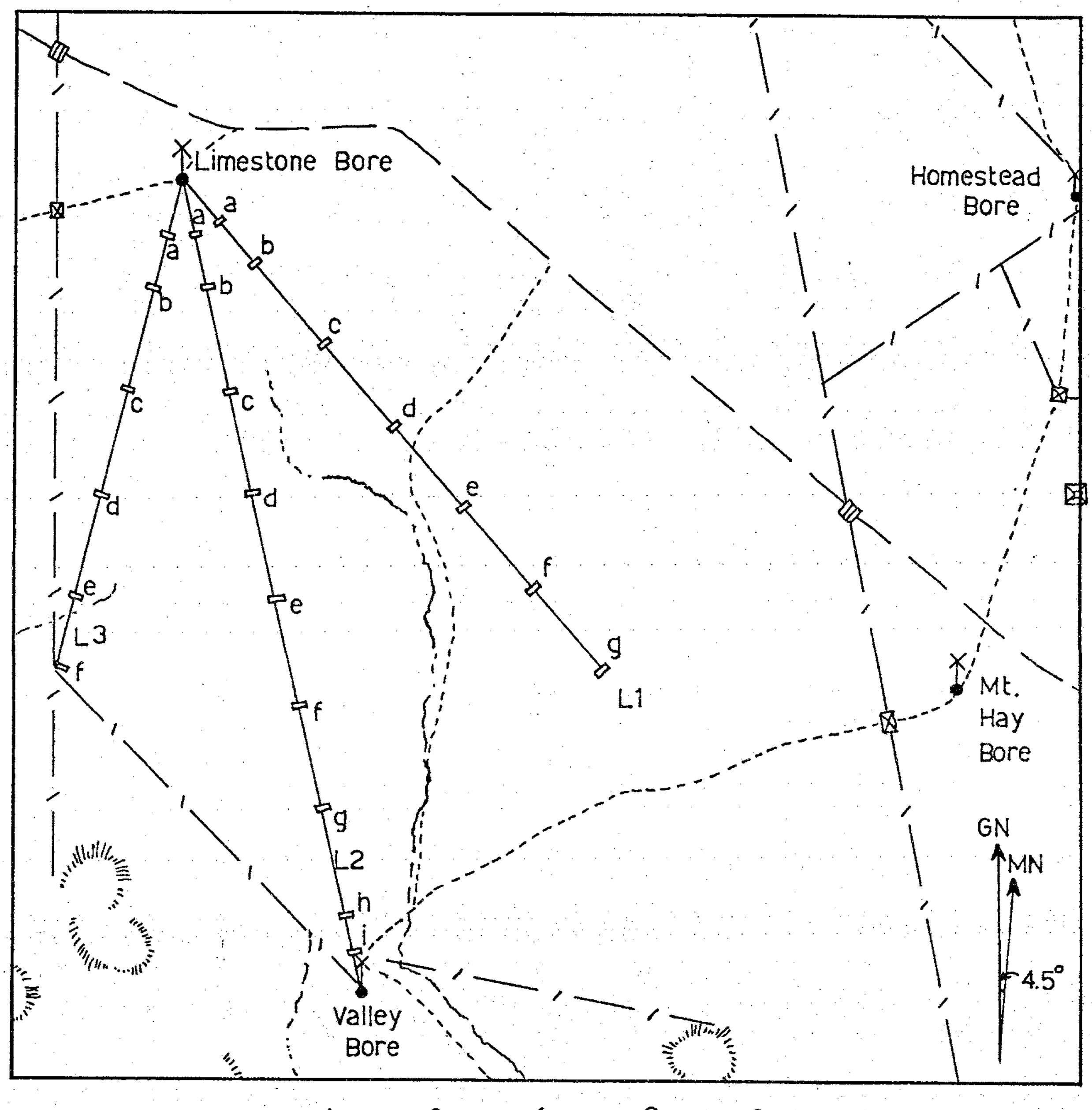
Sampling at Limestone Bore, Amburla

Three study lines were established in the Mitchell Grass plains radiating out from Limestone Bore (Map 4.1, Plate 4.2). The first of these lines, bearing 135°E of magnetic North from the bore, followed the study line of a 1975 Animal Industry and Agriculture Branch survey. Seven sample sites were established along this line at ½, 1, 2, 3, 4, 5, 6 km. distances respectively from the bore. All seven sites displayed very similar site characteristics.

The second of these transects, along bearing 167°E from the bore, was in a direct line between Limestone and Valley Bores - a distance of approximately 8.5 km.. Nine sites were located along this line at ½, 1, 2, 3, 4, 5, 6, 7, 8 km. respectively from Limestone Bore. Intermediate sites along this line at approximately three to four kilometres appeared atypical due to the presence of a nearby drainage line.

Line 3 was in direction 197°E. Only 6 sample sites were surveyed at ½, 1, 2, 3, 4, 4.7 km. distances respectively from Limestone Bore. Sampling was not possible beyond 4.7 km. since the

Map 4.1 LIMESTONE BORE STUDY AREA



SCALE 1:62,500 — 1 0 1 2 3 4 5 km.

LEGEND: Transect/survey site — Bore, Dam

Graded Road — Gate, Grid

Station Track — Creek/Drainage Line

Fence — Hill

The location of Valley Bore differs from that of the 1:250,000 Hermannsburg sheet due to the plotting errors on the latter map.

Source: HERMANNSBURG 1:250,000 Sheet, SF 53-13 Ed. 1, Series R 502, 1969

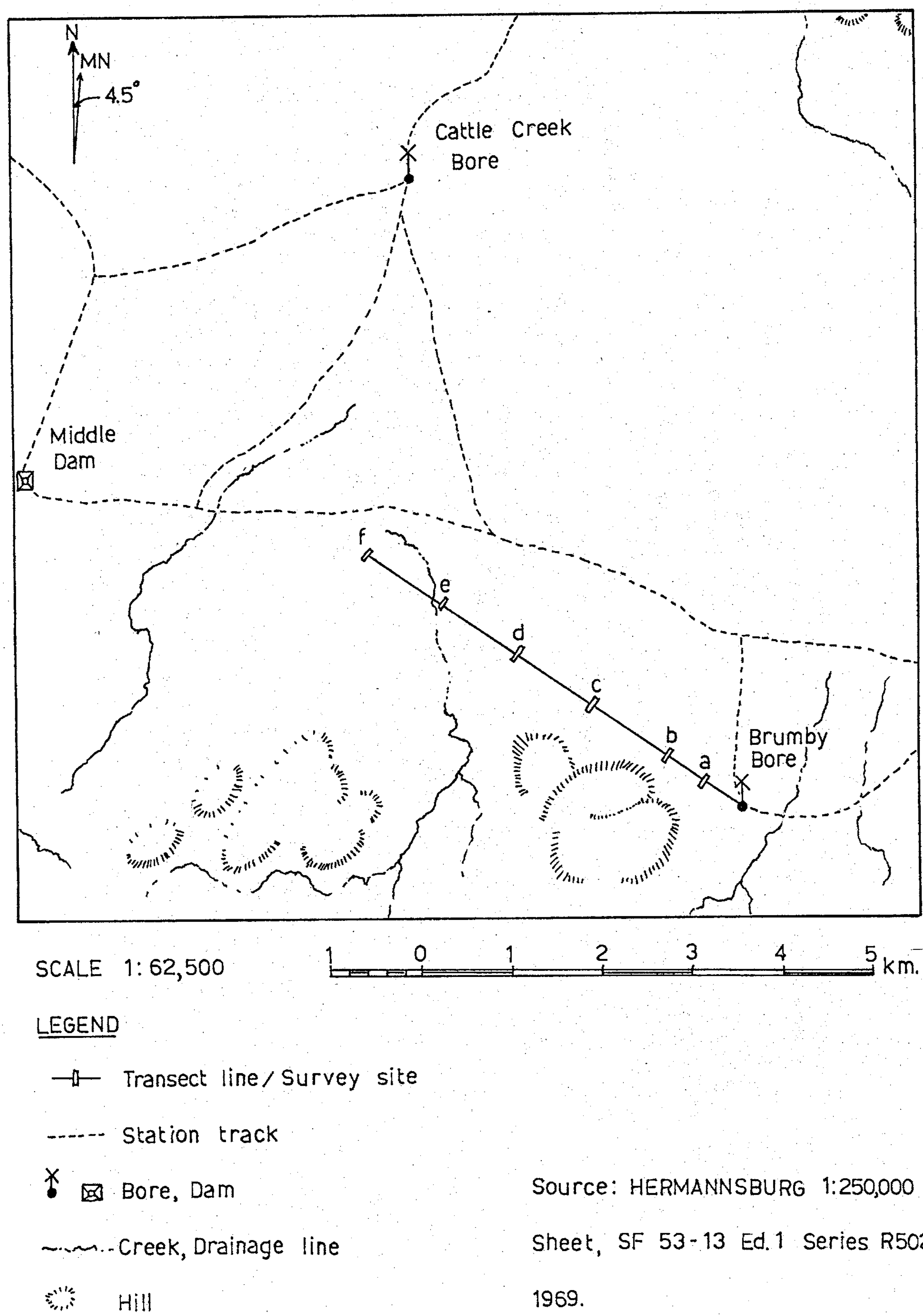
PLATE 4.2 LIMESTONE BORE STUDY AREA

transect was cut by a boundary fence. All sites exhibited similar site characteristics excepting the site at 4 km. which was located adjacent to a large surface depression.

Sampling at Brumby Bore, Milton Park Stn.

Because of time restraints, only one line transect was established at Brumby Bore, extending from the bore in direction 300°E (Map 4.2) (Plate 4.3). Sample sites were established at the ½, 1, 2, 3, 4, 5 km. distances from the bore, and all sites appeared to have similar site characteristics. Substantial variation in vegetation occurred internally within the Open Woodland, and it was at times difficult to choose sample sites showing repeating characteristics throughout the various sampled areas.

Map. 4.2 BRUMBY BORE STUDY AREA



Source: HERMANNSBURG 1:250,000 Sheet, SF 53-13 Ed.1 Series R502 1969.

PLATE 4.3 BRUMBY BORE STUDY AREA

SECTION C - FIELD OBSERVATIONS AND THEIR MANIPULATIONS

CHAPTER 5 - DEVELOPMENT OF FORAGE INDICES

Concept of "Fully-Grazed-Tuft"

The percentage utilization rating scale was not sufficient to estimate the total percentage utilization of fodder species at a given site, and was no direct measure of grazing intensity. The immediate need was to find a means of relating the number of plants of a species in each grazed class to a total forage-consumed equivalent. This was achieved using a weighting system, whereby the 5 classes of utilization of a species were differentially weighted to obtain the number of "fully-grazed-tuft" (plants) equivalent. For example, the removal of forage from 10 plants catagorized in grazed class 1 was regarded as equivalent to the forage removed from one fully-grazed-plant of that species (Fig. 5.1).

This concept of the "equivalent fully-grazed-tuft" was used by du Plessis* (1972) in a study of the ecology of the South African blesbok. Du Plessis only recognized three grazed classes, viz. ungrazed plants, partially grazed plants and fully-grazed plants. The fully-grazed-tuft equivalent for a particular species was : half the number of partially grazed plants + the number of fully grazed plants = total number of "fully-grazed-tufts".

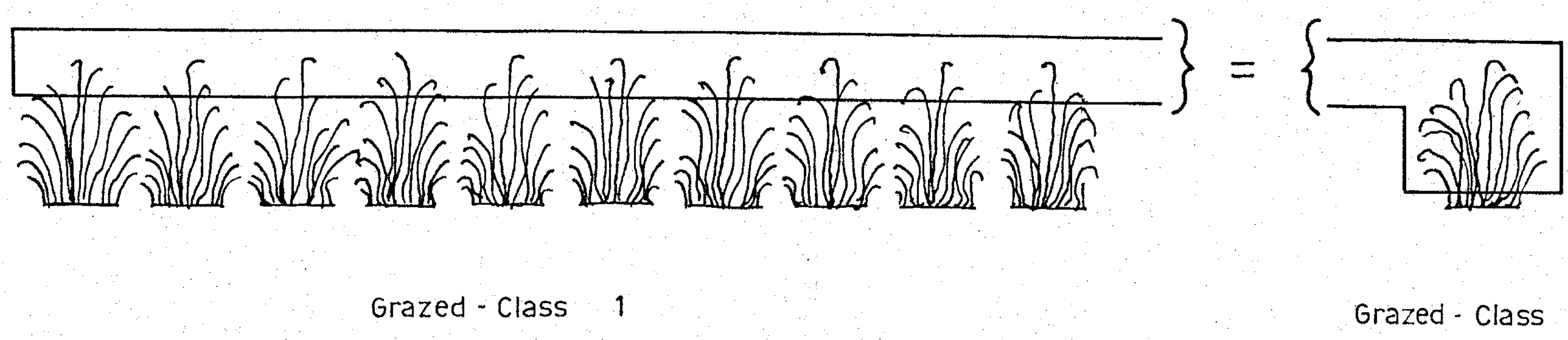
Applying the fully-grazed-tuft approach in a system using six levels of grazing classes presented several difficulties. The weighting co-efficients had to be determined for each of the grazed classes.

---

* The system used by du Plessis was an adaptation of the method described by Petrides and Swank (1965).

Fig. 5.1 CONCEPT OF THE EQUIVALENT FULLY-GRAZED-TUFT : ILLUSTRATION.

It is assumed that the removal of forage from 10 plants catagorized as grazed – class 1 is equivalent to the forage removed from another plant of that species being fully-grazed.



Viz.

Number of fully-grazed-tufts, species A

$(F.G.T._{sp. A.})$

$$\begin{aligned}
&= a \times (\text{no. plants}_{sp.A}, \text{ grazed class } 0) \\
&+ b \times (\text{no. plants}_{sp.A}, \text{ grazed class } 1) \\
&+ c \times (\text{no. plants}_{sp.A}, \text{ grazed class } 2) \\
&+ d \times (\text{no. plants}_{sp.A}, \text{ grazed class } 3) \\
&+ e \times (\text{no. plants}_{sp.A}, \text{ grazed class } 4) \\
&+ f \times (\text{no. plants}_{sp.A}, \text{ grazed class } 5)
\end{aligned}$$

b, c, d, e are the undetermined weighting co-efficients

obviously, a = 0 since un-utilized plants are not considered in the determination of the number of F.G.T.

and, f = 1 since any plant in grazed class 5 is fully grazed.

In determining the weighting co-efficients for the present study, attention was directed to those co-efficients used in other pasture utilization surveys. Du Plessis (1972), classifying plants as either fully-grazed or partially grazed had used weighting factors of 1.0 and 0.5 respectively to determine the unequivalent number of fully grazed plants in the sample, Kruger and Edwards (1972) working on veld grazed by cattle in the Transvaal, classified plants as fully-utilized, more than 50% utilized, less than 50% utilized, or un-utilized. The corresponding weighting co-efficients were 1, $^2/_3$, $^1/_3$, 0. Also working on veld in the Transvaal, Roos, Rothman and Kotze (1973) recorded three levels of utilization, namely, less than 15% utilization, 16 to 30% utilization, and over 50% utilization. Their relevant weighting co-efficients were $^1/_{10}$, $^1/_3$ and 1.

The following equation was used therefore for the determination of the equivalent number of fully-grazed-tufts of a pasture species at a site.

$$\text{Number "fully-grazed-tufts" } (F.G.T._{sp.A}) \text{ species A} = 0.1.n(1) + 0.4.n(2) + 0.6.n(3) + 0.8.n(4) + n.(5)$$

where n(1) = no. of plants, species A, in grazed class 1.
and so on.

The fully grazed tuft concept is of course only a crude measure of grazing intensity. The total number of fully-grazed-tufts can only be used for site to site comparisons of grazing intensity by assuming uniform site characteristics, such as plant density, size and the like.

Development of Forage Utilization Index

The fully-grazed-tuft concept provided an initial step towards the estimation of forage utilization. However, of itself it was not sufficient to express percentage utilization on a species basis. Following du Plessis (1972), a utilization relationship was developed such that

$$U_A = \frac{F.G.T._A \times 100}{N_A}$$

where

U_A = % utilization of a forage species A.

F.G.T. = no. fully-grazed-tufts, species A.

N_A = frequency of occurrence, species A.

Relative Use Values

This index - percentage utilization on a species basis - provided most useful information. In order to determine the various valuable forage species, utilization estimates had to be able to be compared one to another. This was achieved using the index devised by Kruger and Edwards (1972), which measures the contribution of a particular species to total forage removed at a site. It is a measure of the use importance of that species, and provides a means of determining the valuable fodder species. The Relative Use Value, expressed as a percentage, is defined as follows:

$$R.U._A = \frac{F.G.T._A \times 100}{T}$$

where

$R.U._A$ = Relative Use Value, species A.

$F.G.T._A$ = number of equivalent fully-grazed-tufts, species A.

T = total of all equivalent fully-grazed-tufts.

Preference Rating

On the basis of the Relative Use Values of various species, a listing of cattle forage preferences became possible. This list aided the identification of valuable forage species.

Using the terms already derived, the preference rating is defined as follows:

$$P.R._A = \frac{R.U._A}{P_A}$$

where

$P.R._A$ = Preference Rating, species A.

$R.U._A$ = Relative Use Value (%), species A.

P_A = (%) Pasture Composition, species A.

In these terms, a pasture species having a P.R. of value 1 would be classed as a "normal" species, i.e. its consumption and abundance are equal. If a P.R. has a value greater than 1, then the use of the species exceeds its availability and the plant is definitely sought after by stock. However, if the species exhibits a P.R. of less than 1, then its use does not compare with its availability and it is not liked by stock.

Further manipulation of the above relationship leads to a simplified form of equation viz

$$P.R._{sp.A} = \frac{\frac{F.G.T._{sp.A.}}{T}}{\frac{N\ sp.A.}{N}} \quad \text{or} \quad \frac{\frac{F.G.T._{sp.A}}{N_{sp.A}}}{\frac{T}{N}}$$

$$= \frac{U_{sp.A}}{G.L.}$$

where $N_{sp.A}$ = pasture composition, species A.

N = 500

$G.L.$ = grazing level $\frac{(T)}{(N)}$

T = total of all fully-grazed-tufts.

U = (%) utilization of species A.

That is, if the forage utilization of a species at a site is greater than the average utilization of that site, then that species is preferred.

i.e. $U_{sp.A.} > G.L.$

or $P.R._{sp.A} > I$

CHAPTER 6 - LIMESTONE BORE OBSERVATIONS

In keeping with the objectives of this thesis, the following observations based on field measurements will be outlined and explained in the context of their position along radii from the associated waters. The results will be examined under the following headings; basal cover, pasture composition and utilization of pasture species.

Basal Cover

The total number of actual plant-base strikes divided by the number of sample points (i.e. 500) yields an estimate of basal cover* for each survey site. This fraction is then expressed as a percentage, and represents the proportion of ground covered by living plant material.

From a tabulation of the Limestone Bore data (Table 6.1) it is clear that basal cover varies generally from 2.0% to 4.0% irrespective of the distance from the bore. Less than 5.0% basal cover is well illustrated and confirmed by a low-level aerial photograph of the Mitchell Grass plains (Plate 6.1). Although the botanical cover in this photograph is projected cover, the low plant density is definitely reflected by the large proportion of bare clay surface in these plains.

The only apparent significant variation in basal cover is in the region adjacent the bore in line transect no.1. (L1) (Fig. 6.1).

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* Basal cover is different to the usual "projected" cover of vegetation surveys.

