AUSTRALIAN RANGELAND SOCIETY

working papers
3rd Biennial Conference

SEPTEMBER 23rd – 24th, 1981

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Implications of Changes in Land Tenure and Death Duties on Pastoral Business Structure in Far South West Queensland

Denzil M.D. Mills, DPI, Charleville Pastoral Laboratory, Qld. 4470.

Abstract

The effect of certain land tenure requirements and the influence of death duties on pastoral business structures in far south west Queensland is outlined. Seventy-four percent of sheep enterprises were run as family partnerships. These partnerships are assumed to have involved land as well as stock and plant to comply with the former Land Act.

Family partnerships involving stock and plant only, reduce the cost of changes in partnership composition which are necessary to bring younger family members into the partnership and allow older members to retire. Changes in the Land Act and the relaxation of death duties have removed the necessity and much of the incentive for spreading the ownership of land amongst as many people as possible. These changes have facilitated the amalgamation of family holdings.

Large aggregations of holdings run by family partnerships are seen as a successful business structure in the rangelands of far south-west Queensland which should be encouraged by future land policy.

* * * *

Choice of business structure is influenced by a number of factors including personal preference, death duty, taxation considerations and land tenure restrictions.

The land tenure of the grazing lands of Far South West Queensland are chiefly Pastoral Holdings and Grazing Selections.

In the study area shown in the accompanying map, Figure 1, the distribution of the various types of land tenure is as outlined in Table 1.

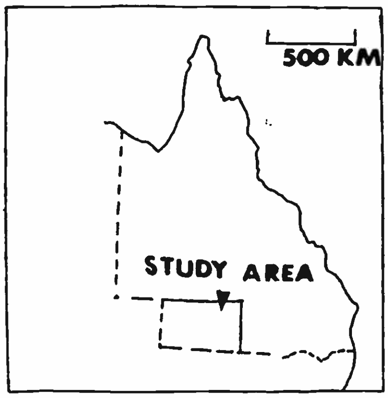

Figure 1. Location of Study Area.

Table 1

Types of Land Tenure

(Western Arid Region Land Use Study - Part 1 Area)

Tenure	No. of Holdings	Percentage of Area
Grazing Farm	97	5.8
Grazing Homestead	125	9.9
Grazing Homestead Freeholding Lease	31	1.5
Preferential Pastoral Holding	82	14.0
Pastoral Development Holding	12	9.9
Pastoral Holding	58	58.9
Total	405	100.0

Source: Western Arid Region Land Use Study - Part 1, Technical Bulletin No. 12, Division of Land Utilization, Q.D.P.I., 1974.

The various land tenures impose restrictions as to what types of business structures can be used to hold the holdings.

The comments in this paper will be confined to Grazing Selections*and Preferential Pastoral Holdings, which together make up 83 percent of the total number of holdings in the area.

The Land Act prohibits Grazing Selections and Preferential Pastoral Holdings being held by companies or corporations, or by a person acting as a trustee for another.

With regard to the use of partnerships, the Land Act requires each partner to have a registered interest in at least one of the holdings subject to the partnership agreement.

The effect of these restrictions is reflected in the fact that seventy four percent of graziers with sheep in pastoral Queensland operate within a partnership situation. Table 2 gives the usage of the various forms of business structure in pastoral areas of Queensland.

* Grazing Farm, Grazing Homestead and Grazing Homestead Freeholding Lease

Table 2

Forms of Business Structure Used on
Pastoral Sheep Enterprises - Queensland
1978-79

Business Structure	Percentage of Sheep Enterprises*-%
Sole Operator	20
Family Partnership	70
Other Partnership	4
Private Incorporated Coy	2
Public Incorporated Coy	-
Other - Trusts, Estates etc.	4

Source: A.B.S., Agricultural Sector Australia - Structure of Operating Units, 1978-79.

*Sheep enterprises include sheep and sheep-meat cattle enterprises but exclude sheep-cereal grains enterprises, in an attempt to approximate pastoral enterprises.

In the past ten years there have been changes in the Land Act which allow the use of family trusts on Grazing Selections and Preferential Pastoral Holdings. Family partnerships are also now allowed to run stock and plant partnerships without each family member having to have a registered interest in a holding.

The gradual removal of death duties between 1973 and 1979 has meant that there is no longer the same strong incentive for spreading the ownership of land among as many people as possible.

Taxation incentives still encourage the spread of income earning assets i.e. stock among a number of family members.

As a result of these changes, the land, stock and plant partnership, for a family situation, is less attractive than a stock and plant partnership operating on land held by one or more family members.

This is because of the extra costs involved in transferring land each time additional partners are bought into the partnership. Just the extra stamp duty on a holding valued at $300 000 would amount to $4 500 for each change in ownership. If there was a debt on the land that had to be transferred as well, then extra stamp duty has to be paid on this amount in addition. For example, a debt of $50 000 would attract duty of $625.

The role of partnerships as a means of operating a pastoral business and also as a vehicle for the intergenerational transfer of property assets was investigated in a study of thirteen properties in the Paroo Resource Region of Far South West Queensland (Mills, 1981a).

The properties studied were either Grazing Selections or Preferential Pastoral Holdings and were selected because there had been some intergenerational transfer of assets in the past ten years.

Eight of the properties operated as land, stock and plant partnerships with the remaining five operating as stock and plant partnerships.

The average length of family involvement with the properties was 36 years. During the period of family involvement with the property, there had been on average 3.92 changes in the ownership of the land with one of these changes being associated with the purchase of an additional block of land.

Changes in the partnership composition occurred on average every eight and a half years. The main reason for a change in the partnership composition was to bring in new partners and/or to let older partners retire. Only seven percent of the alterations in partnership composition have resulted from the buying out of non-working partners.

On these properties, partnerships were used by the majority (eight out of thirteen) as a means of bringing family members into the business; tax and death duty planning were the major reasons behind the formation of partnerships on three properties.

In the past, because of restrictions imposed by land tenure and the impact of death duties, partners had to have an interest in land as well as stock and plant. As a result, on seven of the properties surveyed, each change in partnership composition was also associated with a corresponding change in the ownership of the land.

Because of the final abolition of all death duties on assets passing to family members in 1977, the transfer of the interest in land with each change in partnership composition has become unnecessary. Some lending authorities however for reasons of security, make the transfer of land a condition of finance that is made available to fund the transfers of assets between family members.

As family sources provided the finance in two thirds of the cases, this is probably not a common restriction.

Since the changes to land tenure and death duties it is possible for graziers to consider changing the composition of their family business more frequently.

It is desirable that younger family members be given an interest in (and responsibility for) the property if they are to stay and work on the property for any considerable period of time.

Using stock and plant partnerships, younger family members can gain an interest in the property and start to build up equity in the income earning assets. The home block can remain in the parents name until their retirement, thus cutting down the number of costly land transfers necessary.

If additional blocks of land are purchased, consideration should be given to putting these in younger members' names. If the younger family member has built up his equity in the stock and plant, this can be used to help purchase such an additional area or alternatively to enable him to be in a better position to buy the home block on his parents retirement, if this was necessary to provide a retirement fund for the parents.

A survey of profitability in the Paroo Resource Region (Mills, 1981b) illustrated that over the period 1974-75 to 1978-79, the larger aggregates run by family partnerships were the most profitable. This factor gave the larger enterprises more flexibility in their management options.

Family partnerships with a number of members and large land aggregations have become a popular and apparently successful means of coping with problems of drought, market fluctuations and the cost price squeeze which affect the pastoral industries.

Recent changes in land tenure and the abolition of death duties have facilitated the use of family partnerships as a successful form of business organisation on pastoral holdings. Future policy should further encourage the use of family partnerships.

1. Mills, D.M.D. (1981a). Unpublished data of author.

2. Mills, D.M.D. (1981b). Paroo Resource Region. Survey of Profitability. Queensland Department of Primary Industries, Mimeograph.

THE USE OF RESOURCE REGIONS FOR DATA COLLECTION, POLICY PLANNING AND EXTENSION IN RANGELANDS.

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Abstract

Land system surveys have described the biological characteristics of significant areas of Australian rangelands. For full use to be made of this information it needs to be complimented with property level data on financial and animal performance and management constraints. Findings drawn from the assembled data need to be presented in a form readily understood by various land users such as pastoralists, extension officers, research planners and land policy administrators.

In far south-west Queensland resource regions have proved to be a convenient basis for the collection of the property level data and the communication of findings to land users. Resource regions are geographic areas within which properties have the same mixture of land systems and the same climate and so carry on similar types of grazing enterprises with similar management options.

Background

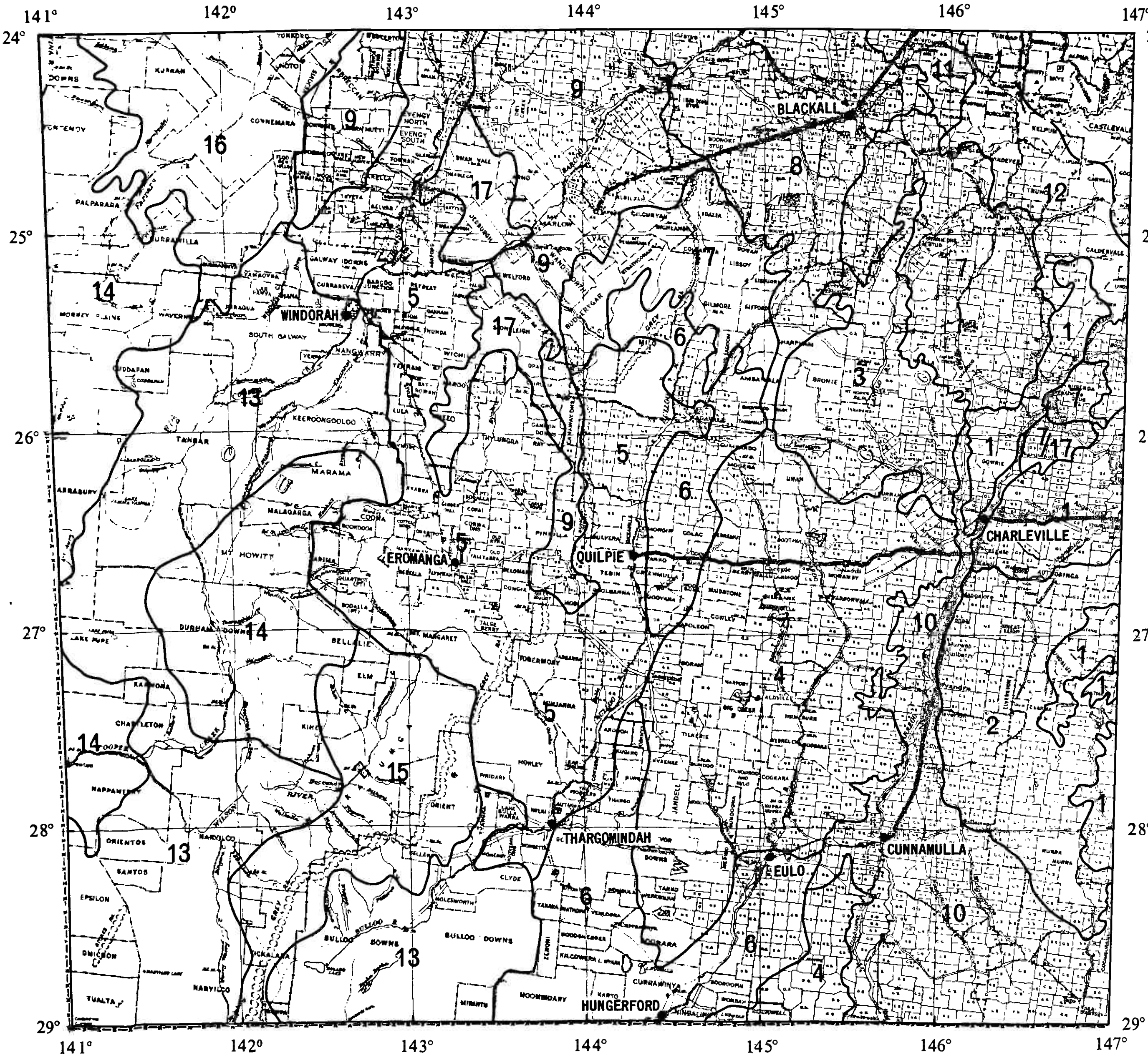
Land systems surveys are available for pastoral lands throughout Queensland and for a number of other areas in Australia. These surveys provide a detailed description of the biological resources of these areas and their characteristics and problems. The overall objective of the land systems mapping program in south-west Queensland was the evolution of principles of land management which would maintain or improve the condition of the country while maintaining adequate financial returns.

To achieve this objective, information such as financial data, animal performance figures, management constraints and other property level data had to be collected and assessed. It was not convenient or even possible to collect this property level data on a land system basis and it became evident that a broader classification which could still be closely related to land systems was needed to bring biological and other parameters together. This information then had to be synthesised into management recommendations.

The Resource Region approach has been used as this basis for data collection and determination of management programs. Information presented on this basis has been seen as relevant and useful by extension staff specialising in other fields who play a major role in the promotion of land management programs because of their frequent contact with the rural community.

Fig. 1

BY J.R.MILLS



SCALE 1:3 500 000

KILOMETRES 40 20 0 40 80 120 160 200 240 KILOMETRES

REFERENCE

RESOURCE AREA	LAND TYPE	CURRENT ENTERPRISE
EASTERN MULGA LANDS		
1 EASTERN MULGA	Mixed hard and soft mulga.	Cattle breeding and bullock depots; wethers and limited sheep breeding.
2 NEBINE	Soft mulga.	Cattle breeding and bullock depots; limited number of wethers.
3 LANGLO	Soft mulga and alluvial plains. Minor ranges.	Cattle breeding and wethers; cattle breeding and eventual fattening or fattening of older stock in above average seasons.
WESTERN MULGA LANDS		
4 PAROO	Hard mulga and associated alluvial plains. Minor ranges.	Wethers and sheep breeding on better types of country; cattle breeding and eventual fattening of older dry stock or younger stock in above average seasons.
5 QUILPIE	Principally hard mulga, with alluvial plains, ranges and areas of stony gidgee.	Sheep breeding and wethers; cattle breeding and fattening in average or above average seasons.
6 EULO	Mulga sandplain and sandplain overlying alluvia. Minor areas of hard mulga.	Sheep breeding and wethers; cattle breeding and eventual fattening of older dry cattle or younger cattle in above average seasons.
DOWNS		
7 TAMBO	Mitchell grass downs, with associated wooded downs and areas of gidgee.	Sheep breeding; cattle breeding and fattening in average or above average seasons.
8 BLACKALL	Mitchell grass downs, with associated wooded downs and extensive areas of gidgee.	Sheep breeding; cattle breeding and fattening in average or above average seasons.
9 BIMERAH	Mitchell grass downs, wooded downs and occasional areas of gidgee.	Sheep breeding; cattle breeding and fattening in average or above average seasons.
WARREGO PLAINS		
10 CUNNAMULLA	Open Mitchell grass plains, gidgee, sand-hills, drainage lines and flooded areas.	Sheep breeding; cattle breeding and fattening
EASTERN RANGES AND DESERT		
11 EASTERN DESERT	Eucalypt woodland and spinifex desert.	Cattle breeding, turning off store weaners; limited number of wethers.
12 CARNARVON	Eucalypt woodland, brigalow and ranges.	Cattle breeding, turning off store weaners and young steers.
CHANNEL COUNTRY		
13 TANBAR	Spinifex sandplain and seasonally flooded channel country.	Cattle fattening on channel country following floods; minor breeding.
14 DURHAM	Stony downs, ranges and seasonally flooded channel country.	Cattle fattening on channel country following floods; some breeding on the stony downs areas.
WESTERN RANGES		
15 NOCCUNDRA	Low ranges, hard mulga and alluvial plains.	Cattle breeding and fattening in above average seasons.
16 FARRAH	Ranges, hard mulga and alluvial plains.	Cattle breeding.
17 SWANVALE	Ranges, hard mulga and areas of stony gidgee.	Cattle breeding and wethers.

COMPILED BY J.R. Mills, Division of Land Utilisation, Queensland Department of Primary Industries

PREPARED BY Division of Land Utilisation, Queensland Department of Primary Industries.

BASE MAP supplied by Department of Mapping and Surveying and reproduced by permission of the Surveyor General, Brisbane.

The Resource Region approach has been used by the Soil Conservation service of the United States Department of Agriculture for a number of years to develop and coordinate soil and water conservation programs, and present a broad synthesis of current knowledge about the land resources of the United States (Austin, 1965).

Definition

The Resource Region is defined as a geographic area within which properties have a similar mixture of land systems, similar climatic patterns, and hence in pastoral lands carry on much the same type of enterprise. These regions have similar problems, characteristics and management options, and can be regarded as broad management units. The size and extent of a Resource Region is flexible depending on the degree of detail required. Resource Regions with important similarities may be grouped into the broader classification of Resource Areas (eg. Eastern Mulga Lands).

In south-west Queensland the Resource Regions shown in Fig. 1 were defined firstly on the basis of industry type, with the Western Dingo Barrier fence dividing the cattle country from the mixed sheep and cattle country to the east (ie. the management constraint of dingoes exercised a major influence on the break-up). Next the Mitchell grass breeding areas in the north and south were separated from the mulga lands. The northern Mitchell grass or 'Downs' area was further subdivided into three Resource Regions because of the decreasing rainfall from east to west across this area.

The remaining mulga lands were subdivided into Eastern and Western areas on the basis of rainfall, with the Warrego River forming a convenient and locally recognised division between the two. The Eastern and Western mulga lands were each further subdivided into three Resource Regions on the basis of land systems and related enterprise type. This separated the properties where limited sheep breeding and cattle fattening is possible, from the wether and cattle breeding enterprises.

Extensive use was made of local adviser's knowledge of properties in the area for compiling the map. A number of the regions correspond to localities previously recognised by people familiar with the area. Childs (1974) used a similar grouping which he referred to as vegetative zones for a property management survey in the south-east of the area.

The map is compiled by first noting on a cadastral map the enterprises carried on on each aggregation. This map is then over-laid with a land system and land zone map and tentative land use patterns are marked out. Further overlays showing climatic features can also be used to further subdivide these land use patterns into resource regions. In far south-west Queensland 17 resource regions were recognised in an area covering 30 m hectares.

Description of Resource Regions

Resource Regions were defined on a 1:1 000 000 scale map using a cadastral base with the names of holdings shown wherever possible. The legend provides a brief description of the land systems involved and type of enterprise carried on, and clearly shows the grouping of Resource Regions into Resource areas.

For detailed biological descriptions users are referred to the relevant land systems maps and reports (Queensland Department of Primary Industries, Division of Land Utilisation Technical Bulletins Nos. 12, 22, 23 and 29*).

The main biological characteristics and problems can be drawn from these reports and highlighted. Our limited experience to date indicates that land degradation problems can conveniently be defined in terms of type of problem, area affected and severity, on a resource region basis. This allows initial prioritising of resource regions' needs, and surveys to collect financial, animal and managerial data can be designed and implemented on this basis.

The analysis of production type information allows an objective assessment in financial terms of the success or otherwise of various types of management strategy, different enterprise sizes and structures in that resource region. The value of production lost through land degradation or other problems can be estimated from average productivity figures for various regions. The financial information also provides an assessment of the capability of graziers in an area to adopt proposed changes in management systems which involve lowering stock numbers and a possible reduction in income from wool and meat production.

Regions where problems can be solved by graziers themselves in response to an active extension program can be recognised and treated differently to areas where high debt levels, inadequate incomes and small holdings make it very difficult for graziers to adopt more conservative stocking policies without Government incentives or aid. Once a properly detailed outline of industry structure, performance and capacity for change, and the cost of biological problems has been built up, the needs of various Resource Regions can be objectively prioritised. This allows limited research and extension funds to be concentrated in regions with the greatest need for action.

* In preparation.

Table 1. Comparison of the Eastern Mulga and Paroo Resource Regions

	EASTERN MULGA (average of 7 properties 1972-3 to 1979-80)	PAROO (average of 10 properties 1974-5 to 1978-9)
Area (ha)	21 000	42 000
Sheep numbers	5 400 (3.8 ha/hd)	10 000 (4.2 ha/hd)
Cattle numbers	550 (38 ha/hd)	620 (68 ha/hd)
Net Income per property $	13 400	34 800
Net Income per family unit $ (after interest and capital)	9 400	13 700
Debt $	66 000	28 000
Gross Margin/Sheep $	4.90	7.46
% of total income from sheep	71%	83%

Source: Holmes, W.E. (1981). Eastern Mulga Land Resource Region Survey. Queensland Department of Primary Industries, Mimeograph.
Mills, D.M. (1981). Paroo Resource Region Survey of Profitability. Queensland Department of Primary Industries, Mimeograph.

The main features to note in this comparison of two resource regions are the larger areas of the Paroo properties, and their higher net income and lower debt figures than the Eastern Mulga properties. This is a result of the lower gross margin/sheep in the Eastern Mulga which in turn reflects the poor wool quality, lower wool cuts and marginal breeding performance of this region.

These figures cover a period of relatively good seasons and it is significant that the Eastern Mulga properties were unable to reduce their debt levels substantially during this period. These properties entered the current drought with a high debt load which may be expected to increase over the dry period. The slightly heavier dependence of this region on income from cattle also makes these small properties more vulnerable to fluctuations in cattle prices.

The ratio of debts to income in the Eastern Mulga shows that these properties generally have insufficient income earning capacity to withstand short term reductions in income due to dry years or more conservative stocking rates which may be desirable to slow further land degradation. Equity and income earning capacity are insufficient to finance further expansion of area which (labour permitting) would enable stocking rates to be reduced without reduction in stock numbers and subsequent income.

Extension programs aimed at encouraging more conservative stocking rates have limited chances of success in this region where economic pressures continually force managers to keep short term production at a maximum. If the estimated costs of land degradation in this area show that changes in land use intensity are desirable in the public interest, Government intervention would seem necessary to achieve these changes.

By comparison the Paroo properties have sufficient income earning capacity and liquidity to be able to accept some short term reductions in income which are associated with dry periods or lower stocking rates. In practice however, these managers chose to acquire more land, and 90% of properties surveyed in this area planned to expand the size of their holdings as soon as the availability of suitable land and finance allowed.

Extension programs to communicate the benefits of lighter stocking rates have a reasonable chance of success in this area where managers have increased financial flexibility and consequently a wider range of management options available. These properties have the capacity to respond to land degradation problems without Government financial assistance, or at least the capacity to pay commercial rates for Government money if priorities indicate changes in land use intensity in this region are desirable.

Financial performance information presented on a resource region basis is of direct value to individual graziers by allowing them to compare their performance with averages of other similar properties. Properties within a region can be grouped according to size, profitability or other characteristics for comparison. In the Paroo resource region the smallest properties carried the highest average debt levels and the larger aggregations returned much higher profits during runs of good seasons.

Conclusion

The outline of financial, structural and management aspects of rangeland animal production is equally as important as the collection of basic land resource information. Some information of this type has previously been collected on a local authority basis. The diversity of resource regions which can occur within shires limits the usefulness of this information and can make it misleading in some cases.

The presentation of information collected in a simple form which is seen as relevant and useful by the appropriate user, is necessary if sound land use policies of real value to graziers and the community are to be adopted. The use of a resource region approach is one way of doing this.

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RANGE CONDITION : VEGETATION CHANGE OR PRODUCTION

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It is readily understood that when natural grasslands and shrublands are grazed there will be some changes in the plant community. The more permanent changes, arising from the loss of some plant species, the invasion of others or a general thinning out of the vegetation, are referred to as changes in Range Condition. Our interest in these changes is not based on the change itself, as the preservation of plant species is not our primary concern. The occupation of land for agriculture is usually accompanied by profound changes in the vegetation, without the connotation of this land being in poor condition. Rather our interest arises from the decline in long-term productivity that may accompany such changes. Two significant examples of this may be noted in Australia - the semi-arid woodlands of N.S.W. and the Pilbara of W.A.

Over the last decade Australian rangeland scientists have attempted to establish systems for recording these changes, with the hope that such measurements will identify problem areas and properties, before they reach a serious stage of decline. In this article I wish to comment on some of the developments in our concepts of what is range condition and how it should be measured.