TABLE 6.1 BASAL COVER (%)

LIMESTONE BORE STUDY AREA

Distance from Watering Point (km)	Transect line L1	Transect line L2		Transect line L3	$\bar{X}$ (mean lines L1,L2,L3)
0.5	12.2	3.2	*1.6	2.0	4.8
1.0	8.8	2.0	*2.2	3.2	4.1
2.0	3.6	1.6	*3.0	1.6	2.5
3.0	5.8	2.0	*2.4	2.0	3.1
4.0	3.6	3.0		4.4	3.7
5.0	3.4			1.8	2.6
6.0	4.0				4.0

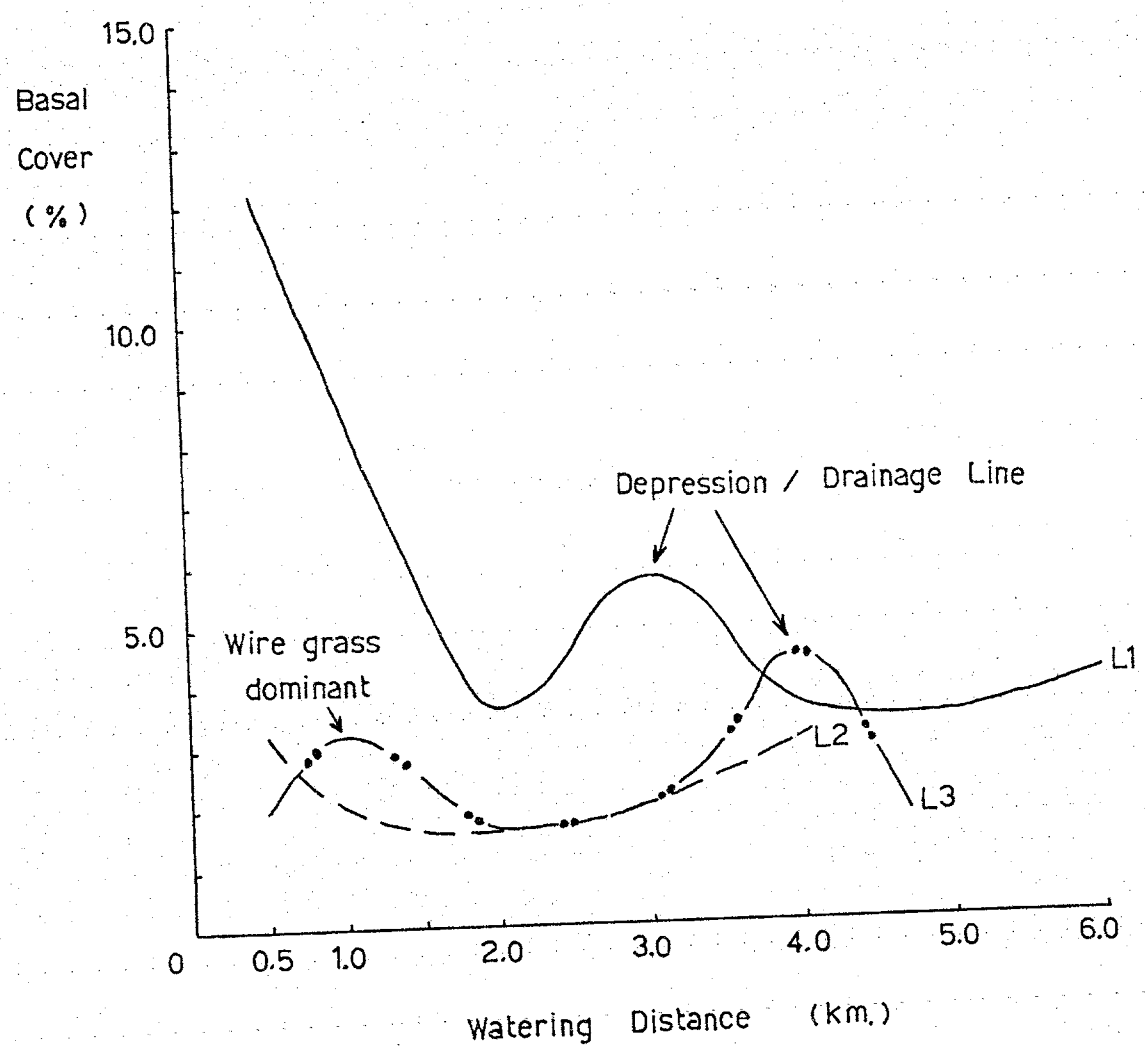
$\bar{X} = 3.54$

* Figures represent estimates from sites 2f, 2g, 2h, 2i at distances 3, 2, 1, 0.5 km. respectively from Valley Bore, and are used analogously with Limestone Bore observations in all calculations, since they represent similar observations at similar distances from watering points in the same pasture type.

PLATE 6.1 LOW-LEVEL AERIAL PHOTOGRAPH OF MITCHELL GRASS PLAINS

Fig. 6.1 BASAL COVER

LIMESTONE BORE STUDY AREA



Basal cover is shown there to be as high as 12.0%. This anomalous figure is now seen as the consequence of the observer not following the proper definition of a "hit" or "miss" when using the wheel-point apparatus. Line 1 was the first transect surveyed. Aerial photo analysis confirmed in broad terms the above explanation.

A close correspondence was found to exist between increases in basal cover and the occurrence of drainage depressions and hollows. This was noted at the 3 km. distance (site 1d) from the bore along transect line no.1, and also at the 4 km. distance (site 3e) along transect line no.3. It seems likely that locally higher moisture concentrations in these areas permitted a greater plant density, and this feature was then reflected in a basal cover increase.

Absolute dominance of an unpalatable pasture species, viz. *Aristida latifolia,* also caused a local increase in basal cover at the 1 km. distance on transect line 3. The large perennial tussock grass grew vigorously at this site, which appeared to deter cattle grazing in the near vicinity.

Pasture Composition

Pasture composition in this study was derived directly from frequency of occurrence of a species in the 500 point sample at a site. It was not possible using the wheel-point method to express pasture composition in terms of species biomass. Had time permitted conversions of species frequency data to biomass (the more realistic unit in grazing studies would have been undertaken.

In the Mitchell Grass Plains, pasture composition varied significantly with increasing distance from the watering point. A marked trend in all transect lines was the increase in the number of pasture species present as distance from water increased. Pasture composition near the bore was very limited with generally four pasture species forming almost the entire pasture complex. However, at 5, 6 kilometres distance from water, the plant cover consisted of at least 9 pasture species.

Also, the proportion of the various species within the pasture varied significantly with distance from water. This feature is well illustrated in Table 6.2. Three of the major species, Mitchell grass, Flinder's grass, and Oat grass each constituted an increasingly larger percentage of the pasture as watering distance increased. In all three cases, the percentage of pasture increase was at least as much as 100% from the 0.5 to 6 km. distance from the bore. This represents quite a significant change in pasture composition over the 5.5 km. distance, as indicated by these dominant species in Fig. 6.2.* However, Neverfail another major pasture species showed the reversal of this trend. Neverfail was dominant within the 1 km. range of the bore, but beyond 2 km. it formed an insignificant portion of the pasture. The minor pasture species, such as Panic grass, *Sida spp.* showed no definite trend in their contribution to pasture composition with varying distance from water.

Forage Utilization

The fully-grazed-tuft index provided a measure for the analysis of pasture utilization with varying distance from watering points.

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* Regression lines were plotted using the Hewlett-Packard 9100B Calculator/Computer.

TABLE 6.2 PASTURE COMPOSITION (%)[1]

LIMESTONE BORE STUDY AREA

MINOR SPECIES NOT SHOWN[2]

Species	Distance from Watering Point (km)							
	0.5	1.0	2.0	3.0	4.0	5.0	6.0	
Mitchell Grass *(Astrebla pectinata)*	13.6	19.2	20.1	20.4	26.4	15.8	29.6	*
Flinders Grass *(Iseilema membranaceum)*	20.6	20.5	24.6	35.9	25.5	40.5	39.6	*
Oat Grass *(Enneapogon avenaceus)*	8.4	0.8	22.3	12.4	22.2	23.8	22.2	*
Neverfail Grass *(Eragrostis setifolia)*	46.3	35.7	6.5	0.5	6.2	5.9	1.6	**
Sida spp.	5.0	0.2	0.7	3.3	1.9	1.4	5.4	
Panic Grass *(Panicum spp.)*	0.5	4.5	3.35	8.5	3.1	3.7	2.6	

1 Columns do not sum to 100%, since individual figures at each distance from water, represent mean estimates of pasture composition for transects 1,2,3.

2 Only dominant pasture species are considered. Minor species (generally <0.2% of pasture) show no distinct trends.

* Indication of definite increase in percent pasture composition with increasing distance from watering point.

** Indication of definite decrease in percent pasture composition with increasing distance from watering point.

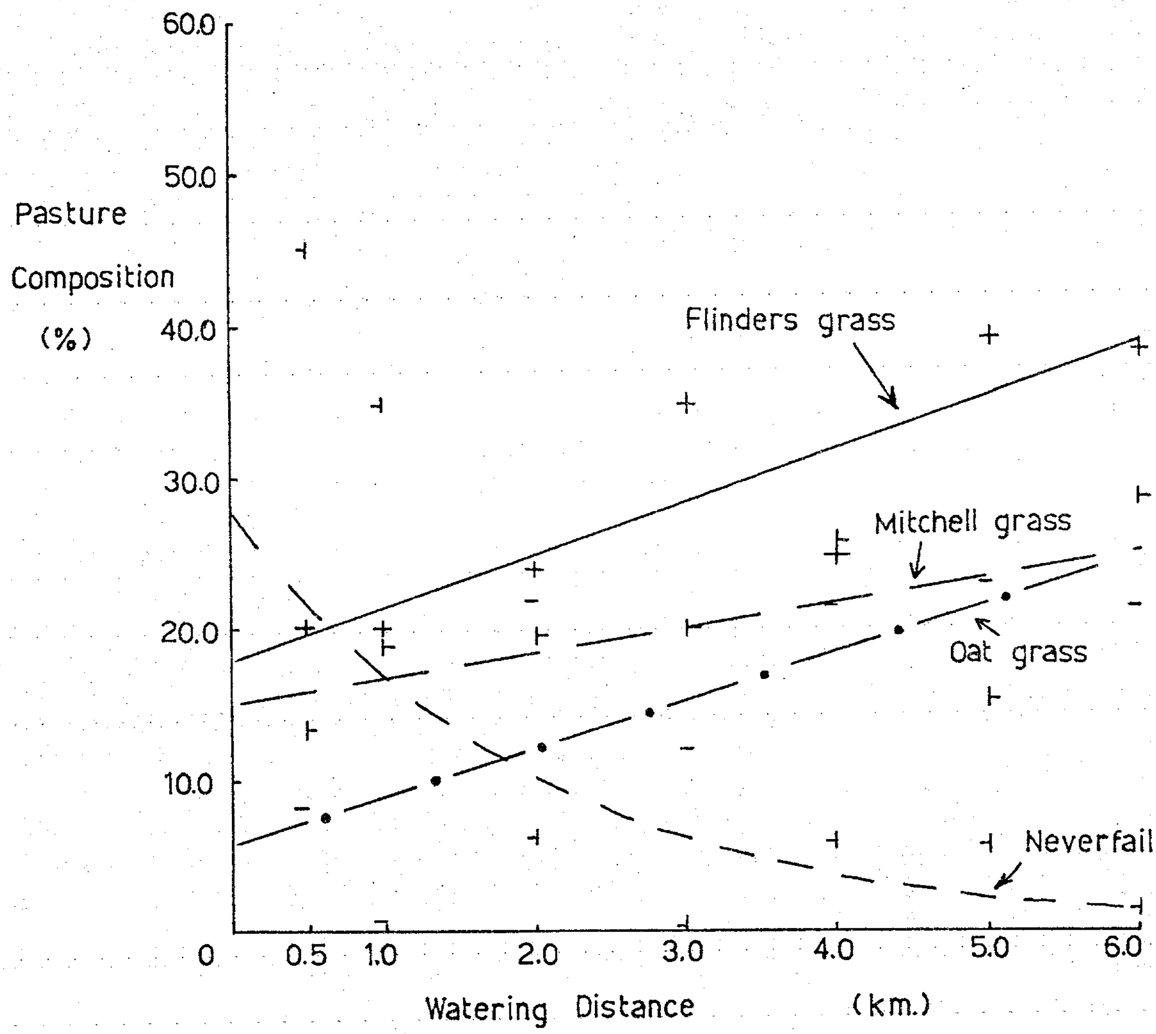
<u>Minor species include</u>: *Agropyrum repens*, *Aristida anthoxanthoides*, *Aristida latifolia*, *Aristebla elymoides*, *Dicanthium sericeum*, *Marselia sp.*, *Sporobolus sp.*, *Themeda australis.*

Fig. 6.2 PASTURE COMPOSITION

LIMESTONE BORE STUDY AREA

MEAN OF TRANSECTS 1, 2, 3.

Minor species not shown



<u>Correlation Coefficients</u>:

Flinders grass,	r = 0.87
Mitchell grass,	r = 0.64
Oat grass,	r = 0.76
Neverfail,	r = 0.65

The total number of equivalent fully-grazed-tufts at each site was analysed for distance/water relationships. A relationship between the fully-grazed-tuft index and watering distance was revealed, and the trend is represented in Figure 6.3.

It is clear that the number of equivalent fully-grazed-tufts at a site is inversely proportional to the distance from the watering point. A near perfect negative correlation in the graphed relationship allowed the determination of the equation defining : the equivalent number of fully-grazed-tufts to be expected at any given distance from the bore. The equation is given as:

$$F.G.T. = -46.83.d. + 310.01$$

where

F.G.T. = no. of equivalent fully-grazed-tufts

d = watering distance.

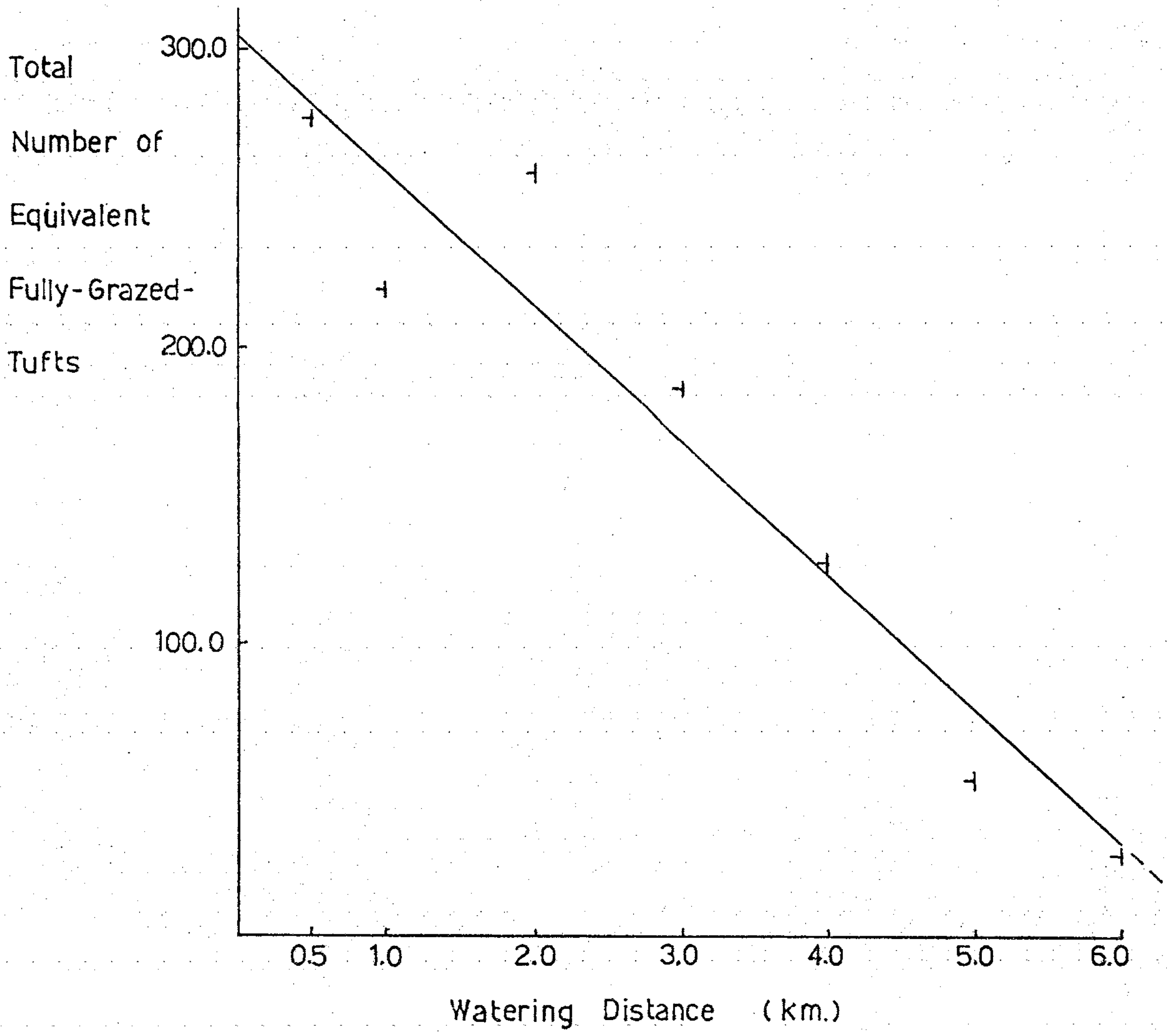
It is significant also to note that at 6 km. distance from water, only 5.0% of tufts present are grazed to any degree, and that the grazing limit defined by this relationship is at approximately 7 km. from the bore.

The indices of equivalent fully-grazed-tufts were then used in the determination of the percent utilization of fodder species at each of the study sites in the plains. Utilization of pasture species was estimated using the index developed in Chapter 5. Again some interesting trends were discovered (shown in Table 6.3) Flinder's grass, Mitchell grass, Oat grass and Panic grass were uniformly less utilized as watering distance increased. These species were generally 80% utilized near the bore, decreasing to less than 10% utilization at 6 km. distant. Computer plotting of the utilization gradients are

Fig. 6.3 TOTAL EQUIVALENT FULLY-GRAZED-TUFTS

LIMESTONE BORE STUDY AREA

MEAN OF TRANSECTS 1, 2, 3.



Correlation Coefficient: $r = {}^{-}0.96$

TABLE 6.3 FORAGE UTILIZATION (%)[1]

LIMESTONE BORE STUDY AREA

MINOR SPECIES NOT INCLUDED

Species	Distance from Watering Point (km)						
	0.5	1.0	2.0	3.0	4.0	5.0	6.0
Mitchell Grass (*Astrebla pectinata*)	81.8	67.8	55.3	43.5	31.3	11.4	6.1
Flinders Grass (*Isceilema membranaceum*)	79.9	77.7	60.6	41.3	9.8	2.9	0.3
Oat Grass (*Enneapogon avenaceus*)	72.9	79.7	64.6	47.1	42.2	26.3	5.1
Neverfail Grass (*Eragrostis setifolia*)	39.7	28.2	33.9	20.7	19.3	7.0	3.8
Sida spp.	79.2	*	71.0	75.9	85.8	45.2	50.4
Panic Grass (*Panicum spp.*)	75.0	64.4	40.4	23.7	31.7	18.7	0.9

1 Columns do not sum to 100%, since individual figures at each distance from water, represent mean estimates of pasture composition for transects 1, 2, 3.

* species not present.

given in Figs. 6.4 and 6.5. A strong correlation was found to exist in all regression relationships. This same behaviour was shown by Neverfail, however at no stage was it utilized more than 40%.

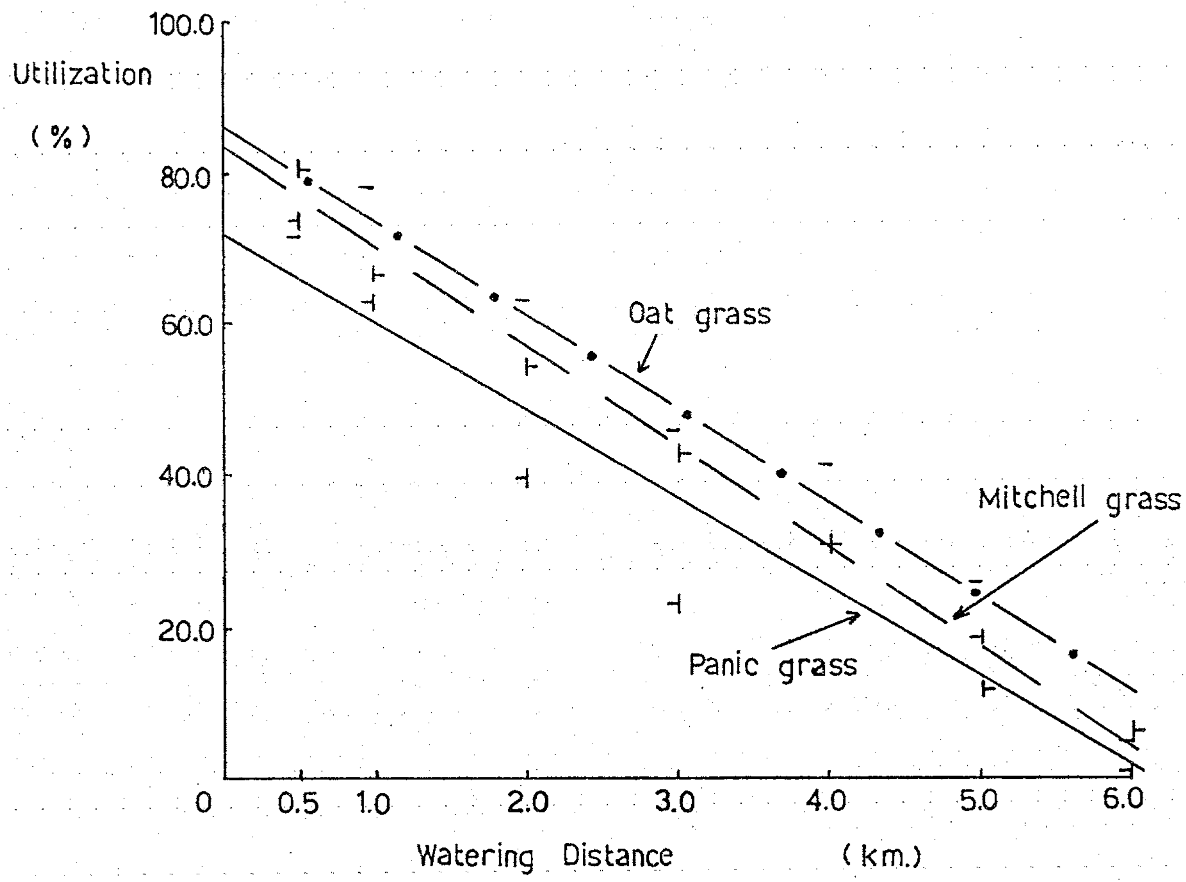
The most interesting trend is shown by *Sida spp*. This species was uniformly heavily grazed (approximately 80% utilization) to a distance of 4 km. from the bore, and only then does it become increasingly less utilized. Even at 6 km. distance from the bore, 50% of available *Sida* is utilized. Minor species showed no distinct utilization gradients.