USA SYSTEMS INADEQUATE

Range scientists in USA have been active in this field for about 50 years. Although many systems have been tried, they now emphasize the Quantitative Climax System (Dyksterhuis 1949) which is based entirely on measuring the changes in percentage botanical composition.

From the beginning attempts have been made to apply this system in Australia (Lendon and Lamacraft 1976; Perry 1976) although other systems have also been proposed (Payne et al. 1974; Christie 1978). This so-called "Dyksterhuis" system has been advocated, principally because it is "ecologically-based" and therefore thought to be superior to other methods based on productivity (Perry 1976; Hacker 1979).

However, many functional problems have arisen with the Dyksterhuis system as attempts have been made to apply it to the Australian rangelands. An initial list of problems may be attributed to Smith (1979); an American working in arid rangelands. A longer list of problems is as follows -

a) The method assumes that original or near-original is 'best'.

b) In extensively altered vegetation, no examples of 'original' vegetation remain.

c) It assumes a stable plant composition in the absence of grazing. Fire and drought effects are ignored.

d) Lay people assume a direct relationship between vegetation change and animal productivity (the item of interest), but this is often not so.

e) The method cannot cope with useful introduced plants.

f) It only records changes in plant composition and ignores declines in plant quantity - an important indicator of loss of production and increased erosion.

g) The degree of vegetation change is not constant - it depends on how it is measured.

Each of these problems can be overcome by appropriate adjustments, but the evaluation of these adjustments is invariably made on the basis of animal production, although rarely stated as such. The South Africans have also noted these problems, and the adjustments outlined by Foran et al. (1978) are of this nature.

ATTRIBUTES OF CONDITION

The problems outlined above arise from an inadequate analysis of the factors that we include in our general perception of changes in range condition. Primarily, the changes noted are in the vegetation, but this includes both composition (which plants are present) and quantity (total amount present). Changes in composition must also include changes in the balance between herbage and shrubs or trees. Secondarily there may be changes in the soil, such as its ability to hold moisture, its fertility, or its rate of erosion, all of which will tend to make the vegetation changes permanent. Finally, there may be changes in productivity, mainly in the number of animals carried, but perhaps also in their weight gain, or in other factors of interest, such as water yield or value as wildlife habitat.

With these many factors, each varying in importance according to vegetation type and land use, the idea of a single and universal measure of condition becomes unattainable. At best, there will be situations where two factors are correlated. The solution to these problems is to abandon attempts to measure range condition as a whole and instead to separately measure each attribute of interest. In particular measures should be constructed of change in animal carrying capacity. These will continue to be based on vegetation measurements, but will be compiled into production indices on the basis of knowledge of the growth, palatability and nutritive value of the species.

VEGETATION CHANGE AND ANIMAL PRODUCTION

Some changes in botanical composition are clearly deleterious. However, the importance of other vegetation changes is not so clear. For instance the loss of the dominant edible shrub Atriplex vesicaria and its replacement by Danthonia caespitosa has been found to either increase or not change the number of sheep that can be carried (Wilson and Leigh 1970). This research relates to the southern part of the Riverine Plain and at first was thought to be atypical. However, R.D. Graetz (personal communication) has recently recorded a similar result in the Barrier Range, where the shrub is replaced by edible Sclerolaena spp. A possible general conclusion is that large changes in botanical composition will not affect carrying capacity, unless the replacement plants are inedible, of low productivity or there is no replacement plant at all.

Neither is it sufficient to assume that perennials are superior to annuals. For instance A. vesicaria is truly perennial, while Sclerolaena spp. are described as biennials. Communities that are dominated by such shorter-lived plants may have high rates of animal production, and ephemerals also have a significant place in animal production (see Leigh et al. 1979).

The conclusion is that vegetation change is not necessarily deleterious and plant species should be classified on a desirable-undesirable scale, rather than on a decreaser-increaser scale. Further, quantity is as important as composition and this information should not be lost by expressing results in terms of percentage composition.

An example of the difference between vegetation change and change in potential productivity is shown in Table 1. In this instance a major change from the edible shrub Atriplex vesicaria to copper burr and perennial grasses is not deleterious to animal productivity. Thus it is of little value to express condition in terms of vegetation change, even though that change is clearly visible. The vegetation is different, but not inferior.

Table 1. Foliar cover of principal species on two Barrier Range plots, across a fenceline of vegetation change (Spring 1978)

Species	Reference cover	'Overgrazed' area
Desirable species		
Atriplex vesicaria	7.1	0.0
Perennial grasses	4.2	9.1
Copper burr (*Sclerolaena* spp.)	5.5	7.4
Bluebushes (*Maireana* spp.)	0.8	0.2
Undesirable species		
Atriplex spp.	5.4	2.4
Poverty bushes (*Sclerolaena* spp.)	2.3	1.9
Total	25.3	21.0

Relative cover of desirable species		95%
Indices of species change:	percentage similarity	54%
	: quantitative climax	60

CONCLUSIONS

It should be emphasized that this paper does not advocate that range condition be equated to animal productivity. Rather that range condition is a general concept about change in land value, of which animal productivity is our most important current interest. At the measurement level we can determine particular attributes of condition, such as plant composition, degree of erosion or potential animal production, but there is no rational way of adding these together to give an overall index of condition. Nevertheless, in our minds, condition becomes equated with the most important of these attributes in the particular land type in which we work.

It has been said that range condition should be measured in terms of vegetation change and then other attributes can be related to this (see Perry 1976, Figure 2). The proponents of such a system may not realize that vegetation change is not an absolute entity. For any given site, the index of change will vary widely according to the method chosen to measure the vegetation (e.g. biomass, cover, density), the species included (annuals and unresponsive species are sometimes excluded), the data transformation used (e.g. percentage) and the similarity index used to measure the departure from a reference site. Hacker (1979) prescribed eight such indices, all of them ecological, and his data show the wide range in recorded condition that may be obtained on one site. Even the choice of biomass as a measure is a decision to emphasize the productive attributes of a vegetation.

So, we can measure vegetation change by one means or another, but the index chosen will reflect judgements that have been made according to our purpose in measuring that change. If botanical composition, as measured by the Quantitative Climax system serves that purpose (e.g. because the major change in our vegetation is from an edible to an inedible plant) then that method can be used. However, this does not make this sytem a universal measure of condition, or more ecologically-based than any other method. The Quantitative Climax method is not wrong, but it is incomplete.

In terms of these comments, it is suggested that the method used for measuring range condition in central Australia which is based on percentage composition (Lendon and Lamacraft 1976) is incomplete. It needs the addition of a quantity factor (e.g. Foran et al.), or more simply the expression of vegetation data in terms of absolute rather than percentage amounts.

It is also concluded that the separation of ecological and productivity-based methods is artificial. Ecologically-based methods will be constructed and interpreted in terms of productivity, while productivity-based methods will depend on the methods and concepts of ecology for their measurement.

A more formal presentation of these ideas has been accepted for publication (Wilson and Tupper 1982).

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COMMUNICATION BETWEEN LARGE AUSTRALIAN PASTORAL COMPANIES AND A STATE DEPARTMENT OF AGRICULTURE

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ABSTRACT

This study examines contact between twelve large Australian Pastoral Companies and the Queensland Department of Primary Industries (QDPI).

Most contact is with the veterinary services branch. There is a large number of contacts between stock inspectors and property managers although most contacts per person were with the middle managers of the pastoral companies. Most suggestions for improvement related to providing a more practically experienced QDPI officer, especially for contact with property managers. However, it was clearly stated that the Department should also publicise its services more widely.

INTRODUCTION

A small number of large pastoral companies conduct grazing enterprises on extensive rangelands of arid and semi-arid Australia. The companies included in this study control 260 000 km^2 which support 1.2 million cattle, 335 000 sheep and 22 240 ha of crop, and employ 1400 people. They therefore have a key role in the management and maintenance of these areas.

The opportunity exists to capitalize on effective liasion among extension workers, researchers and the pastoral companies by operating with a small number of powerful key personnel, consisting primarily of the general and middle managers of the pastoral companies. This report details part of a wider study on the sources of information used by large pastoral companies and the credibility of these suppliers of information (Schmidt, 1978).

METHODS

Key personnel from twelve companies co-operated in the study. All General Managers were interviewed. Three company members operating at middle management levels and 39 of the 48 property managers who were sent questionnaires returned completed replies. Property managers surveyed were confined to Queensland although the companies concerned also operated elsewhere.

All levels of management were asked the number of contacts they had with the Queensland Department of Primary Industries (QDPI) in the twelve month period coinciding approximately with the 1977 calendar year. Some assessment was made of the actual use and perception of the Department as a regulatory and advisory body. The number of invitations to QDPI field days, schools, workshops or demonstrations, and the number of publications subscribed to, received or asked for, were also assessed. These latter questions were designed to assess in part, awareness and use of QDPI publications and the extent to which the department sent written material to the pastoral company personnel.

Middle and lower level management was also asked to co-operate in a critical incident study (Steers and Porter 1975) of their contact with QDPI personnel. Finally all company members were asked to suggest improvements which might be made to the Department's service.

RESULTS

Contact with QDPI

The number of contacts between the company personnel and QDPI is shown in Table 1. In all but a few cases the greatest number of contacts between the two organisations was on the initiative of pastoral company personnel, and most contacts were at the field staff level (878) rather than the head office level (78). This could be expected because there are a greater number of company personnel and QDPI staff at the field than at the head office level.

Overall, 70 percent of the contacts between the two organisations are made at the lower management level of the pastoral companies, 18 percent are made at middle management level and 11 percent at the top management level. On an individual basis however, the middle managers have the highest number of contacts.

Table 1

Number of Contacts Between Pastoral Company and QDPI Personnel Over a Twelve Month Period

Level of Management	Top		Middle		Lower	
Direction of Contact	From COY	From DPI	From COY	From DPI	From COY	From DPI
DPI FIELD STAFF						
Veterinary Officers	30	6	52	20	83	49
Beef Cattle Officers	1	1	20	5	24	20
Stock Inspectors	7	-	46	7	270	145
Agronomists	9	-	-	-	41	33
Other	-	-	-	-	4	5
Total Field Staff Contacts (878)	47	7	118	32	422	252
DPI HEAD OFFICE STAFF						
Veterinary Services	25	12	16	7	-	1
Beef Cattle Husbandry	6	4	-	-	-	1
Other	6	-	-	-	-	-
Total Head Office Contacts (78)	37	16	16	7	-	2
Total Contacts	84	23	134	39	422	254
Total All Contacts	107		173		676	

REGULATORY AND ADVISORY ROLES

Top level managers use the QDPI more as a regulatory body but they see the Department as an organisation with a greater advisory role (Table 2). Lower level managers see and use the QDPI largely as a regulatory body. Thus these managers need to be made more aware of the advisory functions of the Department before they will utilise it more fully. The number of personnel at the middle level of management was too few for the results to be meaningful.

Table 2

Proportion of Contacts with QDPI Which are Regulatory or Advisory and How Companies See QDPI at Three Levels of Management

Proportion of Regulatory to Advisory		Level of Management: Top		Middle		Lower	
		Actual	Perceived	Actual	Perceived	Actual	Perceived
Regulatory	Advisory						
100	-	5	2	-	-	13	12
75	25	1	4	2	1	9	11
50	50	1	6	-	2	9	8
25	75	1	-	-	-	4	4
-	100	-	-	-	-	2	-

ATTENDANCE AT QDPI FIELD DAYS, SCHOOLS, WORKSHOPS OR DEMONSTRATIONS

(i) Top Management

Only three of the twelve general managers said they had received invitations to attend meetings organised by the QDPI. Eight invitations had been received (four field days, two schools and two standing committee meetings) and six had been accepted. No reasons were offered for non-attendance at two of the functions, but one general manager said that he did not usually attend these gatherings and normally directed the invitations to the station managers.

(ii) Middle Management

Only one of the three middle managers received an invitation to a workshop which he attended. He also attended two field days. The other middle managers said they 'had other unavoidable committments on these dates' and there were 'very few in this area and was tied up with work when anything was on'.

(iii) Lower Management

Five of the 39 property managers had attended gatherings organised by the QDPI during the nominated twelve month period. Eight invitations to field days had been received and seven of these had been attended. Two invitations to schools were received, and one of these had been attended.

Twenty three reasons were given by managers for not attending QDPI functions: No field days held in the area to the knowledge of the manager (14); no time to attend (3); unable to get away because of staff shortage (3); too far to travel (2); or conflicted with busy periods on the property (1).

PUBLICATIONS

The general managers have very little contact with the QDPI in this area of communication and the number of publications either asked for or received automatically from the QDPI is very restricted. Seven of them had neither asked for nor received any publication from the QDPI.

All three middle managers had asked for, and two had automatically received, publications from the QDPI.

Only six of the 39 property managers specifically asked for QDPI publications, but Departmental publications reached 50 percent of managers. Newsletters locally produced by the QDPI had the widest distribution, specially as most are published and sent out monthly.

CRITICAL INCIDENT

(i) Satisfying contact with DPI

The satisfying contacts middle managers had with the QDPI were in the disease control, stock movement, tick control and cross breeding areas. One middle manager did not list any contacts and said that it 'all varied with the individual officer'. Another said that 'mostly their contribution has been consultative. However, their advice has been helpful and modified my approach to tick control and breeding programs'.

The satisfying contacts of lower level management were mostly in the field of disease eradication. Over 50 percent of the satisfying contacts related to brucellosis and tuberculosis testing and the remainder covered a wide range of contacts including co-operating with trial work, advice regarding tick control and supplementary feeding.

(ii) Dissatisfying contacts with QDPI

The dissatisfying contacts that middle managers had with the QDPI were in the disease eradication field, changing regulations, and advice received on a cattle yard plan.

The most common dissatisfying contact that lower level management had with the QDPI was with inexperienced officers. Dissatisfaction was expressed also over discontinued trials, lack of contact, tick control, and DPI officers having no interest in weed control.

SUGGESTED IMPROVEMENTS TO QDPI SERVICE

Company personnel were asked what changes they would like to see to ensure that QDPI would be used more in the future.

(i) Top management

Responses varied from 'we have a good liason from both ways' and 'I use them enough now' to 'I don't use them now, except for things of a regulatory nature. They don't particularly sell their services. No idea what they do really' and 'I haven't made any enquiries how they could help us'.

Two selected suggestions for improving the service were:-

<u>Publicise DPI Services</u>: Three general managers said that the Department's Services should be publicised more. One believed that the 'Information was there but it should be widely publicised' and another said that they should 'send out lists of the services available'.

<u>Market Information</u>: Most general managers said this area needed much more attention. The larger companies were selling cattle every week for a major part of the year, and one of the main jobs of top management was to keep in touch with the market.

(ii) Middle management

Only one middle manager had any suggestions to improve the DPI service:

'The turnover of staff in the .... area makes it very difficult to get meaningful information, advice and opinion in certain areas of management relevant to this area. The extensive properties often need comprehensive wide ranging advice, particularly in such areas as nutritional management, advice on improvements, infertility management and disease control. It took me a number of years (3) to become competent to handle many aspects of my job'.

(iii) Lower management

The suggestions from station managers for improvements in the departmental service were constructive and often detailed. Twenty three of the 39 station managers offered suggestions including those which follow:

- Extension staff are too theoretical and not sufficiently practical.
- "I get the impression that my brains are being picked and information gained is passed on to others".
- Extension staff have little useful information.

- "Perhaps it is our own fault that we do not use all the services available".
- QDPI should provide a booklet outlining services available.
- Regular distribution of technical bulletins for local area.
- Increase personal contact on DPI's initative.

CONCLUSION

The result of contact between company members at the middle and lower levels and the QDPI varied considerably. Most satisfying contacts were related to involvement with disease eradication procedures. In these cases contact has to be made as in most instances the operation of the property is at stake. The implication could be that where property managers have had to become involved with QDPI personnel, the contact has been satisfying.

The dissatisfying contacts related mostly to lack of experience in QDPI field officers or the lack of practical experience. Many property managers saw the advice received from some QDPI officers as being impossible to implement. A possible implication is that the advice may be appropriate for the region but the timing for implementation may not be right for particular properties. QDPI officers should be aware that there is a logical sequence of adoption of practices going from the simple to the sophisticated (Crouch 1970) and it is useless suggesting sophisticated practices when the earlier ones have not been adopted.

Many of the suggestions for improvement relate to property managers not being fully aware of the services and publications provided by the QDPI. Effort by the QDPI to advertise their services and send out lists of publications should encourage greater use of their facilities.

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THE CHARLEVILLE EASTERN MULGA SURVEY 1972-73 TO 1979-80 - AN EXAMPLE OF A MIXED SHEEP-CATTLE ECONOMY.

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ABSTRACT

Results are presented of a survey of costs, returns and profitability in the Eastern Mulga Land Resource Region of south-west Queensland. It was based on seven mixed sheep-cattle properties over the period 1972-73 to 1979-80.

The survey showed extreme fluctuations in net cash incomes, with the average for the period being below what would normally be regarded as adequate compensation for the capital and the family labour employed in earning those incomes. This situation began to change with market recoveries in 1978-79.

Sheep were about twice as profitable as cattle for the eight years as a whole, and the income from sheep was much more stable than that from cattle. Complementarity of sheep and cattle diets, however, and their complementary utilization of labour, should ensure that both types of stock will continue to be grazed on these mulga country properties, relative profitability notwithstanding.

INTRODUCTION

The Eastern Mulga Land Resource Region (Mills 1980) is regarded as one of the less productive areas of the Charleville district. The main problems of the region are poor sheep breeding results, grass seed (*Aristida* sp.) contamination of wool, relative inability to fatten cattle, and husbandry problems arising from mustering difficulties in thick scrub.

In December 1977 a survey of costs, returns and profitability was carried out in the Eastern Mulga. This survey was intended to determine the magnitude of the welfare problem which was evident at the time because of depressed wool and beef markets. Subsequently, this survey has been updated to monitor changing profitability as markets and seasons have changed. The survey initially covered 11 properties - now reduced to seven properties, all operated by their owners since before 1972-73, and all comprising country only within the Eastern Mulga land type. The survey now covers the period 1972-73 to 1979-80.

PHYSICAL DETAILS OF PROPERTIES

Properties surveyed all ran sheep and cattle, as do most properties in the Charleville area. Details of property sizes, stock numbers and family labour are shown in Table 1.

ENTERPRISE TYPES

Sheep enterprises generally were breeding with wether retention, although one property (the smallest) had consistently run wethers only, and two others changed over to buying wethers during the survey period. Sheep breeding performances were "marginal" (50 per cent lambings or worse), however graziers have persisted with breeding because the Charleville area generally is poor breeding country, and replacement wethers are difficult and expensive to obtain.

Cattle enterprises are primarily store breeding. The Eastern Mulga is not fattening country, though in some years fats can be produced, and older cattle will eventually fatten. During the beef recession of 1974-75 to 1977-78 the Eastern Mulga area was particularly affected, since store cattle prices were more affected than fat cattle prices. To cope with this situation graziers sold fat cows instead of steers, spayed and fattened some cows, and retained steers to an older age - both to allow eventual fattening and to wait for a market improvement. The beef recession resulted in most graziers avoiding as far as possible selling cattle until forced to do so by dry conditions, beginning in 1977-78.

GRAZING MANAGEMENT

With two exceptions, graziers ran sheep and cattle together in the same paddocks, even though most said they would have preferred to have kept them separate, or to have worked a system of sequential grazing (cattle - sheep - spell - cattle etc). In only one instance were any paddocks spelled and reserved for sale cattle.

The inconsistency between what graziers did and what they said they would like to do was explained by their not having enough paddocks to maintain separation of different categories of stock, while at the same time separating sheep from cattle. To achieve the required separations would require approximately 40,000 hectares and at least eight main paddocks.

The main benefits from separating sheep and cattle were said to be more efficient mustering and better control of how the country is grazed. There would also be some nutritional effects, with cattle probably getting better diets, and sheep worse ones[1]. The strategy adopted would be influenced to some extent by comparative wool and beef prices at the time.

INCOMES AND EXPENSES

Incomes and expenses (means of seven properties) are shown for each of the eight years in Table 2. Table 2 shows the extreme fluctuations in cash incomes over the period. Furthermore it shows that average incomes have been low for the period as a whole, bearing in mind that these represent the return to an average 1.6 male family labour units (unpaid except out of profits), and a capital investment which averaged about $190,000 over the eight years.

What these figures do not show is the huge increase in average equity which occurred as a consequence of the lift in livestock and land values commencing in 1978-79. At the worst of the depression (1975-76) average capital valuation and equity had declined to $160,000 and $77,000 respectively. By 1979-80 these had recovered to $300,000 and $259,000 respectively. Prior to this recovery, land values had been declining steadily since about 1964, and cattle values had been well below those of the early 1970's. Those graziers who had "hung on" in the face of depressed incomes and values were thus rewarded for their patience.

COMPARISONS OF SHEEP AND CATTLE RETURNS

Cash gross margins of sheep and cattle are compared in Table 3. These are calculated as cash gross income less direct enterprise costs (such as shearing, crutching, chemicals and supplements costs). Table 3 also shows inventory changes (changes in stock numbers during the year). These represent non-cash additions to or charges against net income. If desired, dollar values can be calculated on the assumption of "appropriate" per head sheep and cattle values.

Cash gross margins from sheep were higher than from cattle over the period. Sheep comprised 55 per cent of the sheep equivalents, but provided 77 per cent of the total cash gross margin. More importantly, the income from sheep was more stable, which helped graziers cope with the four years of depressed cattle prices from

[1] For example see Graetz and Wilson (1980).

1974-75 to 1977-78.

It will be noted that the four years of low cattle prices do not coincide exactly with the period of low gross margins from cattle. In 1972-73 and 1973-74 cattle prices were buoyant, however most of the surveyed graziers were holding onto as many cattle as possible, or even buying cattle, to build up their numbers. Thus, these high price years were of virtually no benefit to them. Conversely 1976-77 and 1977-78 were periods of low cattle prices, but increased numbers and then dry seasons obliged graziers to commence selling. This sell off continued for the rest of the survey period and coincided with market recovery in 1978-79. By 1979-80 the drought was severe and the poor quality of cattle by then being sold once again depressed cattle incomes.

PHYSICAL PRODUCTIVITY

(i) Sheep. Due to lack of records it was not possible to calculate average wool cuts, although the most profitable three properties averaged about 4.5kg per head over their whole flocks. These flocks comprised about 40 per cent ewes, 40 per cent wethers, and 20 per cent lambs, with a few rams. All three properties were breeding, and net reproduction (lambs marked less sheep died) averaged 13.8 per cent of the whole flock.

(ii) Cattle. No data was obtained on weights of cattle sold, however net reproduction and turnoff were calculated from the accounting records. Mean net reproduction for the eight years was 23 per cent per annum, and turnoff was 25 per cent, the difference being explained by inventory decline of two per cent per annum.

MARKET MOVEMENTS AND RAINFALL

Survey information may be relevant to the present or the future only if it can be "adjusted" for changing economic or seasonal conditions. The means of adjustment are provided in Table 4, which shows prices, cost indices, and rainfall for the years of the survey.

DISCUSSION

The Eastern Mulga survey has revealed a large degree of income fluctuation, with most of the fluctuation originating in the cattle enterprise. Buying and selling decisions were important determinants of the longer term profitability of the cattle enterprise. Buying and selling skills were important also in the conduct of wether enterprises, but were much less important to the success of breed-your-own sheep enterprises.

On the face of it, sheep were more profitable than cattle (per sheep equivalent) over the eight years. However, if sheep and cattle diets in mulga country are complementary, then this would imply that more sheep equivalents can be carried in a mixed situation than would be the case with only sheep or only cattle on the country. Thus, the gross margins as calculated may be understating the real contribution of cattle to net income.

Almost regardless of profitability, graziers in the Eastern Mulga will probably continue to run both sheep and cattle. The sheep are considered necessary to control mulga regrowth but labour limitations restrict the number of sheep which can be managed. Thus, especially on properties which are "large" relative to the supply of family labour, sheep numbers will be restricted by labour supply at critical times of the year (shearing, fly waves etc) rather than by land area. The "slack" can be expected to be taken up by cattle, which are then managed whenever the sheep do not require attention.

An input which biological research can make in the cattle-sheep-mulga system is to define the degree to which sheep and cattle diets are complementary. This information would help to evaluate relative profitability, and it would allow recommendations to be made on changes to grazing management (to favour sheep or favour cattle) in response to changing market conditions. Furthermore, such dietary studies may reveal how better to manage the pastures to achieve or maintain a more desirable balance of species in the pasture.