Fig. 6.4 FORAGE UTILIZATION

LIMESTONE BORE STUDY AREA

MEAN OF TRANSECTS 1, 2, 3.

Minor species not shown



<u>Correlation Coefficients</u>:

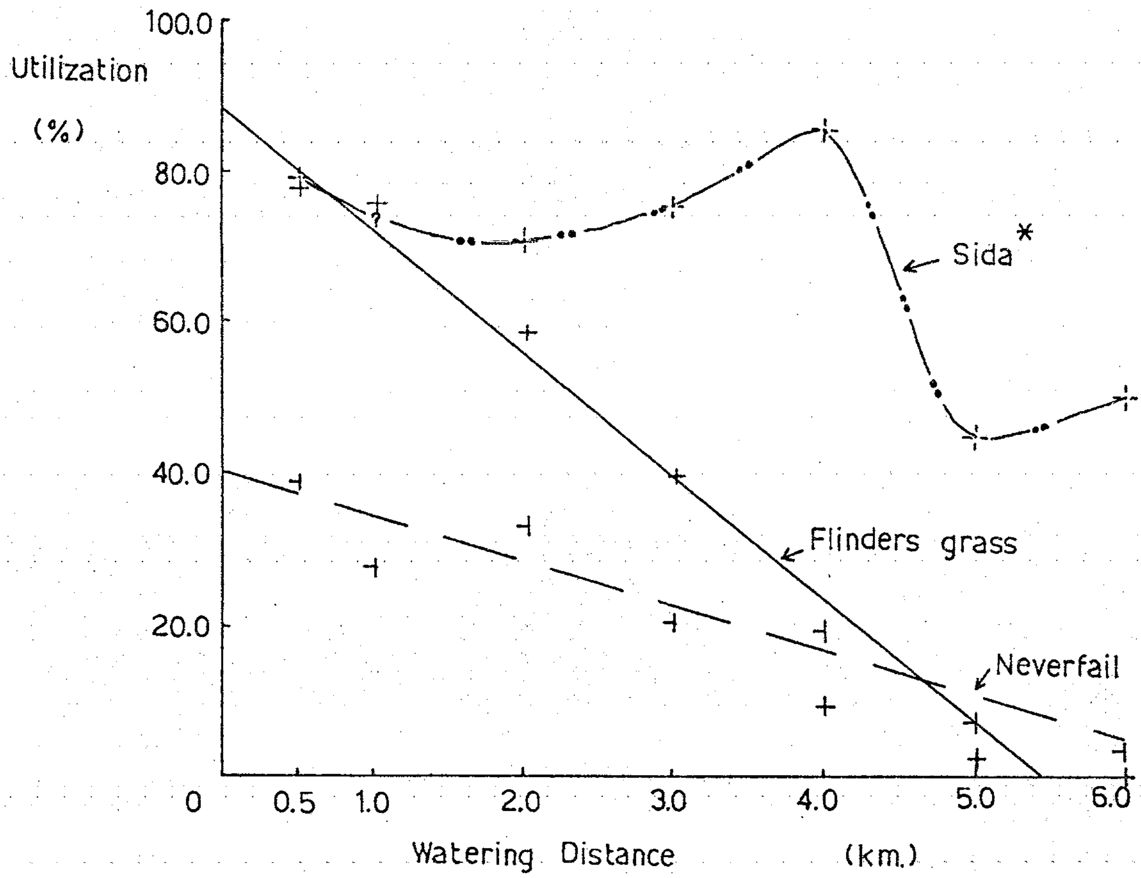
Oat grass,	$r = {}^{-}0.98$
Mitchell grass,	$r = {}^{-}0.99$
Panic grass,	$r = {}^{-}0.95$

Fig. 6.5 FORAGE UTILIZATION

LIMESTONE BORE STUDY AREA

MEAN OF TRANSECTS 1, 2, 3.

Minor species not shown



Correlation Coefficients:

Flinders grass, r= ¯0.97

Neverfail, r= ¯0.95

* where no curvilinear relationship was evident, curves were sketched by eye.

CHAPTER 7 - BRUMBY BORE OBSERVATIONS

It was expected that the pasture trends revealed at Brumby Bore would be similar to those described at Limestone Bore, since the bore appeared to be the focus of grazing activity. In essence the only change from Limestone Bore was that provided by a different pasture type, and a different set of grazing factors. It was anticipated that basal cover, pasture composition and pasture utilization would again vary according to the distance from Brumby Bore.

Basal Cover

Basal cover values recorded in the Open Woodland were significantly less than those in the Mitchell Grass plains. The indices for basal cover for the Open Woodland are given in Table 7.1. Mean basal cover for the 5 km. transect from the bore was only 1.73%, therefore, in this pasture type, the percentage of bare ground is extremely large. This is to be expected as plant communities containing wide spreading trees, generally have less basal cover than pure grassland associations in the same climatic area.

It is interesting to note in Fig. 7.1 that the minimum recordings of basal cover in the Open Woodland are not adjacent to the watering point as would be expected,but at 1, 2 km. distance from the bore. At this distance a section of Cottonbush floodplain* crosses the transect line (Plate 7.1). Basal cover values then increase in both the direction of the bore and westwards along the transect from this point.

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* pasture type recognized by Perry (1962).

TABLE 7.1 BASAL COVER (%)

BRUMBY BORE STUDY AREA

TRANSECT LINE I

Distance from Watering Point (km)	Basal Cover (%) (X)	
0.5	2.4	
1.0	0.2	$\bar{X}$ = 1.73%
2.0	1.0	
3.0	1.2	
4.0	3.0	
5.0	2.6	

Fig. 7.1 BASAL COVER

BRUMBY BORE STUDY AREA

TRANSECT LINE 1

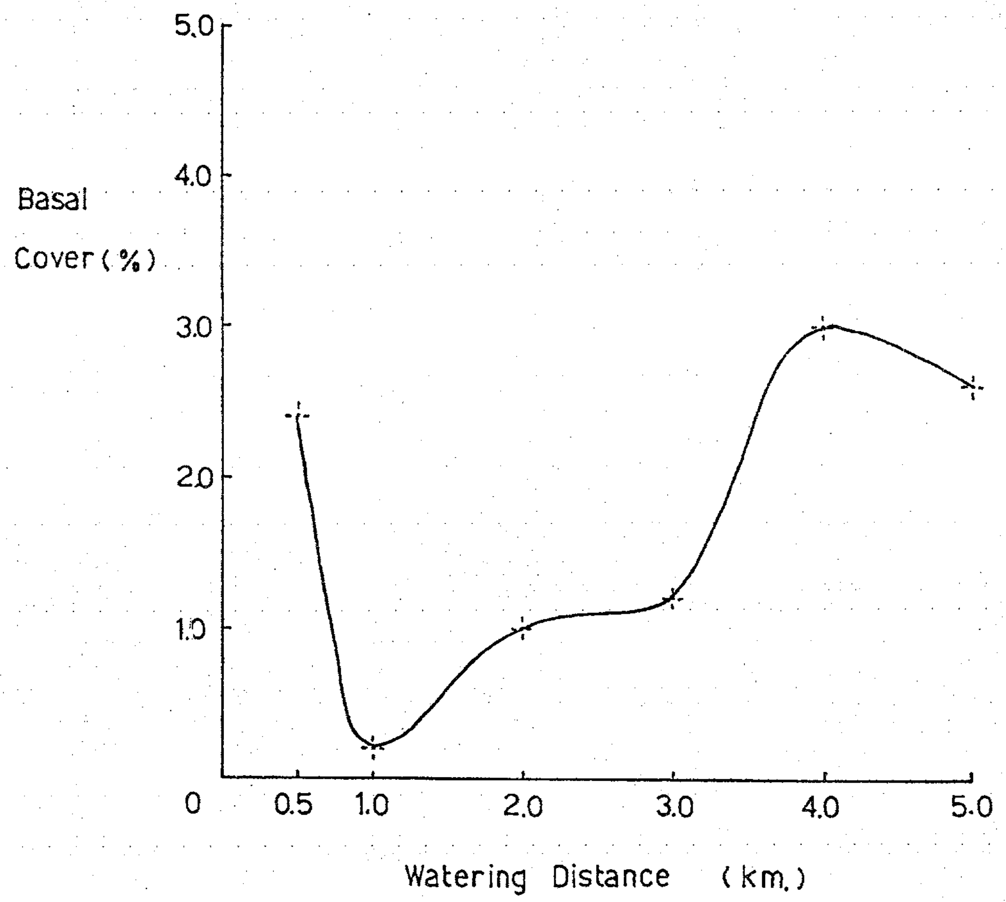


PLATE 7.1 ELEVATED VIEW OF COTTONBUSH FLOODPLAIN

Pasture Composition

The pasture composition of the Open Woodland eco-unit was distinctly different from that of the Mitchell Grass plains. Many new species were encountered. The dominant forage plants were Oat grass, Mulga grass and Eight-Day grass (*Fimbristylis sp. aff dichotoma*) (see Table 7.2).

Pasture composition appeared to vary more significantly with distance from the Cottonbush floodplain eco-unit; than it did from the bore. The watering point no longer seemed to be the control on pasture composition. The vegetation near the floodplain was much simpler in composition than either closer to the bore or further west along the transect, there being distinctly fewer species present at the Open Woodland sites in close proximity to the Cottonbush flood-plain. The presence of the floodplain appears therefore to have had an effect on the pasture composition of the adjacent areas of the Open Woodland eco-unit.

Figure 7.2 illustrates the percentage pasture composition provided by the dominant species. Although computer mapping of these results was not possible due to there being no distinct grazing intensity or watering distance relationships, some general features of these curves are worthy of note. Despite the many fluctuations in these curves, individual species showed a tendency to either increase or decrease in density in the region of the Cottonbush flood plain. Percent pasture composition of the dominant grazed species such as Oat grass Eight-Day grass and Umbrella grass (*Digitaria coenicola*) decreased whilst Mulga grass (generally ungrazed) increased. Closer to the bore and westward along the transect the grazed replace the ungrazed plants as dominants.

TABLE 7.2 PASTURE COMPOSITION (%)

BRUMBY BORE STUDY AREA

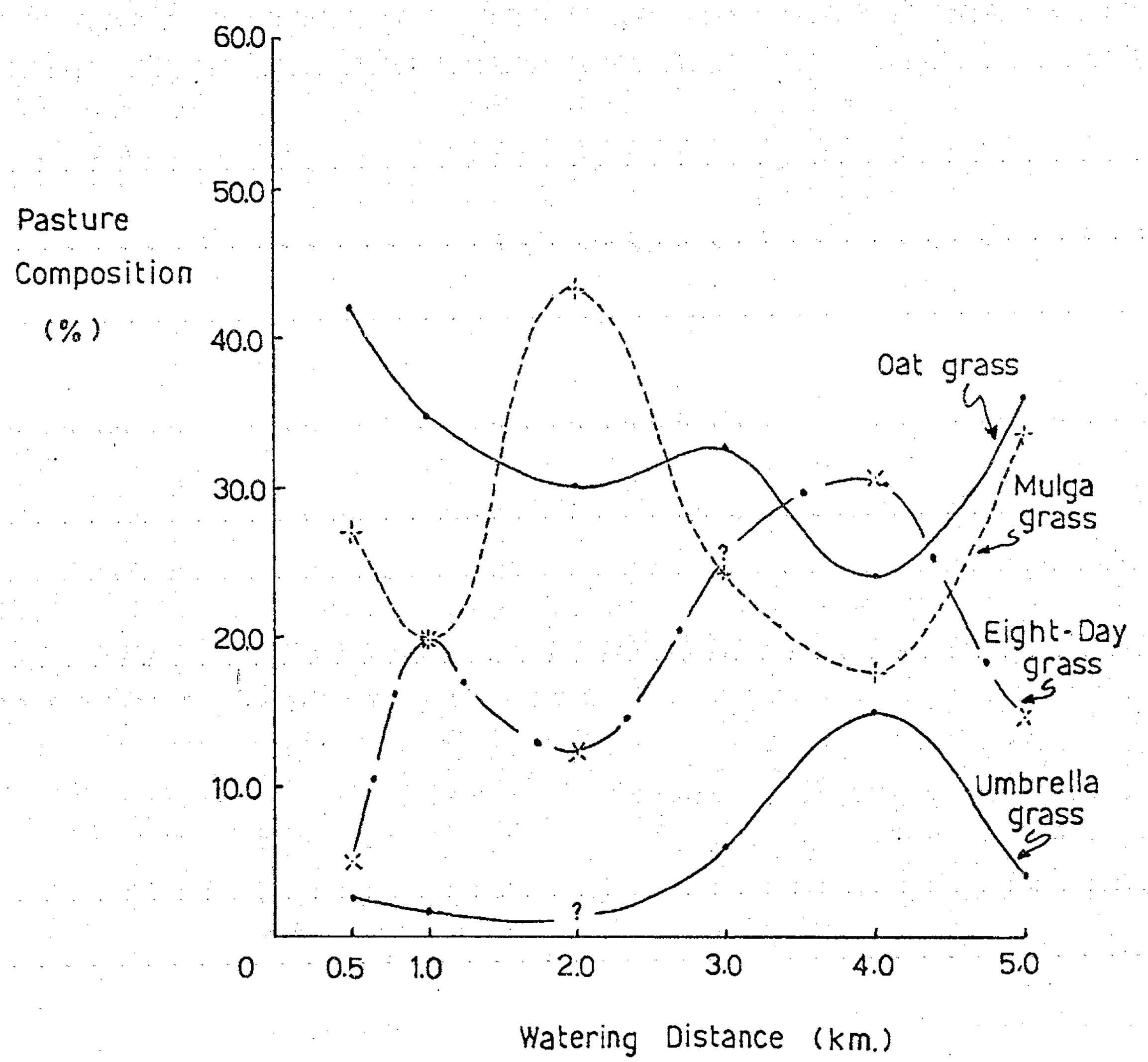
Species	Distance from Watering Point (km)					
	0.5	1.0	2.0	3.0	4.0	5.0
Oat grass (*Enneapogon avenaceus*)	42.0	34.8	30.2	32.8	23.8	36.2
Mulga grass (*Aristida contorta*)	26.8	19.8	43.4	24.2	17.2	33.6
Eight-Day grass (*Fimbristylis dichotoma*)	5.0	20.0	12.2	25.4	30.6	14.4
Umbrella grass (*Digitaria coenicola*)	2.6	1.8		5.8	15.0	3.8
Curly Windmill grass (*Enteropogon acicularis*)	1.2		0.4	0.6	1.6	1.0
Woollybutt (*Eragrostis eriopoda*)	1.6				0.2	0.2
Cotton grass (*Digitaria brownii*)	0.2	0.4		0.6	0.2	
Sida spp.	1.6	5.4	1.2	1.4	0.8	0.2
Scent grass (*Cymbopogon exaltatus*)	0.2		1.0	0.2	1.4	0.4
Helipterum charsleyae	2.4	7.2		1.6		0.2
Rough threeawn (*Aristida strigosa*)	0.2					
Kerosene grass (*Aristida browniana*)	1.0	0.4	0.2	0.2	0.4	0.2
Desert Bluegrass (*Bothriochloa ewartiana*)		0.4				
Camel weed (*Senecio magnificus*)	0.4	0.8				
Purple Plume grass (*Triraphis mollis*)	0.4		2.0			0.8
Other forbs	14.4	10.4	9.6	7.0	8.8	10.4

Fig. 7.2 PASTURE COMPOSITION

BRUMBY BORE STUDY AREA

TRANSECT LINE 1

Minor species not shown



Forage Utilization

During an early reconnaissance of the study area it became clear that many forage species were extremely heavily utilized. Despite this heavy grazing the pastures had been recently examined and were considered to be of fair to excellent condition*. Heavy grazing was reflected in the large number of equivalent fully-grazed-tufts calculated for each of the survey sites along the transect.

The total number of equivalent fully-grazed-tufts for each of the survey sites in the Open Woodland varied substantially from one site to the next. There appeared to be no direct curvilinear relationship between the number of fully-grazed-tufts and watering distance. In view of the Cottonbush floodplain being a point of high grazing intensity, it was expected that utilization of tufts might decrease uniformly away from this region. However, as it is apparent in Fig. 7.3 the total number of equivalent fully-grazed-tufts is at a minimum at 2 km. from the bore. Again, this simply reflects the extremely low plant density at this point (recall Fig. 7.1).

Ignoring the utilization estimate for the site at 2 km. from Brumby Bore, an attempt was made to impose a parabolic relationship upon the points in Fig. 7.3 (broken line), but the correlation co-efficient ($r = 0.28$) showed that there was no such relationship. There does appear to be a decrease in grazing intensity (total number of equivalent fully-grazed-tufts) with increasing watering distance beyond the floodplain, if it is assumed that plant density is relatively constant.

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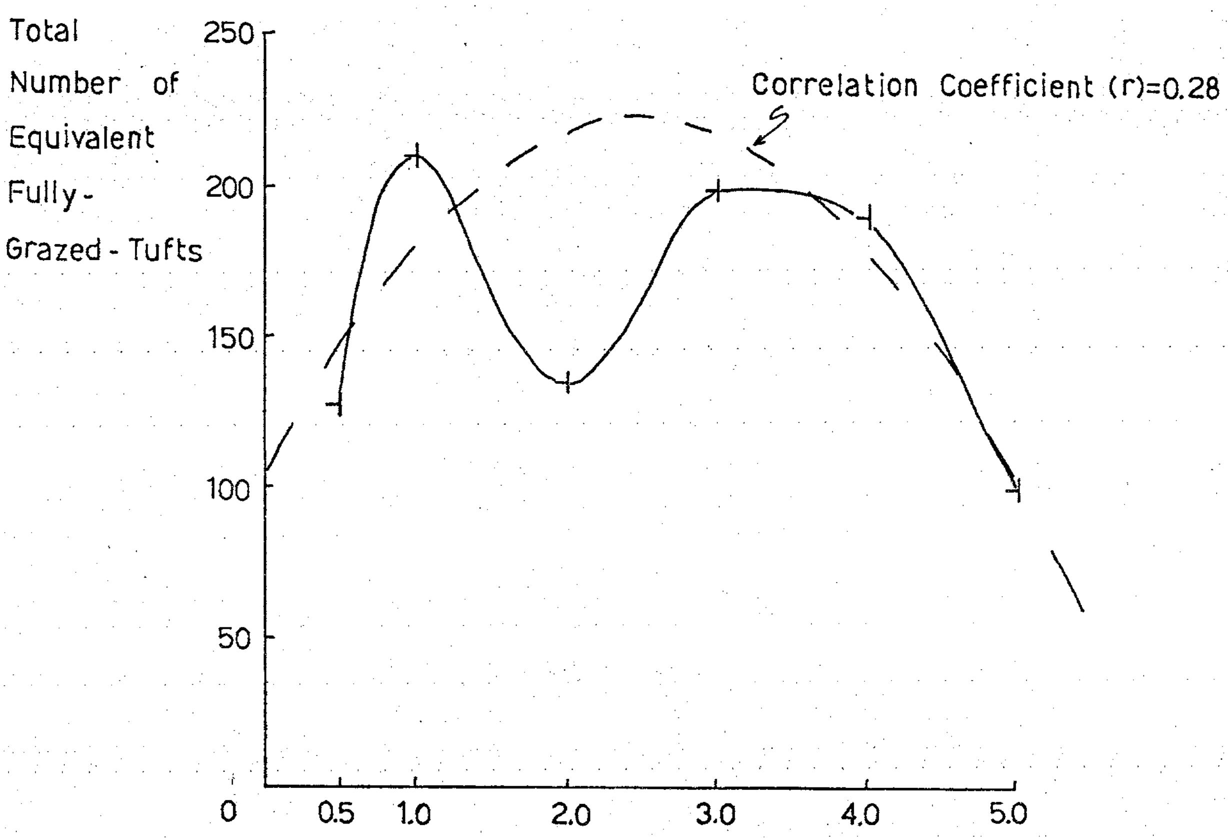
* Joint A.I. & A.B./C.S.I.R.O. Condition Assessment, August 1977.

Fig. 7.3 TOTAL EQUIVALENT FULLY - GRAZED - TUFTS

BRUMBY BORE STUDY AREA



Watering Distance (km.)

More definite relationships were found in the trend of utilization of individual pasture species in the Brumby Bore study area (Table 7.3, Fig. 7.4). Three of the major species, Umbrella grass, Oat grass and Mulga grass showed strong linear, parabolic and exponential correlations respectively.

Oat grass showed an inverted parabolic relationship between watering distance and percent utilization of forage, with its axis of symmetry centred on the Cottonbush floodplain. Curly Windmill grass in Fig. 7.5 exhibits a similar relationship. This indicates that the floodplain is a region of high grazing intensity. Such a conclusion is confirmed by the utilization trend for Mulga grass (Fig. 7.4). Maximum grazing of this unpalatable annual is highest in the region of the floodplain, and then decreases both east and west along the transect. The decrease in the utilization of Mulga grass west of the floodplain is almost a perfect exponential decline relationship.

However, it is appropriate to note at this point that if site no. 1 at 0.5 km. from the bore were judged atypical, then the relationships defining the utilization of Oat grass and Mulga grass would be a linear and an exponential-decline respectively, i.e. the bore would be the point of maximum utilization of forage species. As far as could be determined from general vegetation observation and soil sampling, site 1 was representative of true Open Woodland. Only two plant species in this pasture type, Sida and Umbrella grass show maximum utilization of forage in the immediate vicinity of the bore (see also Fig. 7.5). This type of trend was expected initially since the same relationship was generally found to exist at Limestone Bore.

TABLE 7.3 FORAGE UTILIZATION (%)

BRUMBY BORE STUDY AREA

TRANSECT LINE 1

Species	Distance from Watering Point (km)					
	0.5	1.0	2.0	3.0	4.0	5.0
Oat grass	39.8	48.2	54.7	42.1	26.4	16.0
Mulga grass	11.0	19.3	8.2	3.5	2.3	1.1
Eight-Day grass	24.0	78.1	46.9	76.9	78.3	84.9
Umbrella grass	89.2	73.3	*	73.1	45.1	37.9
Curly Windmill grass	43.3		60.0	86.7	47.5	28.0
Woollybutt	0				0	0
Cotton grass	10.0	50.0		40.0	0	
Sida spp.	85.0	85.9	63.3	85.7	35.0	0
Scent grass	80.0		62.0	10.0	17.14	0
Helipterum charselyae	37.43	0		0		0
Rough threeawn	10.0					
Kerosene grass	18.0	30.0	0	0	0	0
Desert Bluegrass		100.0				
Camel weed	0	0				
Purple Plume grass	0		0			0
Other forbs	0.6	0	0	0	0	0

* species not present

Fig. 7.4 FORAGE UTILIZATION

BRUMBY BORE STUDY AREA

TRANSECT LINE 1

Minor species not shown.

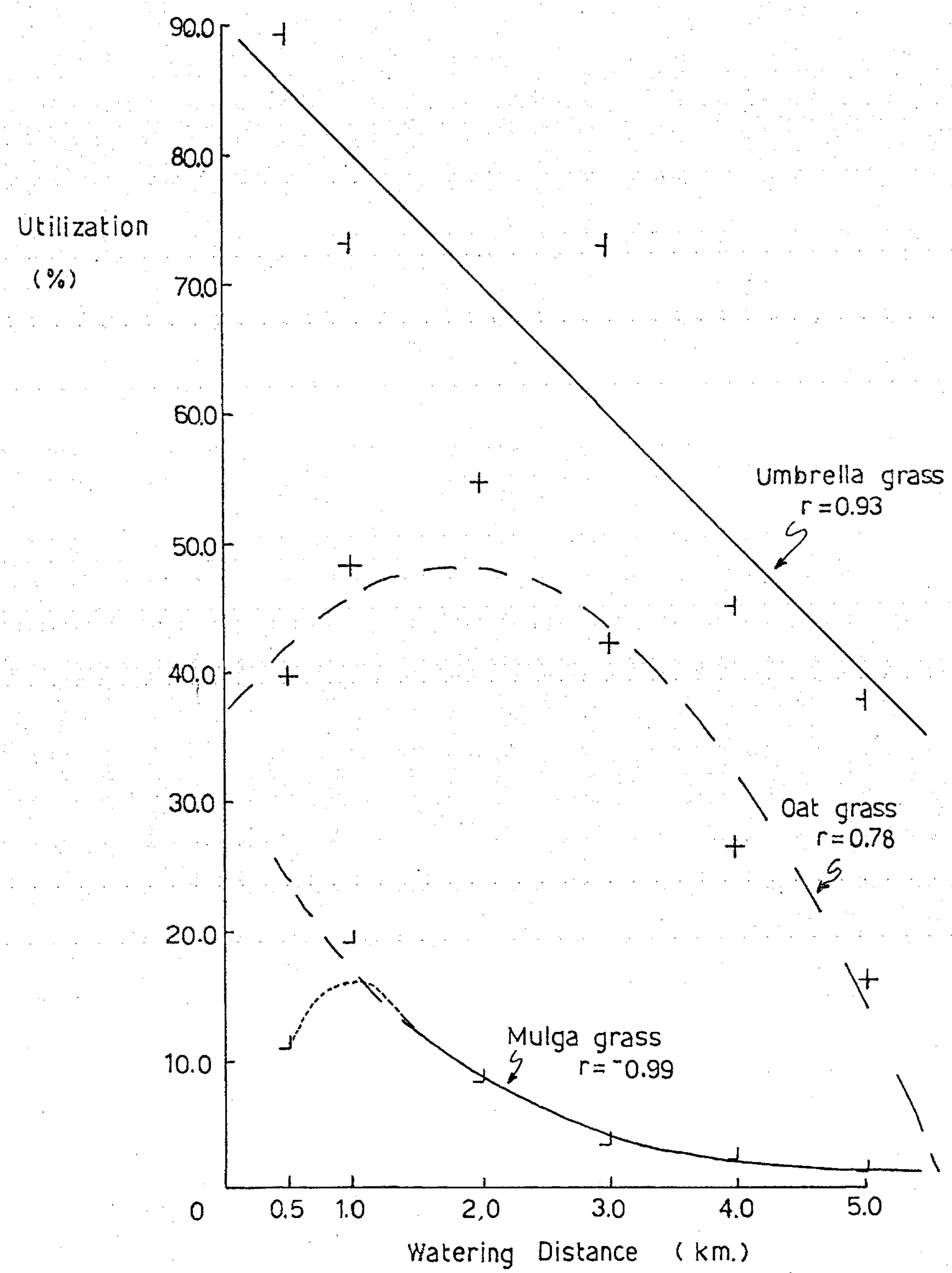
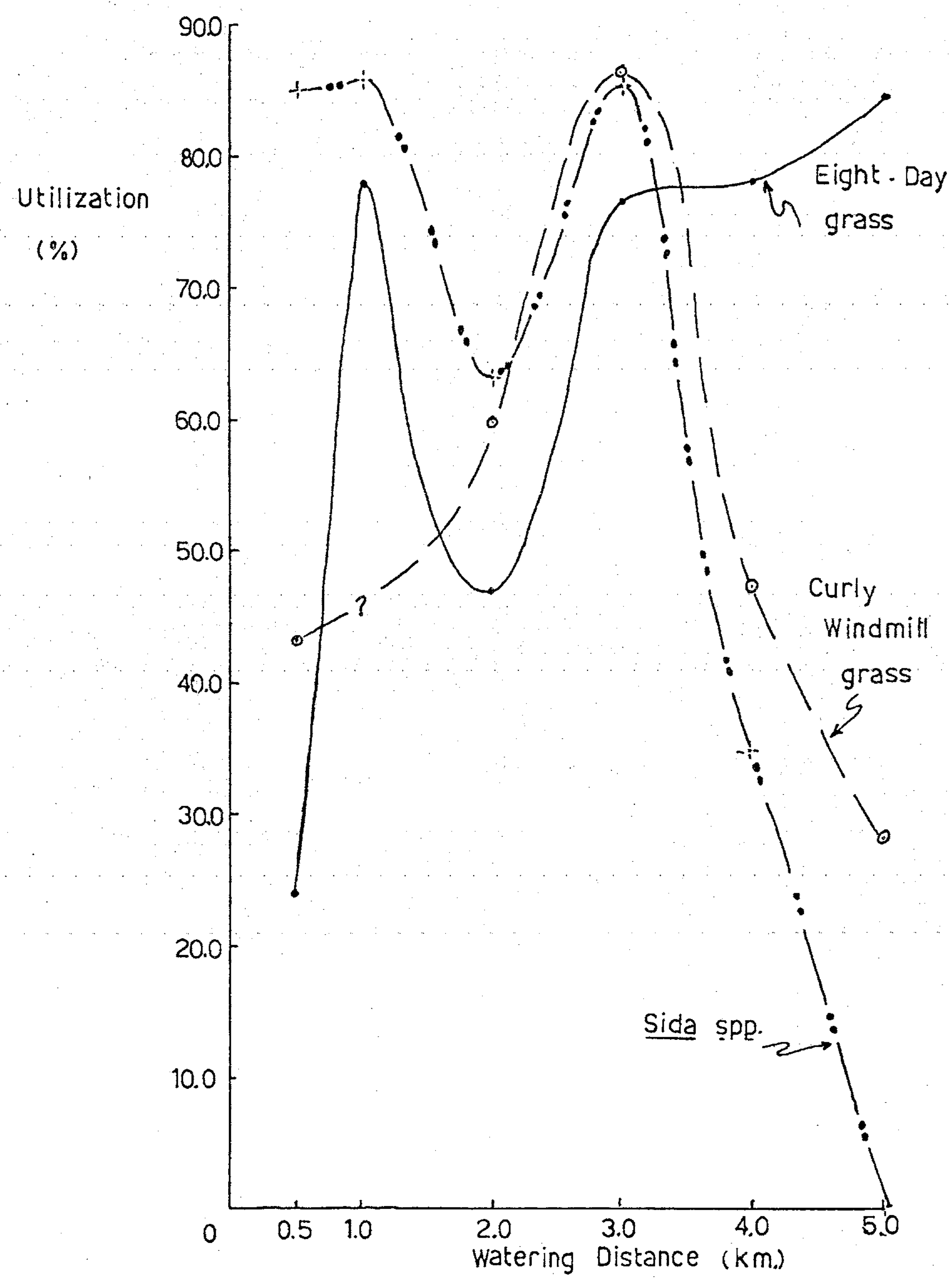


Fig. 7.5 FORAGE UTILIZATION

BRUMBY BORE STUDY AREA

TRANSECT LINE 1

Minor species not shown.



The most peculiar behaviour in the trend of utilization of Eight-day grass should be noted in Fig. 7.5. It is apparent that there is an extra factor involved in the grazing of this species, since utilization increases with increasing distance from Brumby Bore.

Also, both Sida and Eight-Day grass show rapid declines of utilization adjacent to the floodplain. This behaviour is highly unexpected and there appears to be no simple explanation for such an occurrence.

SECTION D - ANALYSIS AND DISCUSSION OF OBSERVATIONS

CHAPTER 8 - THE EFFECTS OF GRAZING

There have been significant grazing effects recorded in both the Mitchell Grass and Open Woodland eco-units examined in this study. In the case of the Mitchell Grass plains, the most obvious effects of grazing were observed in the region surrounding Limestone Bore, which was the local focus of all grazing activity. However, a most unexpected grazing trend was revealed in the Open Woodland west of Brumby Bore. The bore remained the central point of cattle movements, but a point of high grazing intensity was identified some 2 km. west of the bore, focused on a region of cottonbush floodplain.

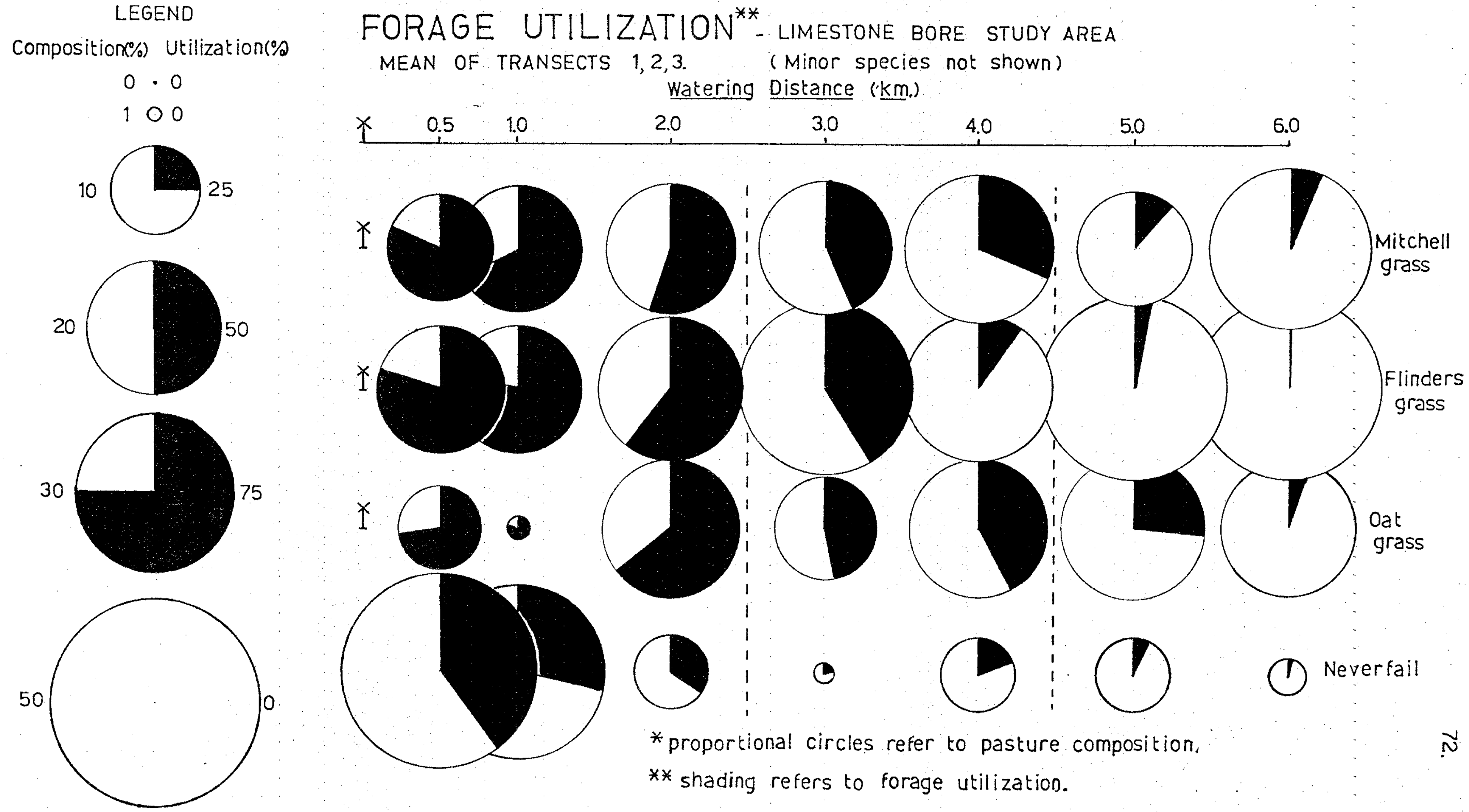
As indicated earlier by the regression of the total number of equivalent fully-grazed-tufts (Fig. 6.3) in the Mitchell Grass plains study area, the centre of maximum grazing intensity is Limestone Bore. It is realistic to use the number of fully-grazed-tufts as an indicator of grazing intensity in this case, as basal cover remained fairly constant, throughout the length of the transects.

Since basal cover is constant with distance, one might conclude, as do most pastoralists, that grazing has had no effect on the plant cover. However, what pastoralists in particular do not recognize is pasture composition change in regions of high grazing intensity. In those areas, less valuable fodder species and weedy plants are given an unfair advantage, since through grazing the vigour of preferred forage types is substantially reduced. Such a change in pasture composition is clearly seen in the region adjacent Limestone Bore, as shown in Fig. 8.1. Some species have decreased in density or percent pasture composition in close proximity to the

Fig. 8.1

PERCENT PASTURE COMPOSITION* AND PERCENT FORAGE UTILIZATION** - LIMESTONE BORE STUDY AREA

MEAN OF TRANSECTS 1, 2, 3. (Minor species not shown)



*proportional circles refer to pasture composition.

** shading refers to forage utilization.

bore, having been replaced by less frequently grazed plants. This of course assumes equal sensitivity of all species to a particular grazing event. However, it is precisely this point that most pastoralists simply overlook. They do not realize that with continuous heavy grazing the pasture is changing form, so that their stock are forced to travel further each day to find their preferred pasture species to graze.

At Limestone Bore it appears that there have been quite significant pasture composition changes to a distance of approximately 2 km. from the bore. This region may be termed the zone of "over-utilization". Throughout this zone, from the bore to the 2 km. point, the density increase of Mitchell grass is approx. 7%, Flinder's grass and Oat grass an increase of 4% and 14% respectively, whilst the density of Neverfail has decreased by 40%. Other species that were not present near the bore also occur at the 2 km. point. This represents a dramatic change in pasture composition.

Also, utilization of species in this zone remained very high. Frequently, utilization of Oat grass, Mitchell grass and Flinder's grass exceeded 75%. Since Neverfail is extremely abundant near the bore, but only lightly utilized in relation to other species present, then it is to be assumed that it is not preferred by cattle. It therefore increases in density to the detriment of more preferred pasture species such as Mitchell grass that are not so abundant and are heavily utilized by stock. It seems clear that to a distance of approx. 2 km. from the Bore there is a zone where significant pasture composition change has already occurred, and where grazing is still very intense.

It has been suggested that the abundance of Neverfail in this region is not completely a result of heavy grazing, but simply a local effect (Latz,* pers.comm.). Occasionally, pastures of predominantly Neverfail are found fringing Mitchell Grass plains that border Mulga communities. This may possibly be the case in the area surrounding Limestone Bore, however all three transects tended to show a uniform decrease in the density of Neverfail with increasing distance from the bore.

Another possibility in accounting for the density of Neverfail near the bore is that the dominance of this plant may be a reflection of the phenological characteristics of the pasture species. At some stage during or following a drought sequence, when the region around the bore was barren of all vegetation, both climatic and site conditions may have been optimal for the germination of only one species - Neverfail. Such an event would establish the dominance of Neverfail, and due to competition, it would be very difficult for other pasture species, such as Mitchell grass to become established. This possibility has been investigated, but it has been found that it does not apply in the case of Limestone Bore. Williams and Roe (1975) examined the recruitment and mortality rates of pasture species in an ungrazed Mitchell Grass community** in south-western Queensland. At no stage during the 25 years of observations (1945-1970) was there a point of recruitment of Neverfail seedlings without a similar recruitment of Mitchell grass.

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* Latz, P. - Botanist, Animal Industry and Agriculture Branch, Alice Springs.

** At similar south-western Queensland study sites, current unpublished observations of Williams confirm that there is no significant difference in recruitment and mortality rates of grazed or ungrazed Mitchell Grass communities.

A "moderately heavily grazed" zone is also apparent in Fig. 8.1 between 2 and 4 km. from the bore. In this zone there has been no significant change in pasture composition, however most species are still heavily grazed. Mitchell grass, Flinder's grass, and Oat grass are heavily utilized at the present time, and if this trend of utilization were to continue as it undoubtedly would in droughty conditions, some major shifts in pasture composition would occur. A greater percentage of Neverfail and significantly reduced Mitchell grass, Flinder's grass and Oat grass could be expected. The outer limit of this zone, at 4 km. from the bore probably represents the maximum grazing range of most of the stock watering at Limestone bore. It was noted in the field that most cows in the herd had very young calves at foot. Therefore, it is possible that the cows were unable to range further than 4 km. from the bore, since the calves could not readily travel greater distances.