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TABLE 1

Physical Details of Eastern Mulga Survey Properties 1972-73 to 1979-80
(Seven Properties)

	Smallest Property	Largest Property	Mean of Seven
Area (ha)	12,640	31,360	20,850
Family male labour units	2	2	1.6
Sheep carried (ha/sheep)	5,140 (2.46)	7,790 (4.03)	5,440 (3.83)
Cattle carried (ha/beast)	212 (59.6)	765 (41.0)	550 (37.9)
Sheep equivalents carried[a] (ha/S.E.)	6,836 (1.85)	13,910 (2.25)	9,840 (2.12)

[a] Assuming one beast = 8 S.E.

TABLE 2

Income and Expenses, Eastern Mulga Survey
(Means of Seven Properties)

Year	Gross[a] Income	Operating Costs	Capital Expenditure	Interest Payments	Net Before Interest	Net After Interest
1972-73	$26,860	$16,510	$2,120	$2,030	$8,230	$6,200
73-74	52,030	19,970	4,300	4,780	27,760	22,980
74-75	25,030	18,160	660	6,070	6,200	130
75-76	28,690	20,850	1,580	6,840	6,260	-580
76-77	38,990	22,490	1,610	8,020	14,890	6,870
77-78	45,980	26,640	2,323	7,220	17,010	9,790
78-79	69,490	30,780	3,340	6,710	35,370	28,660
79-80	84,150	42,860	2,060	5,750	39,230	33,480
Mean	$46,400	$24,160	$2,250	$5,930	$19,370	$13,440

[a] Wool receipts plus stock sales less purchases, all net of selling costs and freight.

TABLE 3

Gross Margins and Inventory Changes, Eastern Mulga Survey

(Means of Seven Properties)

	CASH GROSS MARGINS				INVENTORY CHANGE[a]			
Year	Sheep	($/Hd)	Cattle	($/Hd)	Sheep		Cattle	
1972-73	$20,730	($4.00)	$1,920	($4.70)	+460	(+9%)	+86	(+21%)
73-74	42,440	(8.00)	3,150	(6.20)	-136	(-3)	+116	(+23)
74-75	15,440	(2.90)	2,690	(4.50)	+332	(+6)	+ 56	(+9)
75-76	17,220	(3.20)	2,920	(4.40)	-352	(-7)	+ 96	(+14)
76-77	19,820	(3.50)	9,160	(13.00)	+788	(+14)	- 29	(-4)
77-78	24,126	(4.20)	9,790	(15.80)	-391	(-7)	-145	(-23)
78-79	27,070	(4.70)	31,460	(62.90)	+444	(+8)	- 87	(-17)
79-80	45,740	(8.90)	20,410	(53.70)	-1681	(-33)	-192	(-53)
Mean	$26,570	($4.90)	$10,190	($18.50)	- 73	(-1%)	- 12	(-2%)

[a] Figures in parenthesis are percentages.

TABLE 4

Wool Prices, Beef Prices, Index of Prices Paid

and Rainfall 1972-73 to 1979-80

Year	Wool[a] Price	Beef[b] Price	Index of[c] Prices Paid	RAINFALL (mm)[d] Total	Oct-Mar
1972-73	183.8	74.6	143	538	459
73-74	181.2	78.9	165	746	514
74-75	127.0	31.7	215	398	292
75-76	143.3	38.6	251	699	568
76-77	182.7	48.5	281	567	407
77-78	187.4	52.9	310	286	144
78-79	205.9	110.3	342	510	215
79-80	244.0	153.4	381	230	158
Mean	181.9	73.6	261	497	345

[a] A.W.C. Whole clip average cents/kg greasy.

[b] 300-320kg Ox Cannon Hill, cents/kg estimated dressed weight.

[c] Source B.A.E.

[d] Location Charleville; source Bureau of Meteorology.

THE HISTORY OF LAND MANAGEMENT AND ITS IMPACT ON WATER YIELD ON THE NORTHERN TABLELANDS OF NEW SOUTH WALES

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Australia's Rangelands include the Arid Zone, occupying 70 percent of the continent, and native, or natural pastures in the higher rainfall districts.

This paper is concerned with the latter portion of the Rangelands, and in particular with the pastures on the Northern Tablelands of New South Wales. It briefly examines the changes in Rangeland management which have occurred since early pastoral settlement, and some of the consequences of these changes, particularly upon our most basic rangeland resource - water.

The Northern Tablelands form the catchment area of the Namoi, Gwydir, Macintyre and Dumaresq river systems, all of which flow into the Barwon River, and are therefore of great significance to the Murray-Darling basin. The 3¼ million hectare area stretches from the Moonbi Range in the south to the Queensland border, and effectively across the border to Warwick and Stanthorpe in Southern Queensland. The average elevation approximates 900 metres, rising above 1500 metres on the Eastern scarp, and the average precipitation is 760 mm per annum. Winter temperatures are low, often with long periods of frost, and falls of snow on occasions. The principal soil parent materials are granite, ranging from fine, to coarse (Bull) granite, basalt, and Palaeozoic sediments (Harrington, 1977) but the vegetation has been considerably modified since the coming of European man.

Surveyor John Oxley (1820) records when he ascended to the Tablelands from the Liverpool Plains, and followed up the MacDonald River, a tributary of the Namoi, that "the country, although well clothed with grass, its less luxuriant growth (compared with the Liverpool Plains) showed the difference of soil not to be favourable" p. 289. On the following morning (September 9th) he records that "in the night we had a severe frost" p. 292. These are significant entries, for they indicate the conditions encountered by the pastoralists who were to follow with their flocks and herds, and which initiated, even from the earliest times, their persistent and ultimately successful endeavours to drastically alter the Tableland Rangeland scene.

The history of these endeavours, and the resultant changes in the pastures and stock numbers are documented by Wright (1964), McDonald (1966), Norton (1971) and Whalley et al. (1978). The most important features were ringbarking of trees and regular winter burning of pastures up until well after the turn of the century, and the rabbit plague of the 1920's. Superphosphate was recognised in the late 1920's, and became generally used in the 1930's but the development of aerial top-dressing and seeding in the 1950's led to the rapid increase in pasture improvement which took place from the 1960's onwards. (Table 1 and Figure 1). So fast and successful was this development, so eagerly was it pursued, and so radical were the consequent stocking policies and associated management strategies and decisions that there was little opportunity, even if such had been sought, to observe and monitor associated ecological changes, although a period of drought in the mid-1960's sounded a warning of what might come and created uneasiness in the minds of some.

Table 1: Land-use Changes in the Severn River Valley
(expressed as % of total land-use)(after Banens 1981)

Land Use	1950	1960	1970	1980
Crops	4	7	9	10
Improved Pasture	6	19	27	27
Topdressed Pasture	1	12	20	22
Native Pasture	77	51	29	26
Timbered Land	12	11	15	15

In association with the pasture revolution, and as a consequence of it, there were radical changes in animal husbandry practice and associated property development and management. Stock numbers, both sheep and cattle, rapidly increased (Table 2) and pastoral enterprises changed from a store stock operation, based on the importation of wethers for woolgrowing, and breeding of cattle for sale as store animals, to sheep-breeding for fat lamb and wool production, and the retention of store cattle for sale as fats. These changes brought a requirement for intensive sub-division of properties into smaller paddocks (Table 3), and in turn this precipitated a need for the provision of large numbers of dams for watering points (Table 3). Many such dams were subsequently found to be too small to cater for the greatly increased water consumption, and in the process of their enlargement the

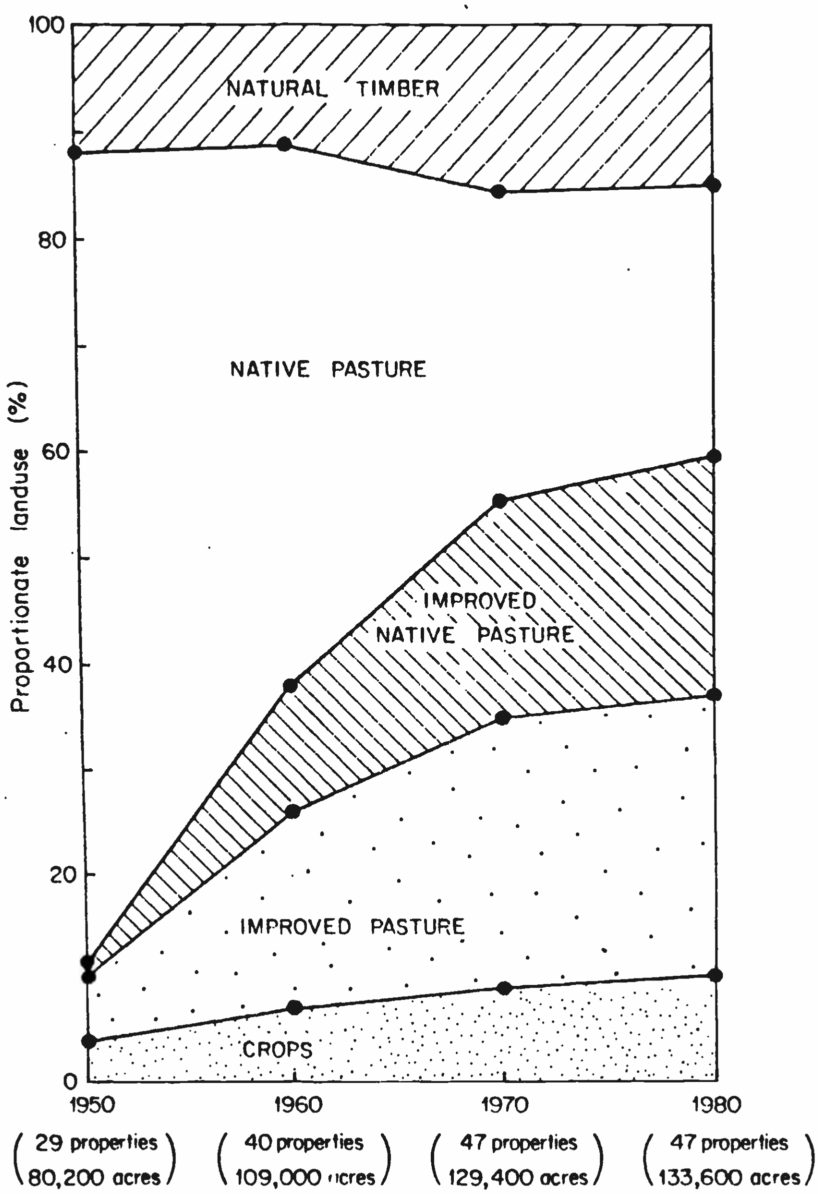

Figure 1: Land-use Changes in the Severn River Valley
(after Banens 1981)

mistake was frequently made of increasing surface area rather than depth, leading to considerable water loss through evaporation. Problems of verge puddling through trampling, siltation and poor water quality soon emerged.

It was also found that many of the hiterto permanent spring-fed creeks containing deep water holes, which were greatly relied upon, became silted from bank erosion caused by stock trampling, particularly cattle, and the free-flow of water was further hindered by the appearance of Cumbungi and other aquatic growths which took root in the silt beds. The most significant change noted however, was an apparent reduction in the amount and intensity

Table 2: Stock Figures
Armidale Pastures Protection Board District

Rated for Year	Cattle	Sheep	Rated for Year	Cattle	Sheep
1957	107,245	2,211,432	1969	195,269	3,710,233
1958	110,556	2,308,317	1970	204,211	3,404,659
1959	108,774	2,389,131	1971	233,230	3,145,463
1960	117,539	2,561,946	1972	279,024	2,863,940
1961	141,615	2,612,532	1973	350,600	2,678,455
1962	156,792	2,552,403	1974	391,434	2,517,236
1963	168,687	2,857,470	1975	429,573	2,638,602
1964	204,901	3,124,700	1976	454,968	2,771,351
1965	220,388	3,612,827	1977	457,039	2,754,391
1966	172,932	3,165,152	1978	458,153	2,868,732
1967	139,620	3,167,374	1979	420,114	2,879,230
1968	179,658	3,842,333	1980	402,654	2,976,445

Table 3: Changes in the Pastoral
Industry in the Severn River Valley Study (after Banens 1981)

	1950		1960		1970		1980	
	Cattle	Sheep	Cattle	Sheep	Cattle	Sheep	Cattle	Sheep
Changes in Livestock Densities (animals per shared 10 hectares)	1.0	17	1.2	22	2.2	27	3.2	26
Changes in average Paddock Size (hectares)	84		60		48		43	
Changes in Dam Densities (dams per 1000 hectares)	4		7		10		13	

of water runoff into streams and dams from storm rains, and a reduction in the flow rate and permanency of the numerous fresh water springs for which the tableland country was noted. These conditions led to the construction of more dams in an effort to store more water when runoff did occur.