Beyond 4 km. from the bore there is very little grazing effect (Fig. 8.1). Mitchell grass, Flinder's grass and Oat grass have become the dominant components of the pasture, and they are seldom utilized at this point. Neverfail has become insignificant in the pasture, and at this point remains ungrazed. This region represents the "lightly stocked or ungrazed" zone, with a pasture composition being very near the pristine condition.* This was determined by a comparison of the current estimates of pasture composition with similar Animal Industry and Agriculture Branch estimates for relict Mitchell grass sites. Although pasture composition from the Government assessments

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* Animal Industry and Ag. Branch: (4/4/77) Mitchell Grass relict site pasture composition (by dry weight) - Mitchell grass (90%), other (10%) which include Flinder's grass, Oat, *Dicanthium sericium*, Sidas, etc.

is given in terms of biomass, and the estimates for this study are frequency-based, a subjective comparison of results was possible. Only through field experience was this a viable comparison.

It is important to note that there was no apparent influence of native grazing animals in the Mitchell Grass eco-unit. Although Chippendale (1962) confirmed that kangaroos graze Neverfail, he indicated that this species was really only important in kangaroo diets during drought. Very few kangaroos were observed in this pasture type during the period of study.

One of perhaps many areas of high grazing intensity in the region of Brumby Bore was the Cottonbush floodplain eco-unit approximately 2 km. west of the bore along the transect line. The bore must remain important as a point where cattle congregate, but it appears that extremely high grazing pressure is centred on the floodplain. It is to be questioned why cattle would focus their maximum intensity of grazing around the floodplain, but it does appear that this region maintains most highly preferred, productive pastures (Lazarides, 1970). The plant species in this eco-unit are not significantly different from those of the open Woodland except for the addition of *Enneapogon polyphyllus* and Cottonbush (*Kochia aphylla*). The floodplain region is more attractive to stock generally because it receives run-on water, and thus has more moisture available for plant growth than is contributed directly from rainfall. Since many cattle graze in the region of the floodplain it is reasonable to expect that the adjacent areas of Open Woodland would also be heavily grazed.

Those species which were frequently heavily grazed such as

Oat grass and Umbrella grass showed a distinct decrease in density at the Woodland sites adjacent the floodplain (see Fig. 8.2). It seems that these species have been over-utilized in this region to the advantage of less palatable pasture components such as Mulga grass. There is a dramatic increase in the density of Mulga grass at this point, and it is possible that this species has replaced those which are more preferred by cattle. This of course is only one explanation for such changes in pasture composition but it does seem the most feasible since in choosing survey sites, considerable care was taken to eliminate some of the other causal factors such as soil changes (Appendix VI) and micro-climatic phenomena.

Also, it is at this 2 km. distance from the bore that the maximum values of forage utilization were recorded. Even Mulga grass, despite its unpalatability is extremely heavily utilized.

Reflecting on Figs. 7.4 and 7.5, some pasture species of the Woodland were heavily grazed between the bore and the floodplain eco-unit. Those species which were heavily utilized in this respect included Umbrella grass and Sida. It is possible that these species were highly selected by cattle whilst travelling between the floodplain and the bore.

Further west along the transect, beyond the merging floodplain and with increasing distance from Brumby Bore, the density of those plants which were frequently heavily utilized (i.e. preferred) increased. At this point it was estimated that pasture composition was approaching that of the pristine state.* This was to be expected

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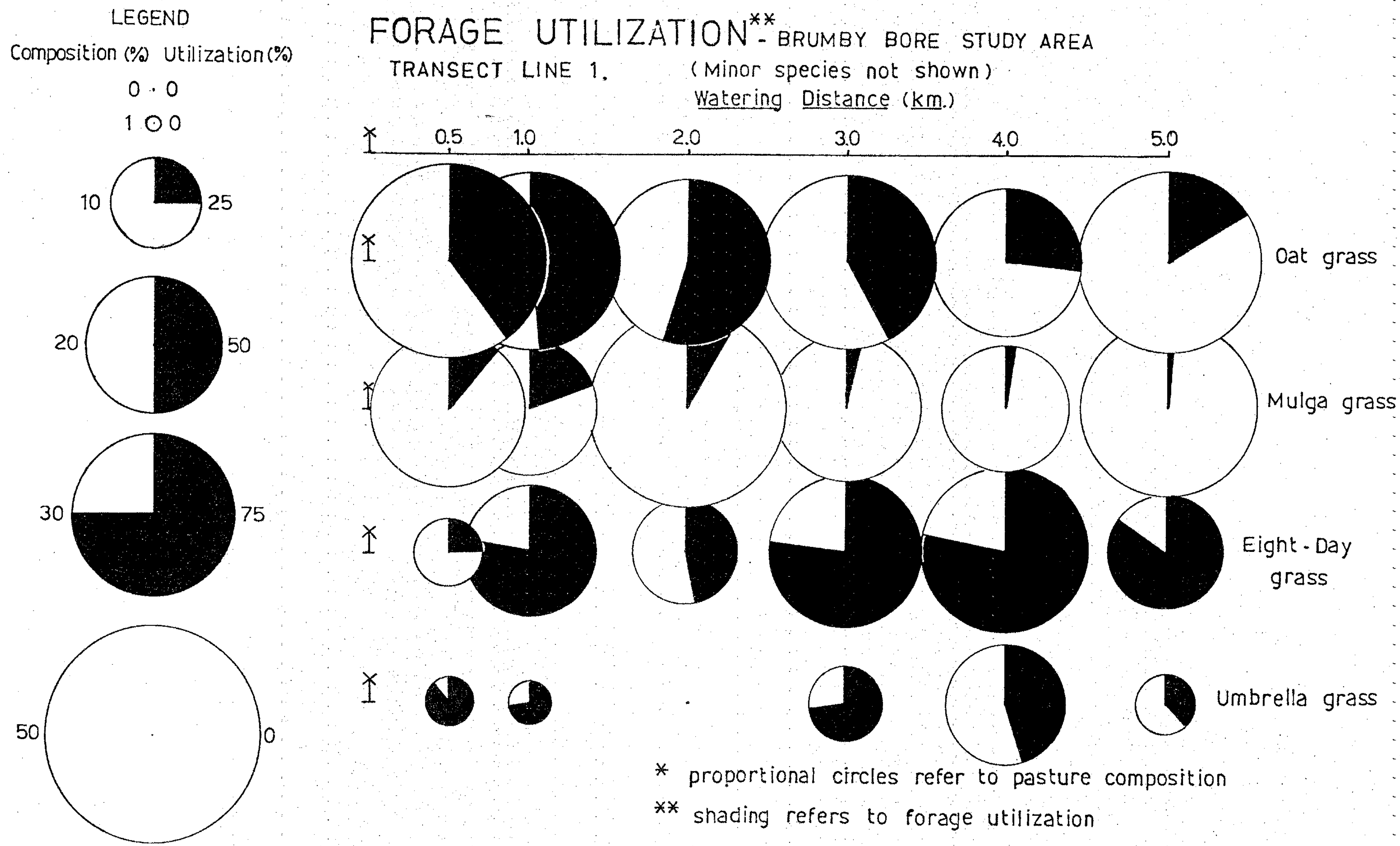
* Animal Industry and Ag. Branch: (4/4/77). Open Woodland relict site pasture composition (by dry-weight): *Enneapogon* spp. (45%), Umbrella grass (30%), Mulga grass (10%), other perennial grasses (5%), other grasses (5%), forbs (5%).

Fig.8.2

PERCENT PASTURE COMPOSITION* AND PERCENT FORAGE UTILIZATION** - BRUMBY BORE STUDY AREA

TRANSECT LINE 1. (Minor species not shown)



* proportional circles refer to pasture composition

** shading refers to forage utilization

as grazing pressure and utilization of species at this distance was significantly less than closer to the floodplain or the bore. At 5 km. from Brumby Bore, less than 20% of available Oat grass and less than 40% of Umbrella grass was utilized.

However, a particular species, Eight-Day grass (in fact a sedge) showed a reversal of the trend of decreasing utilization with greater watering distance. As distance from the bore increased, the percent utilization of Eight-Day grass also increased. This appears to contradict the idea of a negative slope stocking gradient with increasing distance from a watering point, and suggests therefore, another grazing factor involved in the utilization of this species.

Not present in the Limestone Bore study, but readily recognized in the Open Woodland eco-unit were native grazing animals (Plate 8.1). Low *et al.* (1973) examined the stomach contents of red kangaroos grazing Mulga communities in Kunoth Paddock, Hamilton Downs Stn. It was discovered that throughout the year, the dominant grasses eaten by kangaroos were *Enneapogon avenaceus* (Oat grass) - *E. polyphyllus* and that following rain Eight-Day grass was also highly selected. In view of the above evidence it is reasonable to assume that the trend of increasing utilization of Eight-Day grass with increasing distance from Brumby Bore is not due to its grazing by cattle, but by kangaroos. Since kangaroos are more mobile than cattle, they are rarely dependant on a single watering point; in fact, kangaroos obtain most of their moisture from the herbage they consume (Newsome, 1965). It should also be recognized that the intense grazing apparent in the region of the floodplain and adjacent areas, could probably be due to kangaroo grazing. It is even possible that kangaroos may be responsible for the greater percentage of forage

PLATE 8.1 KANGAROOS IN OPEN WOODLAND NEAR BRUMBY BORE

Kangaroos indicated by arrows.

utilization in the Brumby Bore area. The abundance of kangaroo faeces in this region tended to confirm this observation.

CHAPTER 9 - UTILIZATION OF PASTURE: CONTRIBUTION OF SPECIES TO TOTAL FORAGE REMOVAL

Whilst determining the key or valuable forage species in the Mitchell Grass plains and Open Woodland, it was necessary to understand the importance or contribution of each species to total forage grazed. Estimates of cattle preferences could not be derived directly by determining species use values, since no consideration is given therein to pasture composition. A species that constitutes 50% of forage removed and only forms 5% of the pasture has a higher preference value than another species being similarly utilized but forming 90% of the same pasture.

Therefore, in determining cattle preferences for particular pasture species, the initial step taken was to examine the relative use of each species in relation to total use of forage. The index of "relative use" or contribution of each species to total forage removed was described in Chapter 5.

Limestone Bore Study Area

The estimates of relative use of pasture species with increasing distance from Limestone Bore are given in Table 9.1, and illustrated in Fig. 9.1. The stocking gradient in this case is distinct, showing an almost constant decline in the utilization of pasture as watering distance increases.

Within 2 km. of the bore, Flinder's grass, Mitchell grass, Oat grass and Neverfail all contribute significantly to cattle diet, however as utilization further decreases with distance, other species

TABLE 9.1 RELATIVE USE OF PASTURE SPECIES* (%)

LIMESTONE BORE STUDY AREA

Species	Distance from Watering Point (km)						
	0.5	1.0	2.0	3.0	4.0	5.0	6.0
Mitchell grass	21.7	37.0	20.8	20.1	31.7	15.9	25.3
Flinder's grass	31.6	33.4	34.8	37.1	9.1	10.1	1.9
Oat grass	20.5	** 3.2	37.2	29.0	36.1	58.1	20.8
Neverfail	46.1	32.9	4.6	1.0	3.0	5.0	1.1
Sida spp.	6.0	1.1	2.3	8.0	10.5	5.8	50.6
Panic grass	0.9	7.7	2.6	8.4	4.0	3.9	0.4

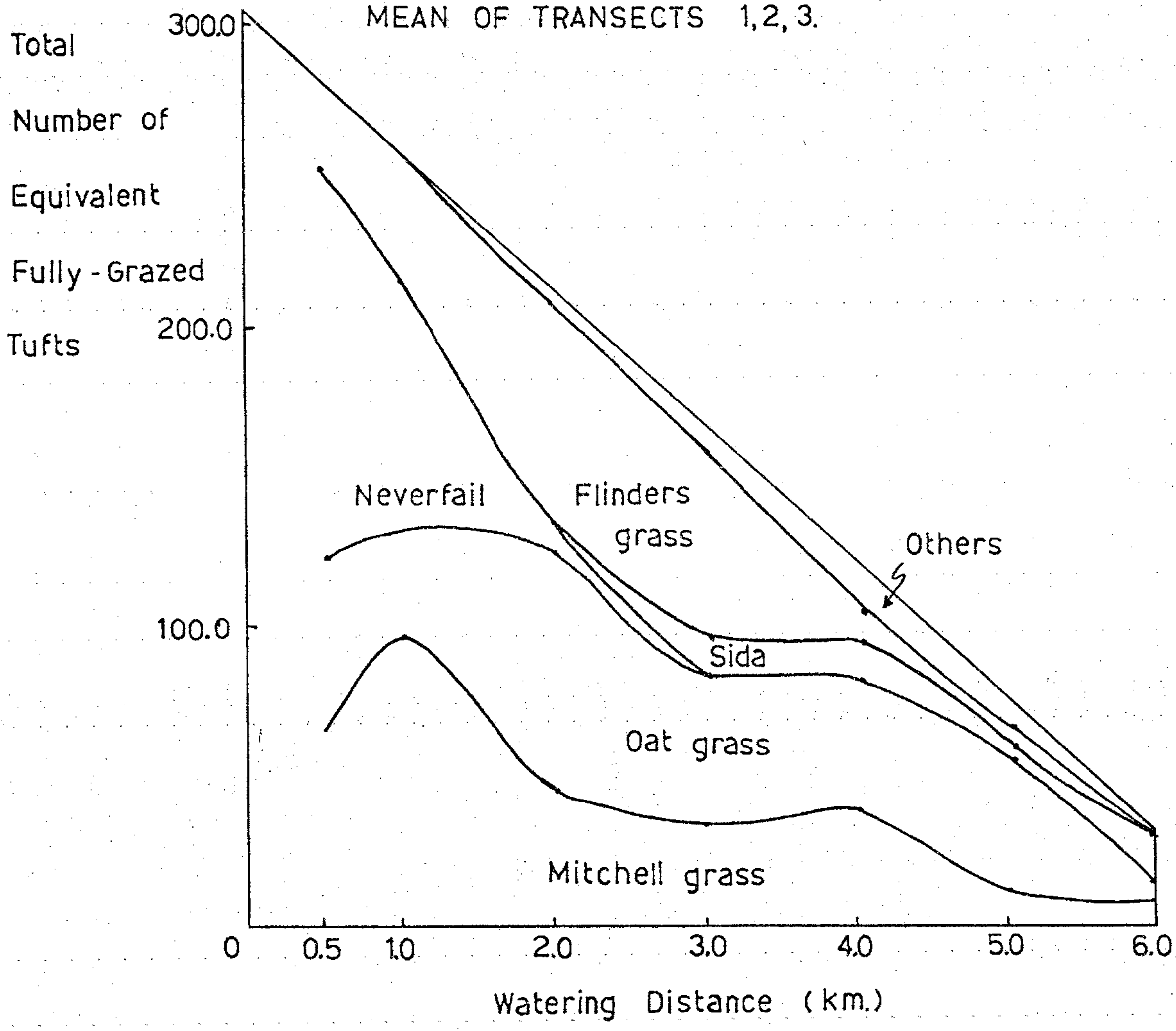
* Columns do not sum to 100% since each estimate is the mean of Relative Use of pasture species for transect lines 1, 2, 3; at each successive distance from the watering point.

** estimate considered unrepresentative.

Fig.9.1 RELATIVE USE* OF PASTURE SPECIES - assuming uniform tuft weight.

LIMESTONE BORE STUDY AREA

MEAN OF TRANSECTS 1, 2, 3.



* represents the contribution of each species to total forage removed

such as Sida, having not been present in sufficient quantity near the bore to contribute substantially to total forage removed.

As watering distance further increases, cattle begin to select a smaller range of species. At 6 km. from Limestone Bore, Mitchell grass, Sida and Oat grass together contribute 96% of grazed forage. This implies that at this distance from the water, when there is a broad range of forage plants present (ref. Chapter 6) stock are only selecting those species which seem highly preferred.

Observations from the present study are confirmed by recent unpublished results of Squires*, which are concerned with the major dietary components of cattle grazing various pasture types in central Australia. Species contribution to cattle diet was in this case determined using animal-based methods of study. Certain animals were oesophageally fistulated and allowed to graze the different pasture types. In the Mitchell Grass plains, Squires discovered that Mitchell grass, Neverfail, and Flinder's grass were the major dietary components of cattle from June to September of this year.

<u>Brumby Bore Study Area</u>

Utilization of forage at Brumby Bore in the Open Woodland eco-unit is shown in Fig. 9.2. The corresponding relative use values are given in Table 9.2.

Oat grass and Eight-Day grass were by far the most important contributions to total forage consumed by grazing animals. Once again, Squires results (unpublished) confirm the observation that *Enneapogon spp*. and Eight-Day grass are the major dietary components of cattle

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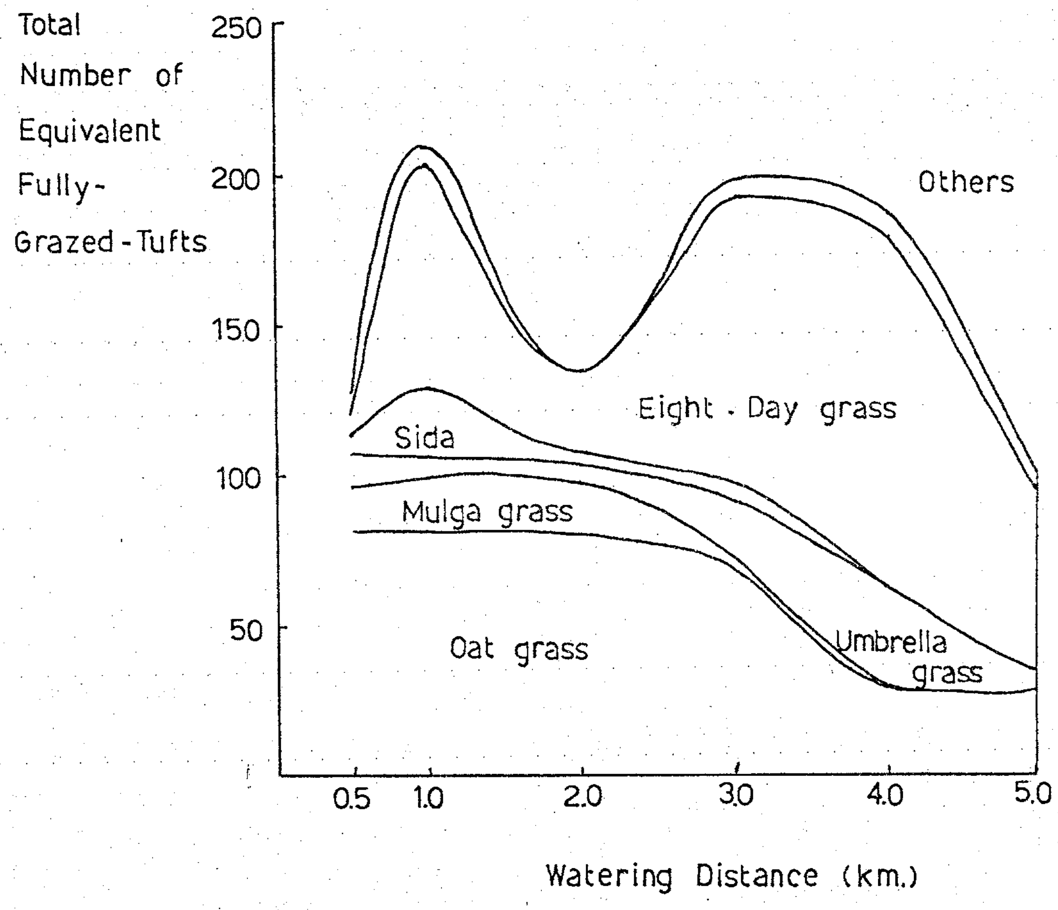
* Squires, V.R., C.S.I.R.O. Division of Land Resources Management, Alice Springs.

Fig.9.2 RELATIVE USE* OF PASTURE SPECIES - assuming uniform tuft weight.

BRUMBY BORE STUDY AREA



* represents the contribution of each species to total forage removed

TABLE 9.2 RELATIVE USE OF PASTURE SPECIES (%)

BRUMBY BORE STUDY AREA

TRANSECT LINE 1

Species	Distance from Watering Point (km)					
	0.5	1.0	2.0	3.0	4.0	5.0
Oat grass	64.4	39.1	60.3	34.2	16.2	28.9
Mulga grass	11.3	8.9	12.9	2.1	1.0	1.8
Eight-Day grass	4.6	36.4	20.9	48.3	61.9	60.7
Umbrella grass	9.0	3.1		10.5	17.5	7.2
Curley Windmill grass	2.0	*	0.9	1.3	2.0	1.4
Kerosene grass	0.7	0.3	0.0	0.0	0.0	0.0
Cotton grass	0.1	0.5		0.6	0.0	
Sida spp.	5.3	10.8	2.8	3.0	0.7	0.0
Others	2.6	0.9	2.2	0.0	0.7	0.0

* species not present.

foraging in Woodland communities. Some species such as Sida were locally important contributors to cattle diet. In regions of intense grazing, such as between the floodplain and the bore, less palatable species such as Mulga grass were grazed.

Clearly if cattle do not utilize Eight-Day grass to any great degree, as indicated by Low, *et al.* (1973), then it is more than likely that kangaroos are the most important grazing animals in this pasture type. This possibility is reinforced by the knowledge that kangaroos also display a high grazing preference for *Enneapogon spp.*

CHAPTER 10 - DETERMINATION OF VALUABLE FORAGE SPECIES

One of the most important aids to range management is knowing just what are the valuable forage species in the most important pasture types, since these pastures carry the bulk of cattle. It should be the aim of management to preserve and maintain those species which are highly valuable to stock.

The last and most important aspect of this investigation was the use of utilization estimates to help identify the valuable forage species in the two important pasture types considered in this study.

An initial consideration of course must be the definition of what is a "valuable forage species". For the purpose of this study, valuable forage species are those which are highly preferred by cattle. It has been suggested by those outside the field of range management that cattle may not display "nutritional wisdom" in their diet selection; that those plants which are heavily selected are not the most nutritionally productive. This claim may well be correct, but it is not taken up in this study.

Stoddart, Smith and Box (1975) describe the possibility of a feedback mechanism that operates to guide animals to the most nutritious plants. However, there is reason to doubt that nutritional selection takes place since some animals reject plants which are as equally nutritious as other plants which are taken. Arnold and Hill (1972) state that "new methods need to be developed to elucidate the role (if any) of 'nutritional wisdom' as it applies to ruminants both in pen and in grazed situations". In a range situation where cattle are presented with a wide choice of plants, the most valuable forage species must be those which are directly preferred by stock. Perhaps cattle in such circumstances do not select the most nutritious species, but since it is not possible to control their forage selection, as in relatively mono-specied improved pasture lands, then it is logical to assume that the most preferred plants are also the most valuable. The valuable or preferred pasture species are defined in this study using the simple preference rating described in Chapter 5.

Applying the estimates of relative use of species, and percent pasture composition to the preference rating equation, a listing of cattle forage preferences was constructed for each site in both the Mitchell Grass plains and Open Woodland. Tabulations of the preferred species (i.e. P.R. > 1) for both eco-units are given in Table 10.1 and 10.2.

There appears to be a broad range of preferred species shown in Table 10.1. Nearly every species present in this list at some stage along the three transects from Limestone Bore has a preference rating of greater than 1. It appears therefore that the definition of a valuable species as having preference rating of greater than 1 is insufficient. There is a need to eliminate from the list of preferred forage plants, those species which formed only a minor part of the total forage consumed.

Those species which are highly preferred but only occur in small quantities in the range (and hence in the diet of stock) are known as "ice-cream" species (Stoddart, Smith and Box, 1975). They are not important, long-term forage plants, and so they are not to be regarded as a valuable source of fodder.

TABLE 10.1

VALUABLE FORAGE SPECIES

LIMESTONE BORE STUDY AREA

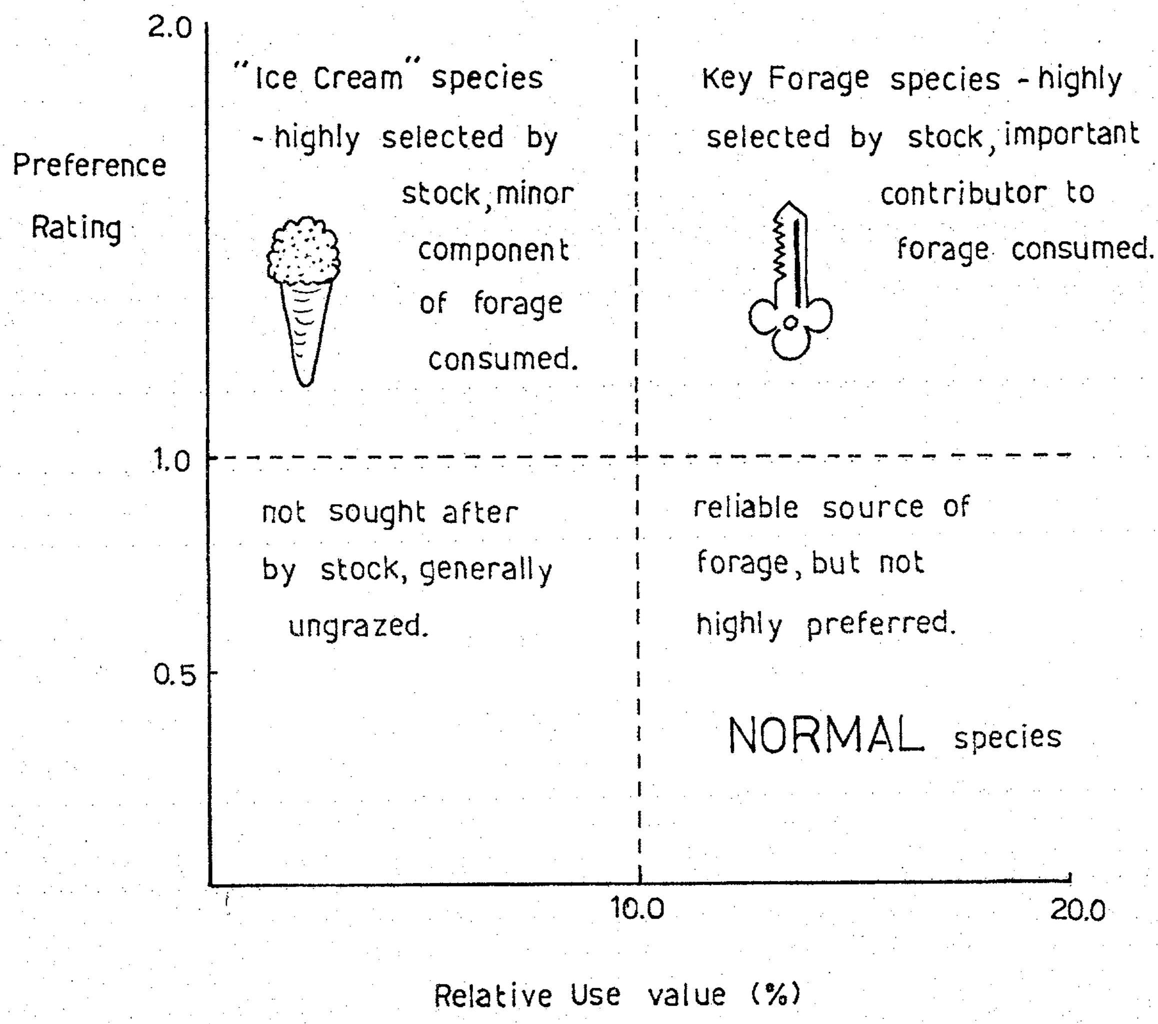
Distance from Watering Point (km.)	Preferred Species (P.R. > 1)			Preferred Species (P.R. > 1, R.U. > 10%)	Preferred Species (P.R. > 1, R.U. > 10%) at 3,4 km. watering distance.
	Transect line 1	Transect line 2	Transect line 3		
0.5	Flinders grass Mitchell grass Panic grass	Kangaroo grass Panic grass Queensland Bluegrass Mitchell grass Couch grass Flinders grass	Flinders grass Mitchell grass Oat grass Sida Panic grass	Flinders grass Mitchell grass Oat grass Sida	
1.0	Flinders grass Mitchell grass Panic grass	Couch grass Flinders grass Mitchell grass Panic grass	Oat grass Flinders grass Panic grass Kangaroo grass Mitchell grass	Flinders grass Panic grass Mitchell grass	
2.0	Oat grass Panic grass	Mitchell grass Flinders grass	Sida Flinders grass Oat grass	Flinders grass Oat grass Mitchell grass	
3.0	Mitchell grass Neverfail Oat grass Sida	Sida Mitchell grass Flinders grass	Sida Oat grass	Mitchell grass Flinders grass Oat grass	Mitchell grass Flinders grass Oat grass
4.0	Sida Oat grass Kangaroo grass Queensland Bluegrass Mitchell grass Panic grass	Sida Oat grass Panic grass Mitchell grass	Sida Oat grass Mitchell grass Panic grass	Oat grass Mitchell grass Sida	Oat grass Mitchell grass Sida
5.0	Sida Oat grass Mitchell grass Neverfail		Sida Oat grass Panic grass Mitchell grass	Oat grass Mitchell grass Flinders grass	
6.0	Sida			Sida	

In the Mitchell Grass community, Sida could be classified as an ice-cream plant. At no stage did it form more than 5% of the pasture, and yet it was always heavily grazed. Using a similar preference rating, as applied to animal-based methods of study, Squires (unpublished) found that Sida, although only a minor component of cattle diet, was a highly preferred pasture species at the time of study. It is probable that Sida was only grazed significantly from June to September of this year because, at that time, it was the only pasture species that had any appearance of succulence. All other pasture species had become very dry and fibrous. Chippendale (1968) confirms this observation. He noted that during prolonged dry spells, stock grazed more perennial herbs such as Sida. Also, Newman (1973) has shown that Sida, particularly in winter, has a high crude protein value and a large phosphorous content, which would render it particularly attractive to stock, even if it is only selected for its succulence. Sida is therefore only important under certain seasonal conditions, and it is not a major contributor to, or important long-term source of forage.

For this particular study, a valuable or key forage species has been judged as one which must have not only a preference rating of greater than 1, but also a relative use value of equal to or greater than 10% (see Fig. 10.1). The preferred species list was thereby somewhat reduced, and is shown in the second last column of Table 10.1.

Even this list however was still insufficient to determine the valuable forage species. It was shown earlier (Chapter 6) that pasture composition varied significantly with distance from Limestone

Fig. 10.1 VALUE CLASSIFICATION OF PASTURE SPECIES



Bore. Since pasture composition is one factor involved in determining preferences, and that it varied with distance from the bore, it was decided that in the final determination of valuable forage species, distance from water should be held constant. Should no allowance be made for the stocking gradient, changes in the list of key forage species at different distances from water might simply be a reflection of the sensitivity of a species to grazing use.

For the Mitchell Grass plains around Limestone Bore, the distances chosen for identification of the valuable forage species were 3 and 4 km. from the bore, namely, the zone of "moderately heavy grazing". The valuable forage species at the 3 km. distance from water had been identified as Mitchell grass, Flinder's grass, and Oat grass. At 4 km. from Limestone Bore the valuable species had been recognized as Oat grass, Mitchell grass, and Sida. Since Sida has only a short-lived, seasonal importance and Flinder's grass is an annual, the perennials Mitchell grass and Oat grass may be seen to be the most valuable forage species in this pasture type.

In a similar vein, the results of the analysis of preference for pasture species in the Open Woodland eco-unit at Brumby Bore are shown in Table 10.2. Quite an extensive list of preferred pasture species at various distances from water could be prepared, and these are presented in column 1. Once again, many ice-cream plants such as Sida were included in the list, and so again the limiting value of relative use (R.U. $\geq$ 10%) was imposed. The valuable forage species could thus be identified.

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* Oat grass may behave as an annual, biennial or perennial, depending on rainfall.

TABLE 10.2 VALUABLE FORAGE SPECIES - BRUMBY BORE STUDY AREA

Distance from Watering Point (km.)	I Preferred Species (P.R. > 1)	II Preferred Species (P.R. > 1, R.U. > 10%)	III Preferred Species (P.R. > 1, R.U. ≥ 10%, at 3 km. watering distance)
0.5	Umbrella grass Sida Scent grass Curly Windmill grass Oat grass _Helipterum charsleyae_	Oat grass	
1.0	Desert Bluegrass Sida Eight-Day grass Umbrella grass Cotton grass Oat grass	Sida Eight-Day grass Oat grass	
2.0	Sida Scent grass Curly Windmill grass Oat grass Eight-Day grass	Oat grass Eight-Day grass	
3.0	Curly Windmill grass Sida Eight-Day grass Umbrella grass Oat grass	Eight-Day grass Umbrella grass Oat grass	Eight-Day grass Umbrella grass Oat grass
4.0	Eight-Day grass Curly Windmill grass Umbrella grass	Eight-Day grass Umbrella grass	
5.0	Eight-Day grass Umbrella grass Curly Windmill grass	Eight-Day grass	

The stocking gradient in this case also influenced pasture composition since pasture species were sensitive to grazing, and so grazing intensity once again was held constant. This was achieved by identifying the valuable forage species at 1 km. from the floodplain region of high grazing intensity, i.e. 3 km. from Brumby Bore. The preferred species thus selected included Eight-Day grass, Umbrella grass, and Oat grass (Table 10.2, Column III). Since Eight-Day grass is generally grazed by only kangaroos, and also has a very short growing period after rain, as suggested by its common name, Umbrella grass and Oat grass were identified as the most valuable forage species in the Open Woodland eco-unit.

In summary, the most valuable forage species of the Mitchell grass eco-unit were identified as Oat grass and Mitchell grass, and those of the Open Woodland were recognized as Umbrella grass and once again Oat grass.

SECTION E - CHAPTER 11 - CONCLUSIONS

Stocking gradients of grazing intensity have been shown to exist in both the Mitchell Grass and Open Woodland eco-units considered in this study. This confirms the earlier findings of Valentine (1949) and Barker and Lange (1969), which revealed that grazing intensity in range country decreases with increasing distance from watering points. In the Mitchell Grass plains, the focus of grazing activity and point of maximum grazing intensity was Limestone Bore. This study revealed almost "text-book" results where constant stocking gradients were recorded extending radially away from the bore.

In the Open Woodland eco-unit at Brumby Bore, the effect of the bore as the point of grazing intensity was somewhat negated by the influence of a heavily grazed Cottonbush floodplain running across the sample transect. This interference produced many variations, which were quite difficult to account for and explain. Also, relationships were not clear since only a single line transect was sampled. In reality this situation is definitely the most common, for very seldom in range work are field workers confronted with such a "controlled" environment as provided by Limestone Bore.

Significant effects of grazing were recorded in both pasture types. The effects are mainly reflected in changes of pasture composition from valuable pasture species to less valuable or weedy plants. This occurred within the first 2 km. of the respective areas of high grazing intensity. Utilization of pasture species, which provided the measure of grazing intensity, decreased significantly with increasing watering distance in both pasture types. Some species were continually more heavily utilized than others, and with some manipulations this provided a means of identifying the valuable forage species in these pasture types. The most valuable pasture species in the Mitchell Grass plains were identified as Mitchell grass, and Oat grass. In the Open Woodland, Oat grass was again recognized as a valuable forage species, and also Umbrella grass.

Using animal-based methods of study, as against plant-based methods, Squires (unpublished) has very recently confirmed the estimates of Relative Use of pasture species, and cattle species preferences derived in this present study.

At quite an early stage it was sensed that conclusions from this work might have restricted application because of the study limitations involved. It is the opinion of the author that the results presented in this report are directly related to the specific physiographic, seasonal and grazing factors operative at the time of data collection. With a different season or different type of stock or even breed of stock, it seems improbable that these results would be duplicated. It is therefore difficult to make conclusions of indisputable value to range managers.

However, the identification of the valuable forage species in the Woodland and Mitchell Grass eco-units should be of help to those involved directly in range management. Some insight has also been provided on the effects of grazing and utilization of pasture at different distances from watering points. Such information indicating the graduated use of forage about a watering point is of direct value to Government Officers in the defining of safe stocking rates for the district properties.

If constantcy of the seasonal and grazing factors were assumed, advising a higher density of watering points would be a valid extension of this study. Since watering points are presently located at approximately 10 km. intervals, and pasture is only effectively utilized to a 4 km. radius of the bores, a higher density of watering points would allow a more uniform utilization of range forage. To minimize the stress on pastures in this situation, rotational access to waters could be practiced. However, due to the high installation costs of bores, and the seasonal limitations of this study, a higher density of watering points may not be feasible.

Maintaining the assumption of constant seasonal and grazing conditions, it is possible to estimate a safe stocking intensity for the Mitchell Grass plains around Limestone Bore. Since there appears to be little grazing effect on pastures at the 3 and 4 km. distances from the bore (Fig. 6.2), then a grazing intensity of 150 equivalent fully-grazed-tufts per 500 point sample should not cause significant future changes in pasture composition. However, attention must once again be directed to the seasonal nature of this study. Such a suggested stocking rate can only apply under similar grazing and seasonal factors.

Further Work

Since the seasonal limitations of this work are very important, the study procedure could be conducted in the same areas during a different season. This would provide valuable comparative information relating to Mitchell Grass range utilization. If repreated periodically, the study would determine the trend of pasture utilization.

An aspect of range research of vital importance to all concerned with proper pasture utilization is the determination of the productivity of the most common preferred forage species in central Australia. Parallel studies are needed to determine the degree of utilization preferred forage species can tolerate without any retrogressive effects.

Finally and realistically, there may be no further need for this form of range research in central Australia, given the current trend in the local beef industry. Despite its immense size, central Australia carries only 0.2%* of the national herd, and profitable production of beef in this area is becoming increasingly difficult. Costs of production and transport are extremely high, a large labour input is required, and there is no large local market for beef. Additional recent factors are unreliable seasons, extremely depressed beef prices, and deteriorated pasture lands. Perhaps in the very near future there will be no beef industry in central Australia.

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* Northern Territory Statistical Summary, 1975 and 1976. Aust. Bureau Stats., Canberra.

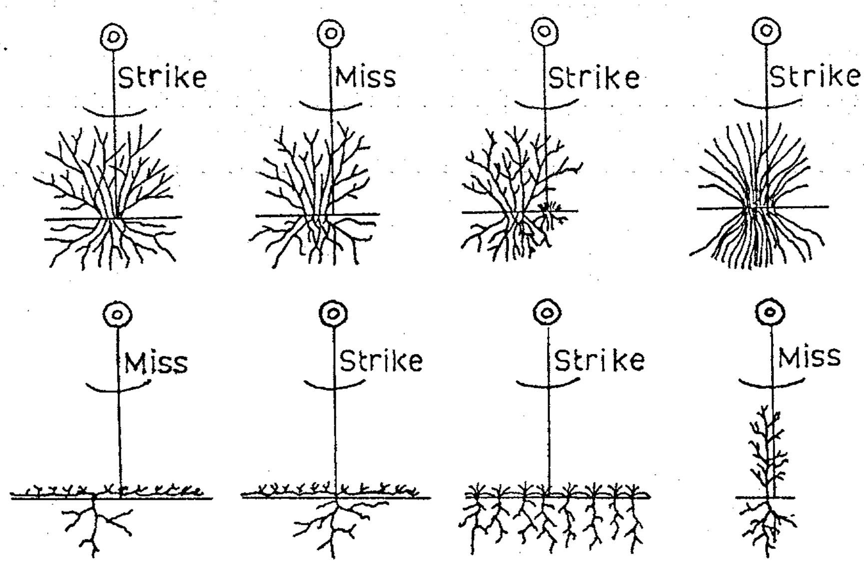
APPENDIX I

WHEEL-POINT METHOD OF BOTANICAL SURVEY : DESCRIPTION

The wheel-point method of botanical survey, after Tidmarsh and Havenga (1955), permits rapid sampling of large areas of grassland. It is therefore a most valuable survey instrument for use in rangeland research.

The wheel-point is a wheel apparatus with spokes extending from a central hub. The model used in the survey had 12 spokes each of length 45 cm.. An individual spoke (the sampling spoke) had a sharpened point, whilst the remaining 11 spokes were bluntened. When the apparatus was in motion, the sampling point made contact with the ground every 3 metres, and the number of revolutions was recorded against the hub by a small counter.

The most important consideration in sampling vegetation with the wheel-point, particularly when measuring basal cover, is the definition of a plant base "strike" or "no strike". The definition used in the present study is illustrated below.



after Tidmarsh & Havenga (1955)

APPENDIX II

ESTIMATION OF SAMPLE SIZE

In both the Mitchell Grass plains and the Open Woodland, the sample size appropriate to the pasture type was estimated on the basis of a pilot study, followed by a statistical testing of the results.

Pasture composition, as measured by the frequency of occurrence of species, was taken as the basic measure for analysis. The wheel-point method was used to sample 1000 points at 0.5 km. from the respective bores. It was hoped that this sample size would be sufficiently large to overcome most of the variation in pasture composition that was evident in both pasture types. The thousand points were recorded by sampling 20 runs of 50 points per run.

The results were then analysed to obtain a subjective estimate of the sample size required. Percent pasture composition was calculated for three of the most frequently occurring plant species. Pasture composition estimates for minor species were not examined, as it was evident that the variance in each case would be so great, that it would not be possible to gain an estimate of the appropriate sample size.

For each of the species, as shown in Tables II.1 - II.6, the percent pasture composition was listed for each run, and a corresponding running mean of these figures was calculated.