However, it was the onset of a two-year drought at the close of 1964 which brought the first real warning of the consequences of the rapid and

and radical changes. The clover dominant pastures blew away in dust; and many of the exotic introduced grass species failed. But more importantly, and significantly, a serious and limiting shortage of water developed. Dams became empty, and springs and streams not known to have failed in the driest of times, dried up. Nevertheless, with the breaking of the drought and ensuing floods, confidence soon returned. The pasture and associated property development programmes were resumed with a vigour which increased with a demand for increased production per acre to offset the impact of a growing cost/price squeeze. The warning of water limitation made many pastoralists uneasy, but an ensuing period of high rainfall dispelled their fears. Stock numbers continued to rise, and there was a significant emphasis on cattle numbers (see Tables 2 and 3).

The bonanza was short-lived. The year 1979 saw the onset of what was to become a far more devastating drought. In contrast to 1965, it was preceded by a period of rainfall sufficient to maintain pasture growth, but insufficient to precipitate runoff from the improved pastures. Consequently, water storages were depleted prior to the onset of the drought and by mid-1980 a water crisis had developed. Water, rather than pasture, had become the limiting factor, and the crisis now was extended to the urban communities, which, over the period under discussion had also increased their demands on available water. Almost every urban supply reservoir reached a stage where remaining supply was calculated in days, not months or years.

Co-incidental with the pattern of changed land-use and management on the Tablelands since the 1950's, there had been a similar change on the Western plains. A traditional pastoral economy was supplanted by intensive agriculture, and the Western rivers, largely fed from the Tablelands source, held vast irrigation potential. This developed on an unforseen and quite unplanned basis, aided by the construction, largely as the result of political pressures and reactions, of large storage dams below the Tableland catchment areas. When drought set in, the consequent drain on these reservoirs reduced them to 20%, and less, of their capacities. Although outflow was curtailed by regulation, and irrigation quotas reduced, the newly-imposed pressure on the rivers reverberated through to the Murray-Darling system. This had obvious, though unforseen repercussions upon their already established irrigation economies, where there is now deep concern not only over the shortage of water, but over resultant problems of salting, and deterioration of water quality. This whole development is now the just cause of extreme concern to South Australia for whom the Murray is the staff of life. However, in looking for solutions to cause and effect, attention must go beyond the new irrigation complex on the upper rivers. It must go also to the Tablelands, which are the staff of life to the Western rivers (see Figures 2 and 3, Severn Valley Rainfall and Runoff Duration Curves). Moreover, it would be dangerous in the extreme to seek simple solutions such as the provision of more water from other sources, as envisaged in the concept of the diversion of Eastern-flowing rivers to the West. In the light of repercussions now being experienced as a result of interference with the natural state of things, such may well exacerbate and extend the problems, rather than cure them.

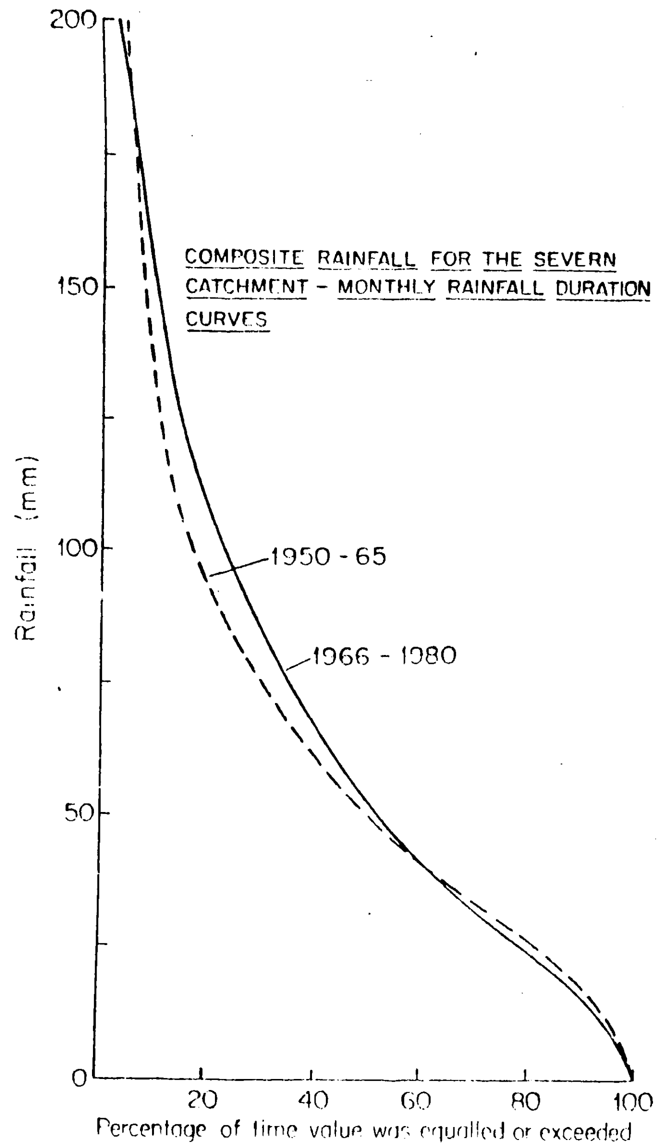

Figure 2: Severn Valley Rainfall Duration Curves

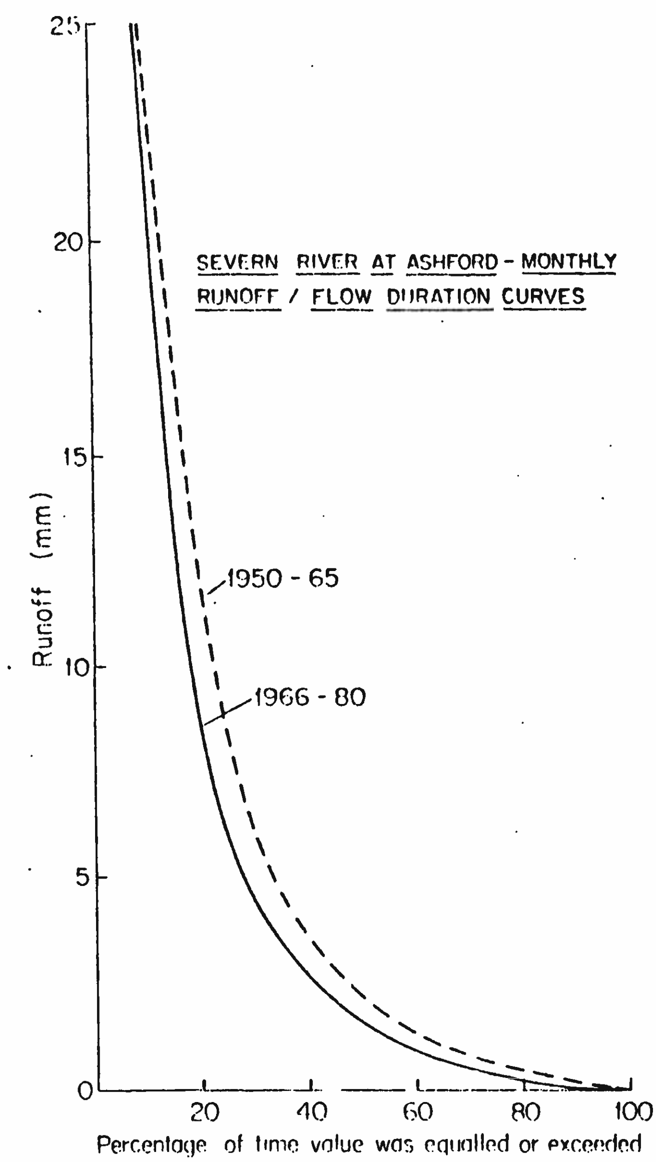

Figure 2: Severn Valley Runoff Duration Curves

The manifestations of this time-fractional chapter in Rangeland mismanagement have now engendered deep concern.

Accordingly, the Resource Engineering Department of the Faculty of Resource Management at the University of New England, in co-operation with a group of graziers, farmers, Local Government representatives and citizens, and with the support of the Conservation Society of New South Wales, has embarked on a Water Management Research programme, with the goal of "Water For the Future". The first phase of this programme, now completed, constituted a study of the Hydrology of the 3500 sq. km. catchment area of the

Severn River, which forms the headwaters of the Macintyre River. This region typifies the pasture development history of the Tablelands.

In summary this study (Banens 1981), which was largely conducted on a personal interview/questionnaire basis revealed the following (see Tables 1 and 2 and Figures 1, 2 and 3):

1. A decrease in native pasture from 77% of total land-use in 1950 to 26% in 1980.
2. An increase in sheep numbers of 55%, and cattle numbers 225% in the same period.
3. An increase in dam density of 230%.
4. A reduction by 50% in paddock size.
5. Despite increased precipitation in the last 15 years as compared with the preceding 15 years, there was a reduction in runoff over the latter period.

These findings substantiate the uneasiness engendered in the 1960's, and confirmed by the drought of the 'eighties', the lesson is that water is a finite resource. We simply cannot continue to take it for granted that there is plenty more where it comes from. Perhaps there is another lesson. The use and management of our Rangeland resources must become less the province of chance and opportunity, to be exploited unthinkingly by land-users, agricultural advisers, economists, politicians, public servants and even scientists. All have their part to play in determining patterns of land-use, but those parts must in future be played with knowledge afore-thought, not knowledge afterthought.

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RUNOFF AND THE AMELIORATING EFFECT OF PLANT COVER

by

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Abstract. Surface runoff was recorded from small plots situated in the mulga rangelands of Queensland. Even small falls of rain (< 15 mm) produced runoff equivalent to over 50% of the rain. Plant tussocks were instrumental in decreasing the number of rainfall events which generated runoff. The maintenance of a perennial grass basal area of > 2% is considered essential to reduce soil movement or erosion through the action of runoff.

Introduction

The mulga (*Acacia aneura* F. Muell) lands of Queensland have been classified as mulga sand plains, soft mulga, hard mulga and dissected residuals (Dawson *et al.* 1975). These authors state that the first two classes are stable, but their productivity and susceptibility to erosion is influenced by plant cover. Mismanagement of the latter two systems increases their inherent instability (Dawson and Boyland 1974).

Surface water movement is somewhat arrested by plant material (Dunin and Downes 1972, Branson 1975). The amount of vegetation required for this in the mulga lands has not been elucidated, even though work in the Northern Territory indicates that sediment yields of 120 kg ha^{-1} are possible on these rangelands from < 30 mm of rain (Gifford 1978). In this paper I look at how the frequency of runoff varies with the quantity of rain, and the effect of plant cover on runoff frequency.

Materials and Methods

Rainfall and runoff were recorded between November 1972 and January 1974 from twenty four micro-catchments, each 2.4 m x 1.2 m, installed in the soft mulga zone under tree densities ranging from 0 to 4 000 trees ha^{-1}. Soils were infertile sandy loams (Gn 2.12, Northcote 1965) ranging between 1 and 2 m deep. The frequency of occurrence of four classes of runoff - < 1 mm, > 1 ≤ 5 mm, > 5 ≤ 10 mm and > 10 mm - recorded from five classes of rainfall - > 10 ≤ 15 mm, > 15 < 30 mm, > 30 ≤ 50 mm, > 50 ≤ 100 mm and > 100 mm - was then calculated.

Surface runoff was also collected from 100, 1 m x 1 m plots installed in the soft mulga, hard mulga and dissected residual land zones. Water was applied through a shower rose using a modification of the equipment described by Costin and Gilmour (1970). Water was applied to initially dry soil for either 90 minutes or when the equivalent of 10 mm runoff was collected, which ever occurred first. The basal area of all vegetation within the plot was then measured using either a line transect technique, or measuring the circumference of individual grass tussocks with a flexible steel tape. The frequency of five classes of runoff - expressed as a percentage of rainfall - were calculated for four basal area classes - ≤2.0%, >2 ≤4.0%, >4 ≤8.0%, >8.0%.