Viz.

$$\bar{X}_i = \frac{X_i + \bar{X}_{i-1}}{2}$$

where $$\bar{X}_{i-1} = \frac{X_{i-1} + X_{i-2} + X_{i-3} + \ldots X_o}{i - 1}$$

i.e. a fresh mean was calculated each time.

The correct sample size for the pasture was determined at the point where the mean value ceased to change significantly. This of course assumes that the percent pasture composition of the most frequently occurring species is normally distributed. The fluctuation of the mean was measured by the co-efficient of variation (C.V.)

$$C.V._i = \frac{Si}{\bar{X}_i}$$

where S_i = standard deviation

$$Si = \sqrt{\frac{\sum_{i=o}^{i} (x_i - \bar{x}_i)^2}{i - 1}}$$

In botanical sampling, a C.V. of less than or equal to 10.0% is regarded as an acceptable amount of variance (Foran, pers.comm.). Therefore, it was concluded that 500 points was a sufficient sample to be reliably representative of the pasture composition of the respective pasture types. ref. Kershaw (1964)
Greig-Smith (1957)

TABLE II.1 MITCHELL GRASS : MITCHELL GRASS ECOUNIT

PERCENT PASTURE COMPOSITION : FREQUENCY BASED

Run No.	Percent Pasture Composition (X)	$\bar{X}$	S	C.V.
1	14	14.00	0	0
2	8	11.0	4.24	0.39
3	18	13.33	5.03	0.38
4	8	12.00	4.90	0.41
5	10	11.60	4.34	0.37
6	4	10.33	4.97	0.48
7	8	10.00	4.62	0.46
8	6	9.50	4.50	0.47
9	4	8.89	4.59	0.52
10	6	8.60	4.43	0.51
11	6	8.36	4.27	0.51
12	8	8.33	4.08	0.49
13	10	8.46	3.93	0.46
14	2	8.00	4.15	0.52
15	4	7.73	4.13	0.53
16	0	7.25	4.43	0.61
17	4	7.06	4.37	0.62
18	0	6.67	4.55	0.68
19	0	6.32	4.68	0.74
20	0	6.00	4.77	0.79

TABLE II.2 FLINDERS GRASS : MITCHELL GRASS ECOUNIT

PERCENT PASTURE COMPOSITION : FREQUENCY BASED

Run No.	Percent (X) Pasture Composition	$\bar{X}$	S	C.V.
1	16	16.00	0	0
2	8	12.00	5.66	0.47
3	16	13.33	4.62	0.35
4	12	13.00	3.83	0.29
5	10	12.40	3.58	0.29
6	8	11.67	3.67	0.31
7	4	10.57	4.43	0.42
8	6	10.00	4.41	0.44
9	4	9.33	4.58	0.49
10	6	9.00	4.45	0.49
11	4	8.55	4.48	0.52
12	6	8.33	4.33	0.52
13	4	8.00	4.32	0.54
14	4	7.71	4.29	0.56
15	12	8.00	4.28	0.53
16	6	7.88	4.16	0.53
17	8	7.88	4.03	0.51
18	2	7.56	4.15	0.55
19	14	7.89	4.29	0.54
20	6	7.80	4.20	0.54

TABLE II.3 NEVERFAIL : MITCHELL GRASS ECOUNIT

PERCENT PASTURE COMPOSITION : FREQUENCY BASED

Run No.	Percent Pasture Composition (X)	$\bar{X}$	S	C.V.
1	66	66.0	0	0
2	84	75.0	12.73	0.17
3	66	72.0	10.39	0.14
4	80	74.0	9.38	0.13
5	76	74.4	8.17	0.11
6	80	75.3	7.66	0.10
7	88	77.1	8.47	0.11
8	86	78.3	8.45	0.11
9	92	79.8	9.13	0.11
* 10	88	80.6	9.00	0.11
11	90	81.5	8.99	0.11
12	84	81.6	8.61	0.11
13	84	81.8	8.26	0.10
14	92	82.6	8.39	0.10
15	82	82.6	8.09	0.10
16	94	83.2	8.32	0.10
17	88	83.6	8.14	0.10
18	94	84.2	8.27	0.10
19	86	84.2	8.05	0.10
20	92	84.6	8.03	0.09

* sample size sufficient.

TABLE II.4 OAT GRASS : OPEN WOODLAND ECOUNIT

PERCENT PASTURE COMPOSITION : FREQUENCY BASED

Run No.	Percent Pasture Composition (X)	$\bar{X}$	S	C.V.
1	48	48.0	0	0
2	46	47.0	1.41	0.03
3	38	44.0	5.29	0.12
4	52	46.0	5.89	0.13
5	46	46.0	5.10	0.11
6	46	46.0	4.56	0.10
7	32	44.0	6.73	0.15
8	38	43.25	6.58	0.15
9	44	43.33	6.16	0.14
* 10	32	42.2 0	6.83	0.16
11	46	42.55	6.58	0.15
12	38	42.17	6.41	0.15
13	40	42.00	6.16	0.15
14	24	40.71	7.63	0.19
15	54	41.61	8.11	0.20
16	46	41.88	7.92	0.19
17	38	41.65	7.72	0.19
18	40	41.56	7.50	0.18
19	44	41.68	7.31	0.18
20	56	42.40	7.80	0.18

* sufficient sample size: although C.V. is not ≤ 10%, the mean does not vary substantially beyond this point.

TABLE II.5 MULGA GRASS : OPEN WOODLAND ECOUNIT

PERCENT PASTURE COMPOSITION : FREQUENCY BASED

Run No.	Percent Pasture Composition (X)	$\bar{X}$	S	C.V.
1	18	18.0	0	0
2	24	21.0	4.24	0.20
3	24	22.0	3.46	0.16
4	24	22.50	3.00	0.13
5	28	23.60	3.58	0.15
6	28	24.33	3.67	0.15
7	32	25.43	4.43	0.17
8	38	27.00	6.05	0.22
9	20	26.22	6.12	0.23
10	30	26.60	5.89	0.22
11	28	26.73	5.61	0.21
12	26	26.67	5.35	0.20
13	32	27.08	5.33	0.20
14	38	27.86	5.89	0.21
15	22	27.47	5.88	0.21
16	30	27.63	5.71	0.21
17	24	27.41	5.60	0.20
18	30	27.56	5.47	0.20
19	26	27.47	5.33	0.19
20	14	26.80	6.00	0.22

TABLE II.6 EIGHT-DAY GRASS : OPEN WOODLAND ECOUNIT

PERCENT PASTURE COMPOSITION : FREQUENCY BASED

Run No.	Percent Pasture Composition (X)	$\bar{X}$	S	C.V.
1	6	6.0	0	0
2	8	7.0	0.41	0.20
3	6	6.67	1.15	0.17
4	6	6.50	1.00	0.15
5	6	6.40	0.89	0.14
6	4	6.00	1.26	0.21
7	2	5.43	1.90	0.35
8	6	5.50	1.77	0.32
9	4	5.33	1.73	0.32
10	2	5.00	1.94	0.39
11	6	5.09	1.87	0.37
12	16	6.00	3.62	0.60
13	4	5.85	3.51	0.60
14	8	6.00	3.42	0.57
15	2	5.73	3.45	0.60
16	10	6.00	3.50	0.58
17	8	6.12	3.43	0.56
18	14	6.56	3.81	0.58
19	12	6.84	3.91	0.57
20	10	7.00	3.87	0.55

APPENDIX III

FIELD DATA SHEET

DATA SHEET

SITE NO.	NAME OF ASSOCIATED WATER
DATE	DISTANCE FROM WATER
MAP REF.	DIRECTION FROM WATER
PHOTO. REF.	NATURE / AGE OF WATER
LAND SYSTEM	LAND UNIT

SEASON OF SURVEY		FORAGE CONDITION			
N.A. or can't tell	( )	green	( )	abundant	( )
response from summ. rain	( )	drying off	( )	mod. abundant	( )
response from winter rain	( )	dry	( )	sparse	( )
mixed response	( )				

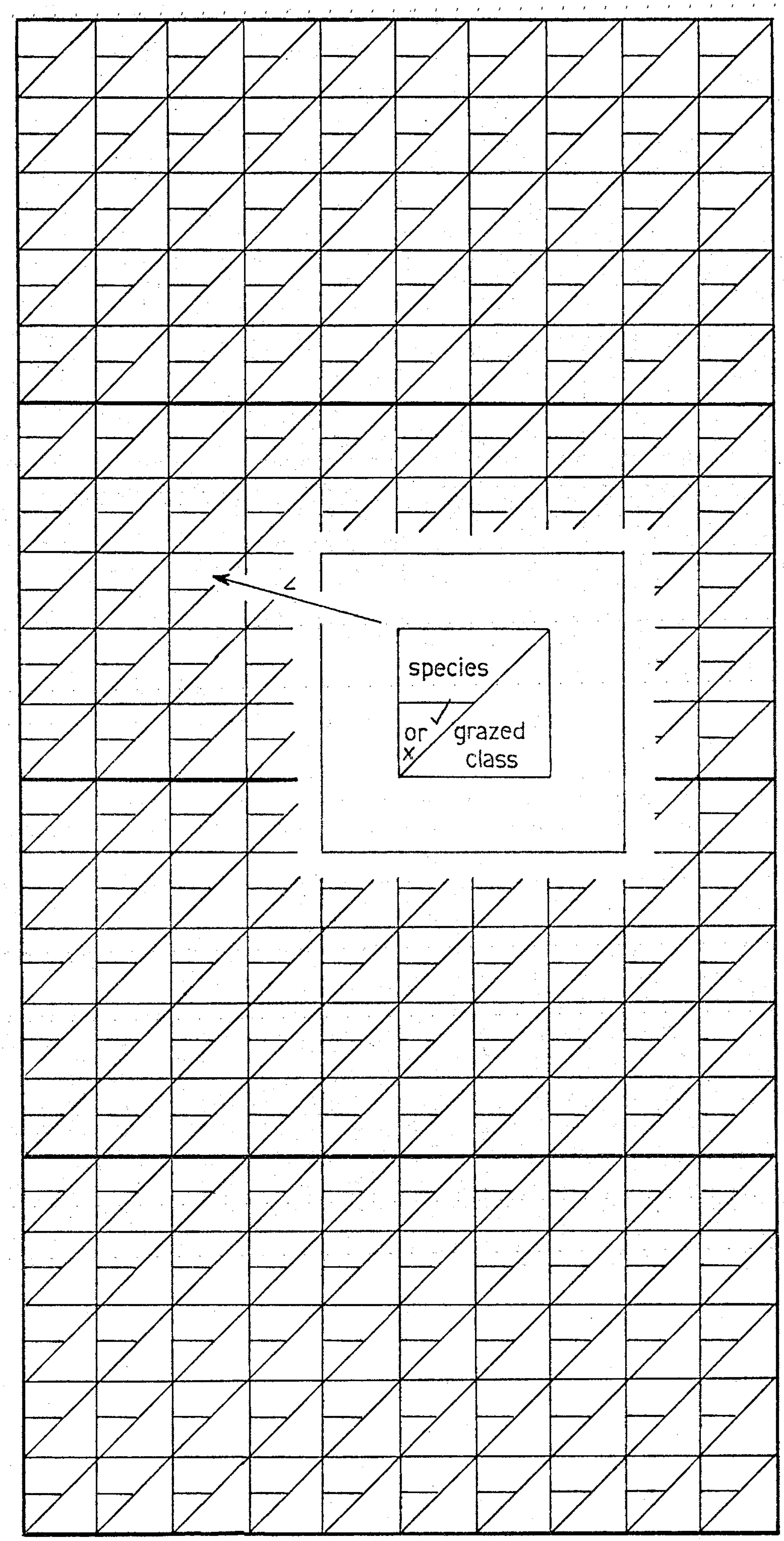
KEY

✓ denotes strike   × denotes no strike

UTILIZATION

Grazed Class (Rank)	Percent Utilization
0	0
1	1 – 25
2	26 – 50
3	51 – 75
4	76 – 99
5	100

SECTION SAMPLE OF FIELD DATA SHEET



APPENDIX IV

FIELD UTILIZATION GUIDES

BASED ON GRAZED-CLASS METHOD OF ESTIMATING

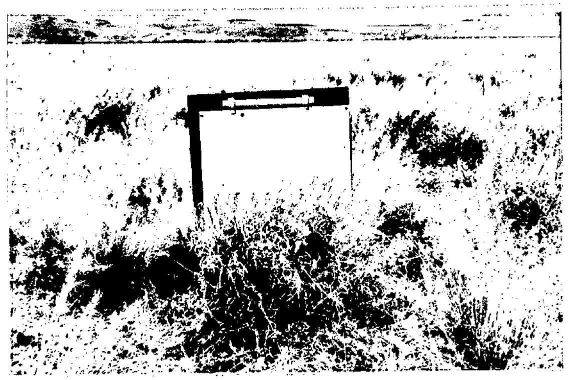
FORAGE UTILIZATION

Grazed Class (Rank)	Present Utilization (% forage removal)
0	0
1	1 - 25
2	26 - 50
3	51 - 75
4	76 - 99
5	100

MITCHELL GRASS (*Astrebla pectinata*)

Grazed Classes

0



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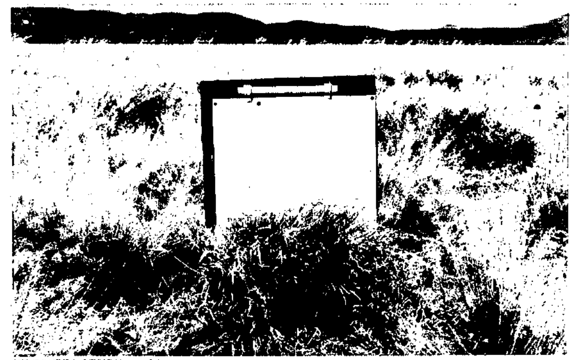

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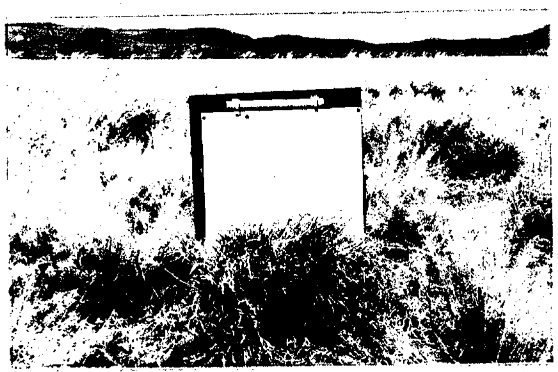

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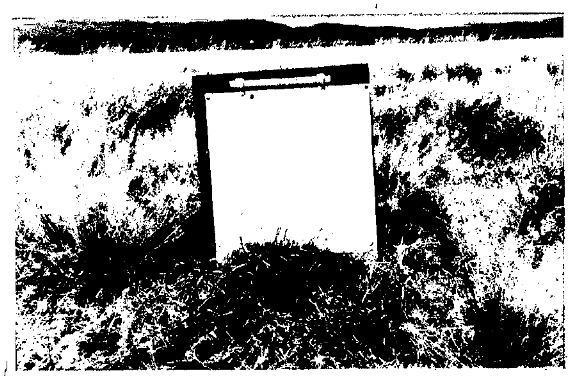

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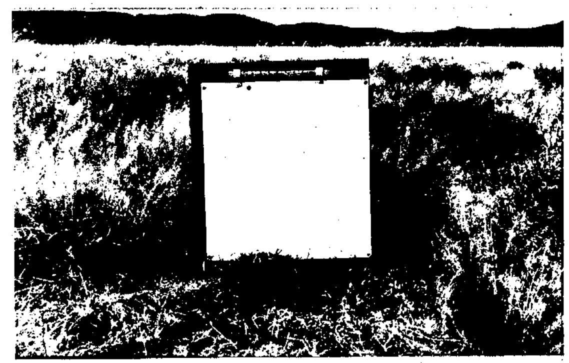
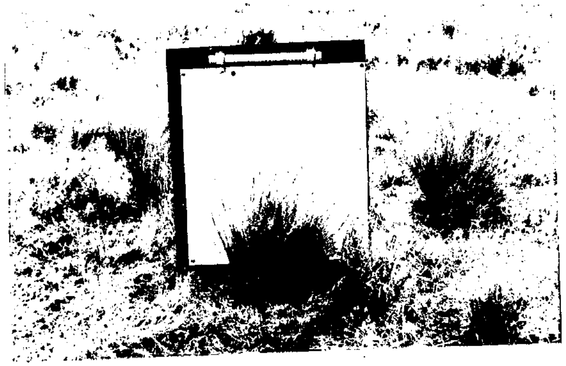


5

NEVERFAIL (<u>Eragrostis setifolia</u>)

Grazed Classes



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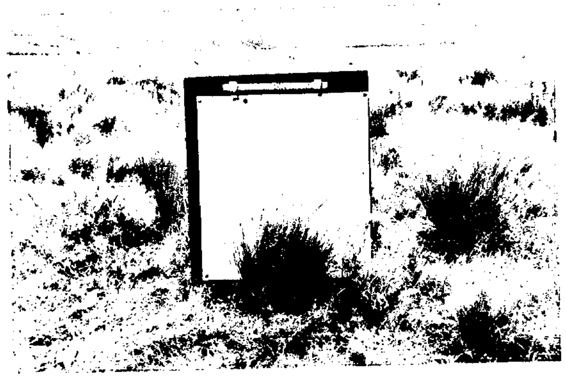

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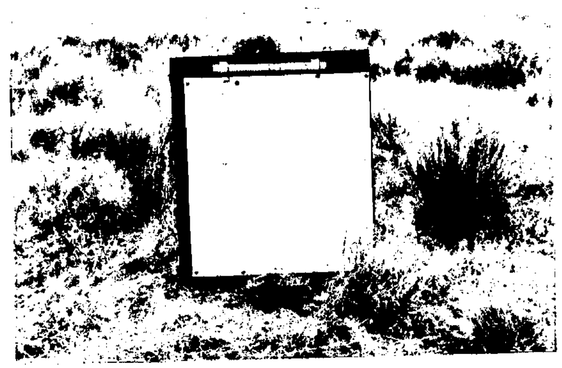

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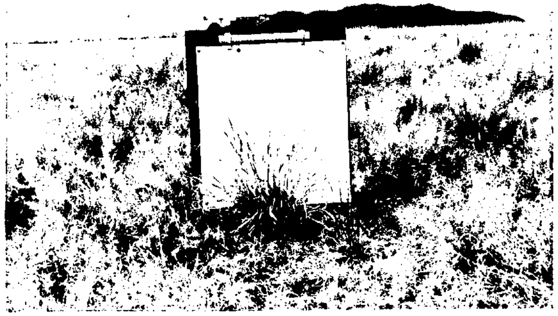
PANIC GRASS (*Panicum whitei*)

Grazed Classes



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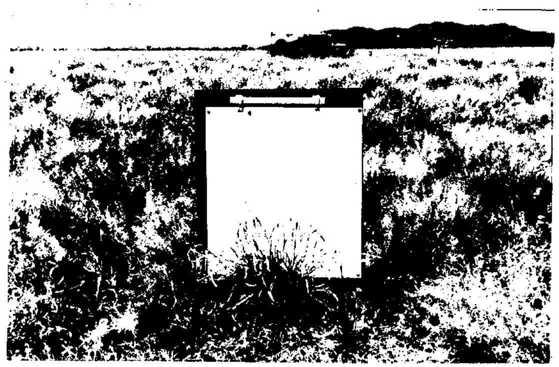

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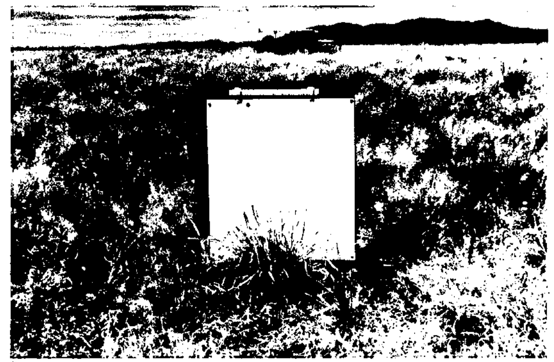

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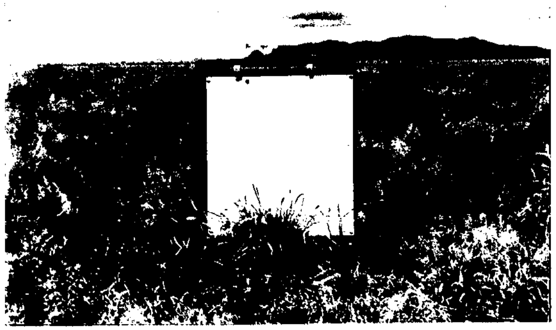