Results and Discussion

More than 88% of natural runoff events recorded from rainfall >10 ≤15 mm were <5 mm in aggregate, but in excess of 11% were in the range >5 ≤10 mm (Figure 1). Further, while over 76% of runoff events from rainfall >100 mm exceeded 10 mm, 17% of the runoff events recorded were <5 mm. Rainfall intensity and antecedent soil moisture conditions played some part in these anomalies. For example, 22 mm of rain falling over five hours yielded 88 mm of runoff from 24 plots, whereas 20 mm over eight hours yielded 3.5 mm from the same plots. Similarly, 82 mm falling in 18 hours yielded 246 mm from 22 plots, contrasted with 92 mm runoff recorded from the same plots from 72 mm of rain falling over 42 hours.

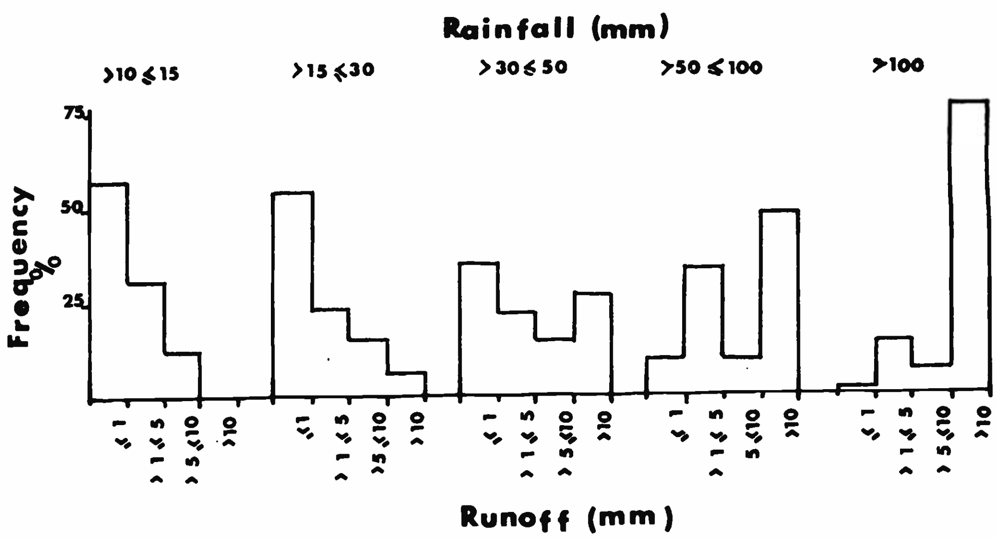

Figure 1. The frequency of four classes of runoff events related to amount of rainfall.

Rainfall totalling 42 mm fell two days after 165 mm of rain. The soil surface was wet and runoff exceeded 308 mm from the 24 plots. In contrast, 40 mm fell over a similar time interval three months later yielding only 212 mm of runoff from the same plots. The soil surface was dry prior to this as no rain had fallen for the previous 3 weeks and no runoff was recorded in the plots between the two events.

The frequency distribution of runoff with respect to four classes of plant basal area is shown in Figure 2. Runoff in excess of 60% only occurred when basal area was < 2%.

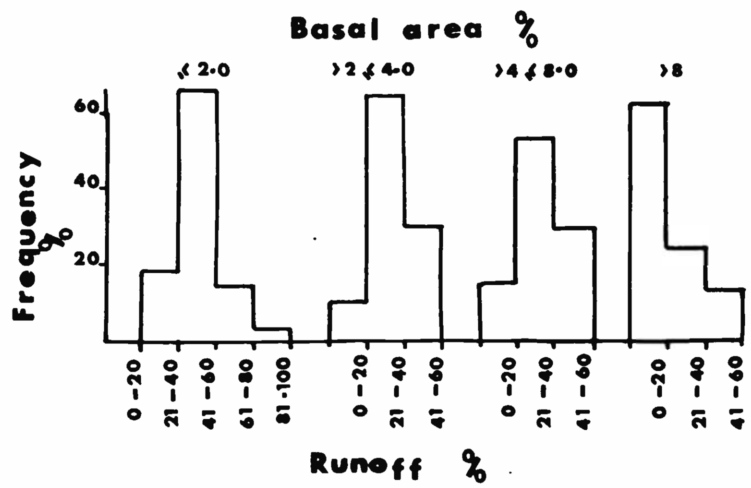

Figure 2. The effect of the basal area of vegetation on the frequency of runoff, expressed as a percentage of rainfall.

The overall data show that basal area was positively correlated with runoff but there was no relation when the data from the hard mulga and residuals were analysed separately from the soft mulga areas. This is probably a reflection of the low basal cover of the vegetation on these areas: the maximum and mean basal area recorded for them was 2.6% and 0.7% respectively. It appears that on these areas other factors such as the bulk density of the soil, and slope tend to dictate runoff potential, and unless the basal cover of the pasture can be increased substantially it is unlikely that stock management will succeed in reducing runoff.

However, as basal areas on the soft mulga areas (3.9 ± 0.6%) are higher than those on the hard mulga and dissected residuals (0.7 ± 0.1%), the data in Figure 2 indicate that stock management to maintain a basal cover in excess of 2% on these areas will result in less surface water movement and greater infiltration of rain water. The removal of standing plant biomass and litter through extended periods of over-grazing or other means will tend to increase runoff and together with increased wind and water erosion - particularly on the hard mulga land zones and dissected residual land zones (Skinner and Kelsey 1964) - will inevitably lead to poorer conditions for germination and establishment of plants (Condon et al. 1967). Major changes to the soil surface condition will then be necessary to encourage increased soil water availability and thus plant growth.

It is inevitable though that deterioration of portions of some mulga landscapes will occur - if not from the extended periods of drought common in the mulga regions, then from the continuance of the present stock management. A more flexible attitude to stock numbers may be one way of reducing this problem. Research in the Charleville district is continuing towards a management policy of adjusting stock numbers at the end of summer in accord with pasture on offer at that time. This approach may also result in a reduction in the quantity of mulga pushed or cut for stock feed and so aid in the maintenance of ground cover.

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EROSION IN PASTORAL REGIONS OF AUSTRALIA

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INTRODUCTION

Explorers records of inland Australia indicate that much of today's pastoral zone was subject to wind and water erosion before the land was subjected to domestic stock. Australia's contribution to the United Nations (1977) survey of arid land degradation indicates that Australia now has serious man-made problems of desertification and contributes substantially to the 5.2 million/ha which is added annually to the global area of desert.

In Ratcliffe's (1938) words "Australians have every reason to be intensely proud of their record in settling the great spaces of the inland. They are to be blamed only in that they seem to have done the job too thoroughly". The erosion situation in the pastoral zone was officially recognized as a serious problem for the first time in Australia when a Royal Commission was established in 1901 to investigate the position in the Western Division of New South Wales. Not surprisingly the Commission found an ill-advised land tenure system and gross over-estimation of the carrying capacity to be prime causes of land deterioration. Perry's (1967) graph of the sheep numbers from 1860-1960 in the Western Division demonstrates the return to realistic stocking rates at the turn of the century. The most recent national survey (Dept. of Environment, 1978) indicates that 48% of the arid zone presently suffers from some form of erosion. (Table 1).

The importance of the pastoral region to the national economy is reflected in the fact that the arid and semi arid zones alone carry approximately 34% of Australia's cattle and sheep populations.

SIGNIFICANCE OF EROSION IN THE PASTORAL REGIONS

Although the significance of erosion cannot be evaluated solely in monetary terms, the present estimate (Dept. Environment 1977) of the expenditure required to alleviate erosion in the arid zone is $65 million compared with $86 million in intensively cropped regions.

Surveys of the financial value of pastoral production eg. Bureau of Agricultural Economics' Survey of the Australian Grazing Industry 1973-4, fail to indicate the changes in carrying capacity associated with erosion in the pastoral zone as shown in Figure 1. However, the Department of Environment's (1977) survey estimates that of the 4693,000 km^2 constituting the grazing zone of Australia; 1010,000 km^2 requires management practices to be applied and 3200 km^2 requires a change in land use to protect its productivity. Within the arid zone $13 million is required for soil conservation treatment works in the class of "urgency level 1", ie. within the next 10 years. An investment of $96 million is quoted for a similar period in the non-arid grazing zone. The distribution of the types and severity of erosion is shown in Figure 2.

Although runoff experiments have been criticised from a research point of view and extrapolation to the property scale requires caution, the Hill Grazing Experiments of the Soil Conservation Service of N.S.W. (1953) have a special significance. The demonstration and educational value of these experiments carried out at several stations over a long period has been overlooked by many extension workers in the pastoral region. These data, as shown in Table 2 demonstrate not only the striking differences in runoff resulting from differential stocking, but even more striking differences in soil losses. When these losses are related to Leigh's (1974) estimates of the level of deterioration of each major vegetation type, the significance of the results of both studies becomes more evident.

CAUSES OF EROSION IN THE PASTORAL REGION

Despite the identification of overgrazing as the prime cause of erosion by many authors (Blake 1936, Beadle 1948, Perry 1967, Moore 1969 and Roberts 1972) there exists a sequence of causes which include ecological, historic, economic and social factors.

Beadle's (1960) evidence indicates that the vegetation of the semi-arid zone evolved under relatively light grazing except in the vicinity of permanent waterholes. This is ecologically very different from the evolution of grasslands on other continents where intermittent heavy grazing by large herds of migratory hard-hoofed animals was an important evolutionary force (Roberts 1971).

Perry (1968) points out three other differences between Australia's arid grazing lands and those of other countries:

(a) A short history of use by domestic stock in Australia – in some regions barely 100 years.

(b) Almost total government ownership of Australia's arid lands.

(c) A lack of opportunity to apply a nomadic or seasonal pastoral system due to land tenure, distances and topography.

While much has been written on the evils of overgrazing, Davies (1955) points out that while overgrazing is harmful, moderate grazing may improve the vigour of certain semi-arid pastures as demonstrated by Wood (1936) in the saltbush country of New South Wales. Similarly, Ehersohn (1967) has postulated that stocking may have a beneficial effect in Mitchell grass on cracking clays, through the effect of animals hoofs on soil moisture relations.

PROCESSES LEADING TO EROSION

The relationship between plant cover and soil loss by water and wind erosion is well known. In the open grassland situation Roberts (1975) has suggested that particular sequential relationships exist between the four main phases of deterioration, as shown in Figure 3. For shrub-dominated vegetation Marshall (1970) has postulated the mechanisms of vegetative protection against wind.

It is of the utmost importance that the irreversibility of certain advanced stages of these processes be recognised by those responsible for determining policy and the allocation of funds for soil conservation. This is particularly the case in areas where the soil is prone to scalding, leading to an ecological fix in which the absence of soil moisture prevents ecesis and succeeding developmental stages in revegetation. In addition, the loss of topsoil nutrients must be accepted as a permanent loss that will be reflected in both the quantity and quality of vegetation growth which follows such losses. The only Australian research to accurately quantify the reduction in yield and nutritive value of plants growing on differentially eroded soils is that of Daniel (1969).

POSSIBILITIES OF ECOLOGICALLY BASED MANAGEMENT

The view is held by many researchers and landholders that variation in annual rainfall has such an overriding effect on the vegetation, that the effects of management can never be more than marginal. Theoretically there exists a relationship between defoliation and plant cover and in the same way erosion rates are generally related to plant cover. The writer (Roberts 1972) has enumerated those factors which may be considered as managerial variables. Within the cost/price structure in which the landholder must operate, the following factors can be controlled:

1. Total number of livestock
2. Breeds of each type of livestock
3. Ratio of cattle to sheep
4. Combinations of animal groups running together
5. Heavy intermittent grazing of paddocks
6. Fencing of main vegetation types into separate paddocks
7. Positioning of waters and licks
8. Burning
9. Mechanical shrub control
10. Water spreading
11. Seeding of improved species

The above factors hold a wide range of combinations which could affect the vegetation and the rate of erosion substantially. Basic to the economic and ecological maintenance of any grazing enterprize is the need for property size to be sufficient to constitute a "Living Area" in the region concerned.