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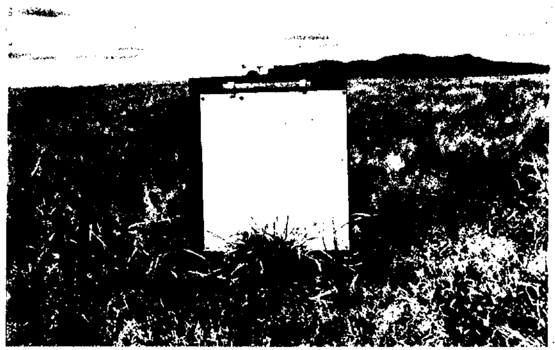

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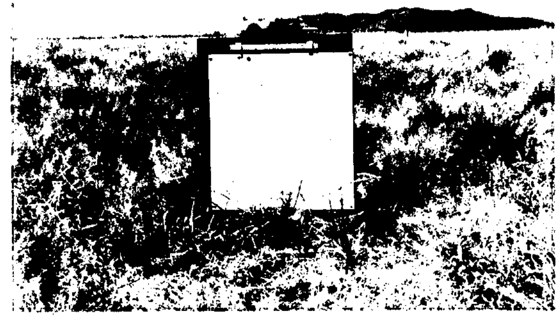

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SIDA

Grazed Classes


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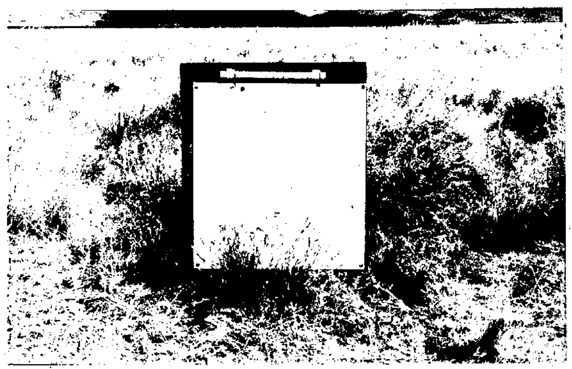
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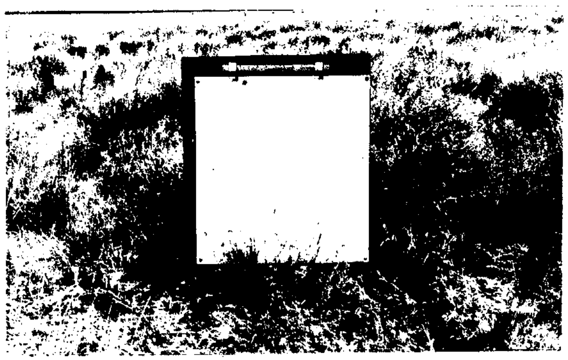
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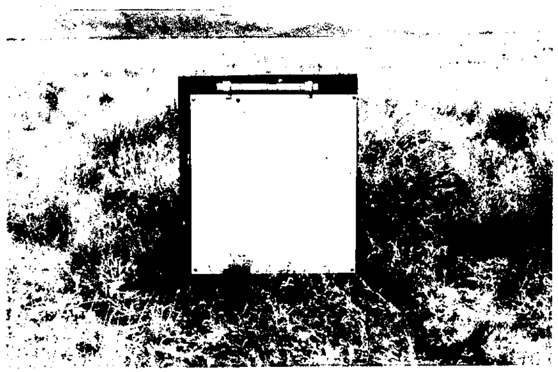
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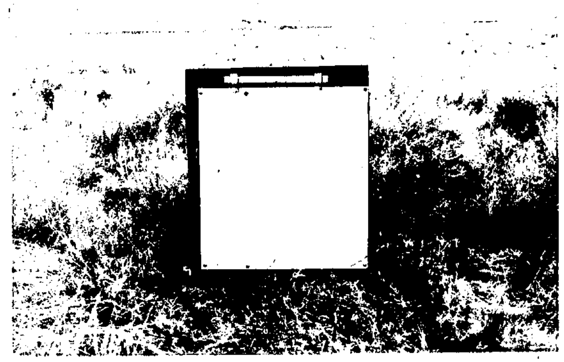
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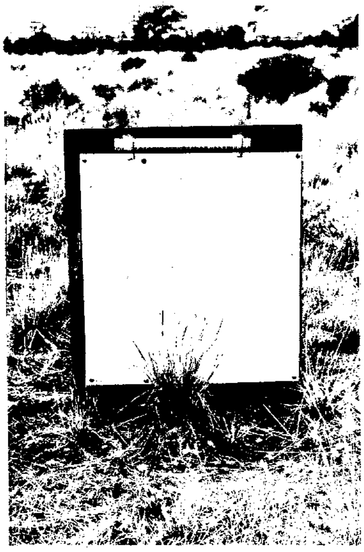
OAT GRASS (Enneapogon avenaceus)

Grazed Classes



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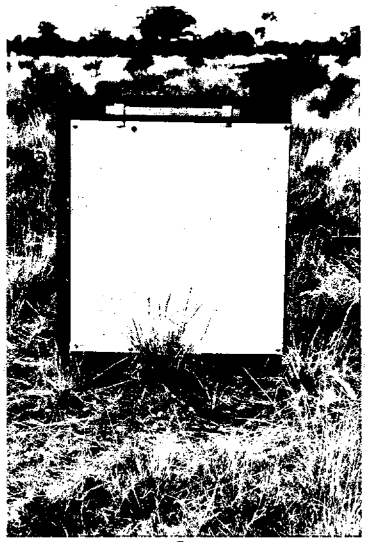

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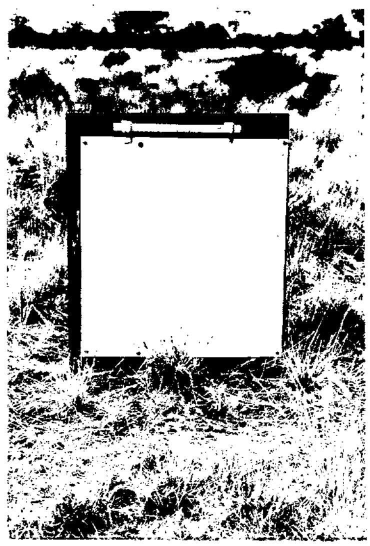

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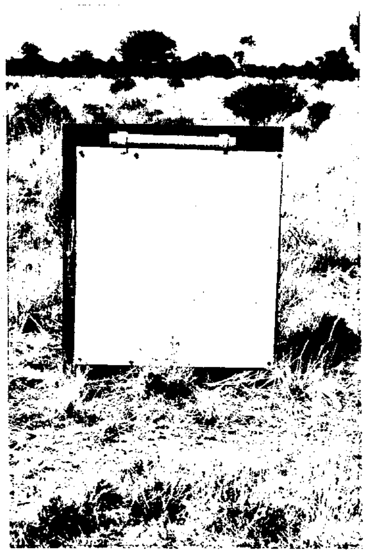

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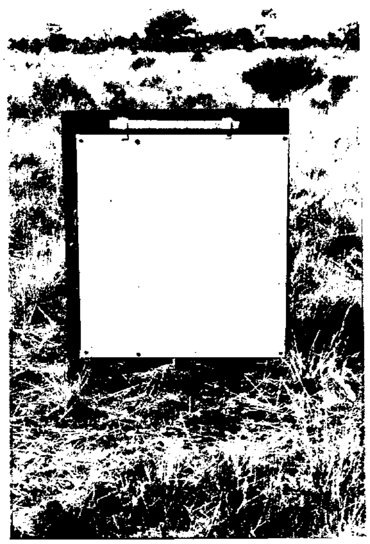

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MULGA GRASS (*Aristida contorta*)

Grazed Classes

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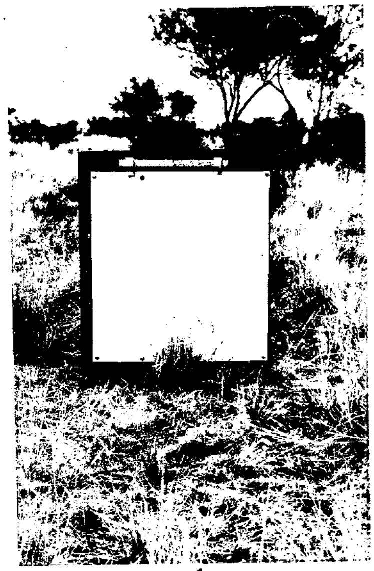

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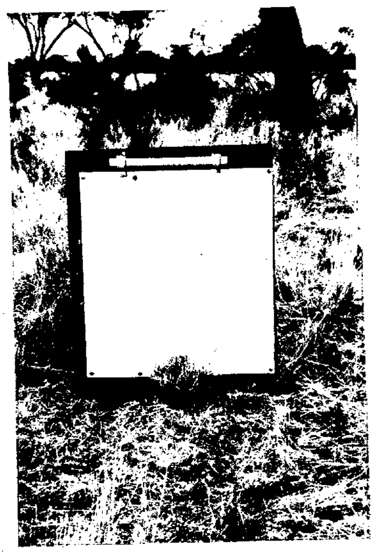

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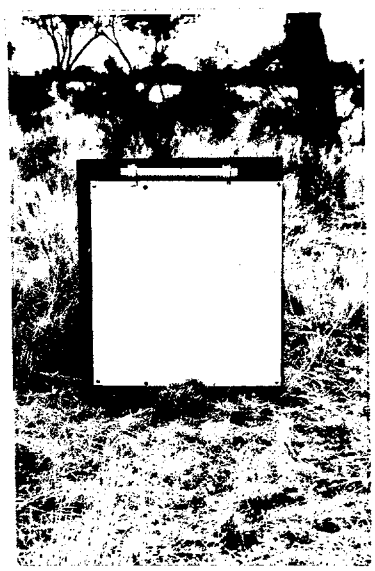


5

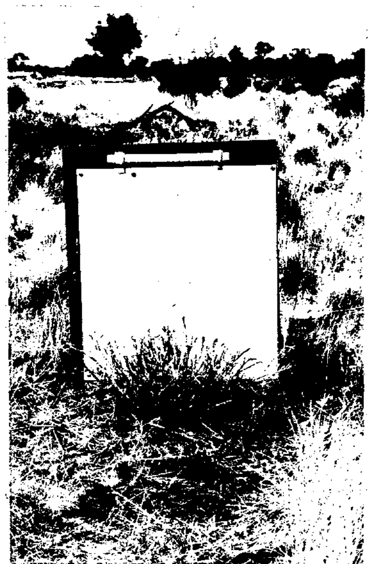
UMBRELLA GRASS (Digitaria coenicola)

Grazed Classes

0

1

2



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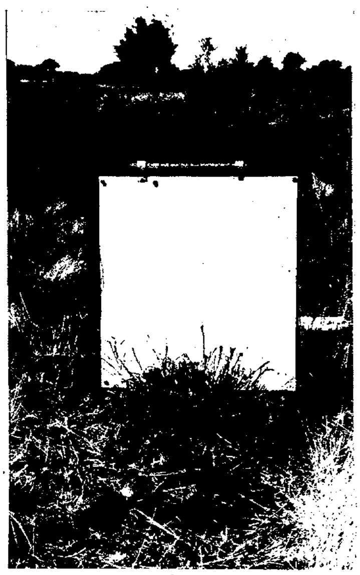

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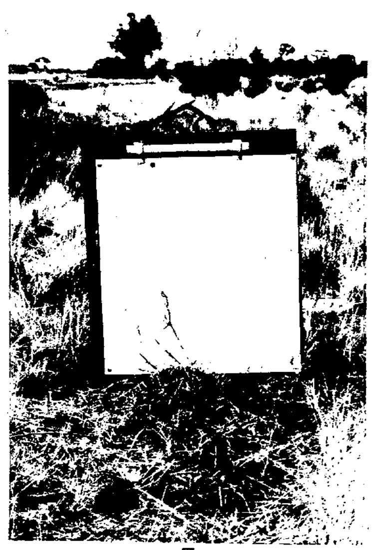

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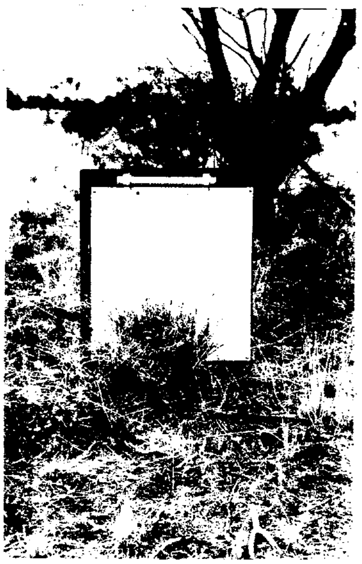
Grazed Classes

0

1



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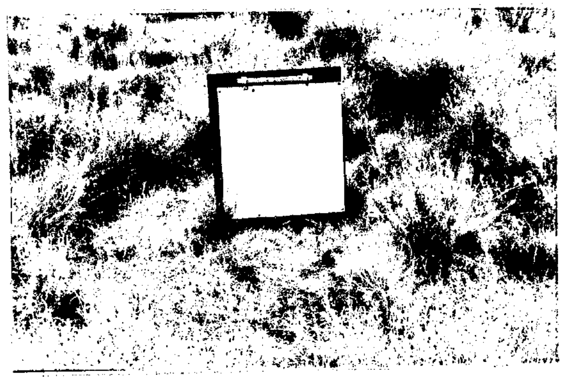
5

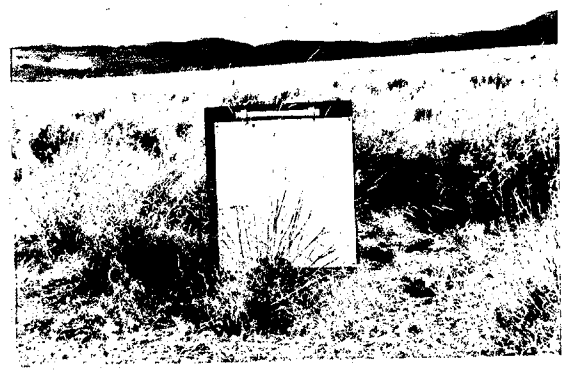
FLINDERS GRASS (*Iseilema membranaceum*)

Grazed Class 0



Grazed Class 3

WIRE GRASS (*Aristida latifolia*)

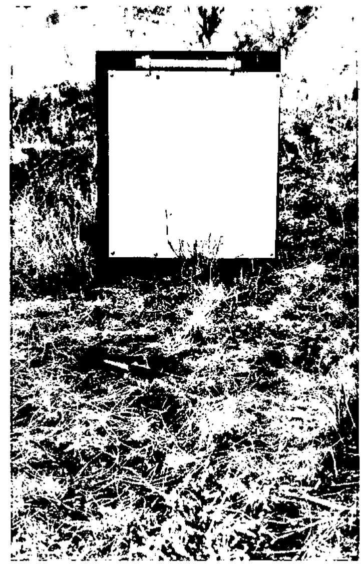


Grazed Class 0

SCENT GRASS (*Cymbopogon exaltatus*)

Grazed Class 0

EIGHT - DAY GRASS (*Fimbristylis sp. aff. dichotoma*)



Grazed Class 4

APPENDIX V

SOIL DESCRIPTION : LIMESTONE BORE STUDY AREA

SOIL COLOUR: according to Munsell Soil Colour Charts (Munsell, 1954)

eg. 5 YR 5/6 (yellowish-red)
(hue) (value)/(chroma)

SOIL STRUCTURE and SOIL TEXTURE: according to Queensland Dept. of Primary Industry, Soil Classification System.

* All soil samples taken at 5 cm. below mean surface.

LIMESTONE BORE : LINE TRANSECT 1

Site Number	Soil Colour	Soil Structure	Soil Texture	pH Value
1a	5 YR 4/6 yellowish-red	moderate, very fine to fine, angular blocky. stones present	heavy clay (>40%) no sand sticky, coherent	9
1b	5 YR 4/4 reddish-brown	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9
1c	5 YR 4/6 yellowish-red	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9-10
1d	5 YR 4/4 reddish-brown	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9
1e	5 YR 4/4 reddish-brown	moderate, very fine, angular blocky. stones present	heavy clay (>40%) no sand sticky, coherent	9
1f	5 YR 4/4 reddish-brown	strong, fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9
1g	2.5 YR 3/6 dark red	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9

LIMESTONE BORE : LINE TRANSECT 2

Site Number	Soil Colour	Soil Structure	Soil Texture	pH Value
2a	5 YR 4/4 reddish-brown	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9
2b	5 YR 4/4 reddish-brown	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9-10
2c	5 YR 4/4 reddish-brown	strong, fine to medium angular blocky	heavy clay (>40%) no sand sticky, coherent	9
2d	5 YR 4/4 reddish-brown	moderate, fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9-10
2e	5 YR 4/3 reddish-brown	strong, fine to medium angular blocky. stones present	heavy clay (>40%) no sand sticky, coherent	9
2f	5 YR 4/4 reddish-brown	strong, fine to medium angular blocky. stones present	heavy clay (>40%) no sand sticky, coherent	9
2g	5 YR 4/4 reddish-brown	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9
2h	5 YR 4/4 reddish-brown	moderate, very fine, angular blocky. stones present	heavy clay (>40%) no sand sticky, coherent	9-10
2g	5 YR 4/4 reddish-brown	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9

LIMESTONE BORE : TRANSECT 3

Site Number	Soil Colour	Soil Structure	Soil Texture	pH Value
3a	5 YR 4/8 yellowish-red	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9
3b	5 YR 4/8 yellowish-red	moderate, fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9
3c	5 YR 4/8 yellowish-red	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9
3d	5 YR 4/6 yellowish-red	moderate, very fine, angular blocky	heavy clay (>40%) no sand sticky, coherent	9
3e	5 YR 4/8 yellowish-red	strong, medium to coarse, angular blocky	very heavy clay (>40%) no sand unmouldable sticky, coherent	9-10
3f	5 YR 4/4 reddish-brown	strong, fine to medium, angular blocky	heavy clay (>40%) no sand sticky, coherent	9-10

APPENDIX VI

SOIL DESCRIPTION : BRUMBY BORE STUDY AREA

BRUMBY BORE : LINE TRANSECT 1

Site Number	Soil Colour	Soil Structure	Soil Texture	pH Value
a	5 YR 4/6,8 yellowish-red	weak, fine to very fine, crumb structure	sandy, clay loam (20-35% clay) coherent, plastic	6
b	5 YR 4/6 yellowish-red	moderate, fine crumb structure	sandy, clay loam (20-35% clay) coherent, plastic	6-7
c	5 YR 4/6 yellowish-red	moderate, fine crumb structure	sandy laom (10-20% clay) slightly sticky	6-7
d	5 YR 4/6 yellowish-red	weak, very fine, crumb structure	clay loam (25-40% clay) distinctly sticky smooth, plastic, coherent	6-7
e	5 YR 4/8 yellowish-red	weak, very fine, crumb structure	sandy clay loam (20-35% clay) coherent, plastic	6
f	5 YR 5/6 yellowish-red	weak, very fine crumb structure	loam, slightly sandy (10-25% clay) sticky, coherent	6-7

APPENDIX VII

SEQUENCE OF SITE PHOTOGRAPHS
LIMESTONE BORE STUDY AREA

TRANSECT LINE 3. (Distance from bore stated on photograph)

APPENDIX VIII

SEQUENCE OF SITE PHOTOGRAPHS

BRUMBY BORE STUDY AREA

TRANSECT LINE 1 (Distance from bore stated on photograph)

APPENDIX IX

SPECIES LIST

BOTANICAL NAME	COMMON NAME
Agropyrum repens	Couch grass
Aristida anthoxanthoides	Yellow threeawn
Aristida browniana	Kerosene grass
Aristida contorta	Mulga grass
Aristida inequiglumis	Unequal threeawn
Aristida latifolia	Feathertop Wire grass
Aristida strigosa	Rough threeawn
Astrebla elymoides	Hoop Mitchell grass
Astrebla pectinata	(Barley) Mitchell grass
Bothriochloa ewartiana	Desert Bluegrass
Chloris virgata	Feathertop Rhodes grass
Cymbopogon exaltatus	Scent grass
Dicanthium sericeum	Queensland Bluegrass
Digitaria brownii	Cotton grass
Digitaria coenicola	Umbrella grass
Enneapogon avenaceus	Oat grass
Enneapogon polyphyllus	Woolly Oat grass
Enteropogon acicularis	Curly Windmill grasd
Eragrostis eriopoda	Woolybutt
Eragrostis setifolia	Neverfail
Fimbristylis sp. aff. dichotoma	Eight-Day grass
Helipterum charsleyae	
Iseilema membranaceum	Flinders grass
Marselia sp.	
Panicum decompositum	(Native Millett grass
Panic grass	(
Panicum whitei	(Pepper grass
Senecio magnificus	Camel weed
Sida spp.	Sida
Sporobolus sp.	Fairy grass
Themeda australis	Kangaroo grass
Triraphis mollis	Purple Plume grass

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