The search for impirical evidence of the difference in condition and long term productivity between well managed and poorly managed properties must continue. Only such differences will convince landholders and policy-makers that erosion control and long term stability can be significantly improved through land management. In this regard, the evidence in favour of lowering stocking rates to increase liveweight gains per animal and to lower costs needs to be further evaluated.

THE ECONOMIC FIX OF REHABILITATION

It is clear that even partial destocking is not acceptable to many landholders whose decisions are largely controlled by financial institutions and pastoral agencies. In many cases the land tenure system has encouraged exploitation and the conservative landholder has not found careful husbandry of the land to be in his best interests. In certain freehold areas, the price paid for the land has borne very little relationship to the level of returns which can be expected at a safe stocking rate. In virtually all cases the low productivity of arid lands cannot bear any financial costs aimed at controlling erosion by the construction of earthworks.

Added to the inability of grazing land to carry restorative costs, is the generally serious position relating to property incomes in the pastoral zone overall. The B.A.E. survey (1976) of the grazing industry indicated that of all the properties in the pastoral zone (as shown in Figure 1), 36% had a negative income and a further 28% had an income of less than $10,000 per annum, giving a nett property income of $7805.00 for all properties in this zone, as compared with $14,125.00 for the wheat-sheep zone.

From an economic viewpoint, careful consideration must be given to which of the four target levels of erosion control should be aimed at: i) Do Nothing, ii) Retard, iii) Maintain or, iv) Improve present erosion rates.

A decision to improve the situation could prove to require an investment beyond the means of many landholders. For instance, while most landholders were making less than 5% on their total investment, one in 5 landholders in Western Queensland had debts exceeding 60% of their property market value (Bain and Waring 1970). Taken in this context, the required soil conservation expenditure of $59/ha in the arid zone and $1300/ha in other pastoral regions (Dept. Environment 1978) is unlikely to be committed unless substantial subsidy increase is forthcoming. Serious anomolies arise when restoration costs exceed land costs and in the 55% of the arid zone and 36% of other pastoral zones requiring soil conservation treatment, deterioration is likely to continue ("Do Nothing") in the absence of more realistic financial aid.

CONCLUSION

The pastoral zone is suffering widespread deterioration some of which has reached serious proportions. Certain of the retrogressive processes are irreversible in the absence of expensive restorative practices. The economic situation presently precludes landholders from undertaking much of the required conservation work. The economic value of the pastoral regions to the nation warrants greater support through research, extension and financial assistance if the productivity of these regions is to be maintained.

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TABLE 1: Form of degradation and construction costs of necessary works in areas requiring treatment in arid zone of Australia at June, 1975 (Dept. Environment, 1978)

	Land used for grazing		Construction cost of works needed.	
	000 km²	(%)	$m	(%)
Area in use	3356	-	-	-
Area not requiring treatment	1506	-	-	-
Vegetation degradation and little erosion	950	(51)	10	(15)
Vegetation degradation and some erosion	467	(25)	25	(38)
Vegetation degradation and substantial erosion	284	(15)	21	(32)
Vegetation degradation and severe erosion	148	(8)	10	(15)
Dryland salinity - sometimes in combination with water erosion	1.1	(0.059)	0.18	(0.28)
Total treatment needs (areas and costs)	1850	(100)	65	(100)

Figure 1: Pastoral Zone (B.A.E., 1976)

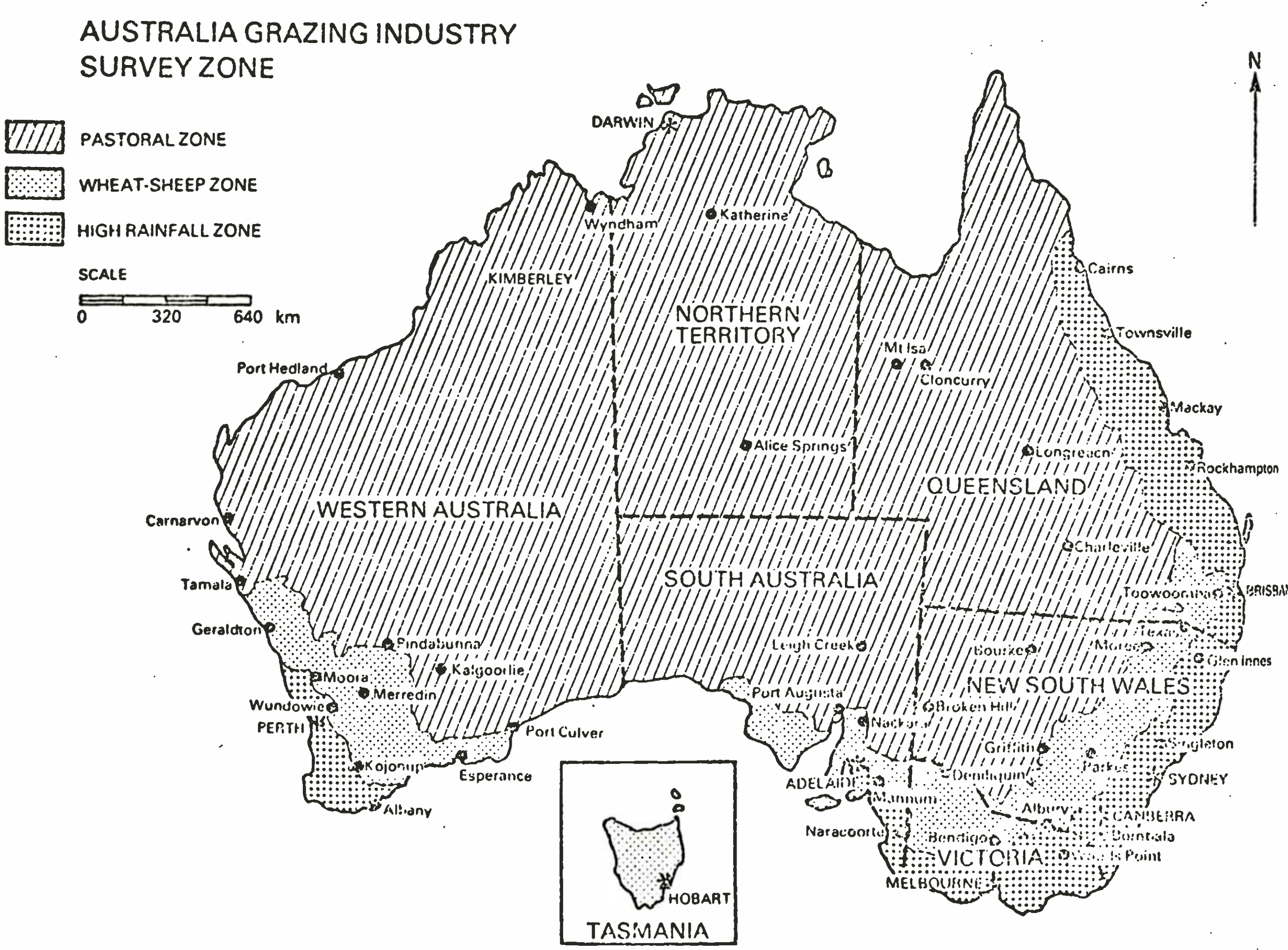


TABLE 2: Run-off and Soil Loss from Hill Grazing Experiments, Soil Conservation Service of N.S.W. (See Buckley 1953).

GUNNEDAH RESEARCH STATION*

Grazing Treatment	Run-off (inches)	Soil Loss (lbs/acre)
Heavy	20.67	18,584
Light	2.68	709
Nil	1.10	127

* Totals are from 1948 to 30th June, 1972.

WELLINGTON RESEARCH STATION [T]

Grazing Treatment	Run-off (inches)	Soil Loss (lbs/acre)
Heavy	11.28	12,638
Light	1.50	738

[T] Totals are from 1st September, 1949 to date.

COWRA RESEARCH STATION [(a)]

Grazing Treatment	Run-off (inches)	Soil Loss (lbs/acre)
Heavy	4.03	806
Light	0.73	84

(a) Totals are from 1953 approximately to 30th June, 1972.

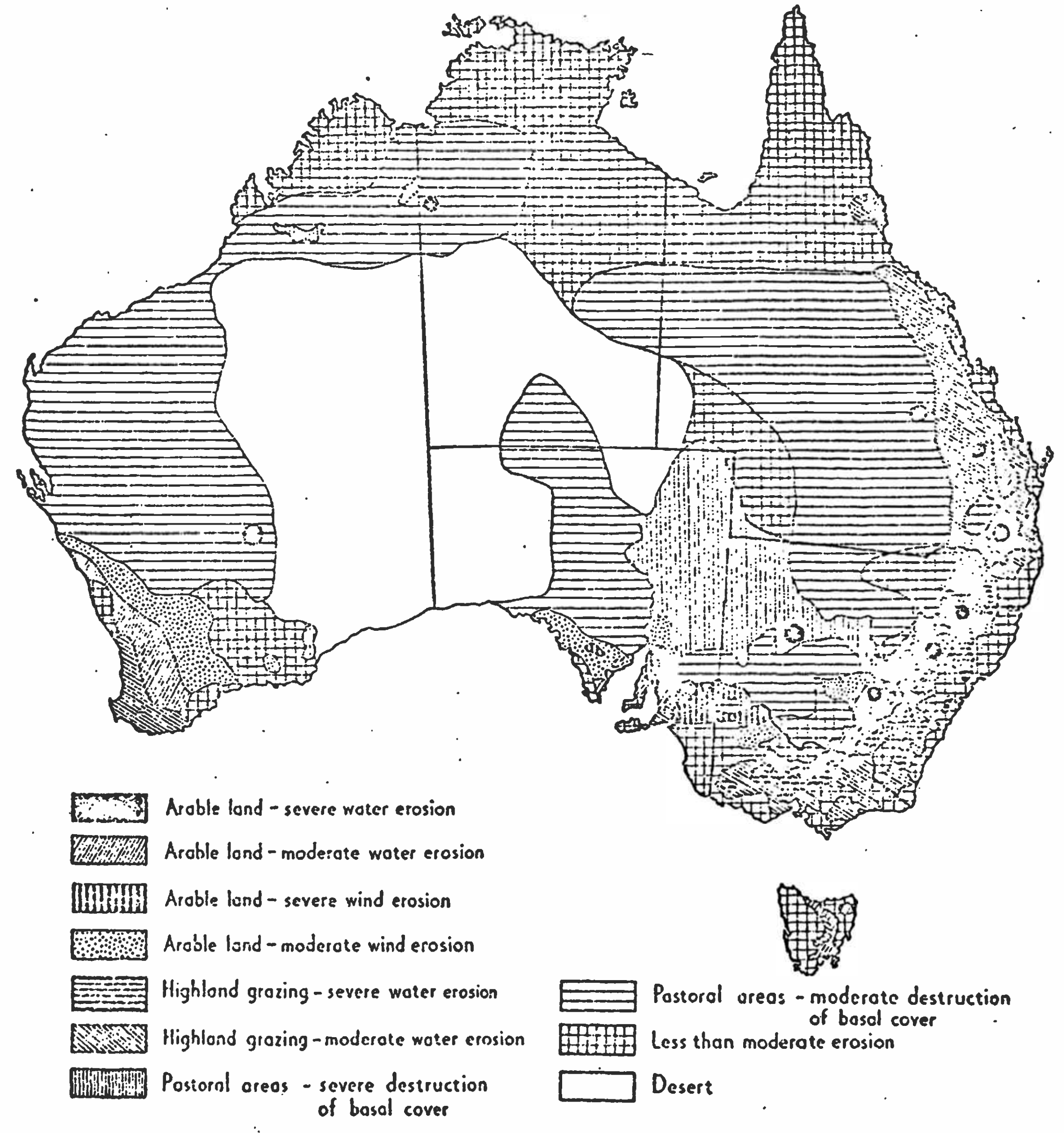
WAGGA RESEARCH STATION [(b)]

Grazing Treatment	Run-off (inches)	Soil Loss (lbs/acre)
Heavy	16.76	5,278
Light	4.35	431

(b) Totals from 1950 approximately to 30th June, 1972.

(1" = 25mm; 1lb = 0.45kg; 1 acre = 0.4 ha)

Figure 2: Distribution of Soil Erosion in Australia *



* Adapted from a map by R.1. Heriot, Dept. Agric. S.A.

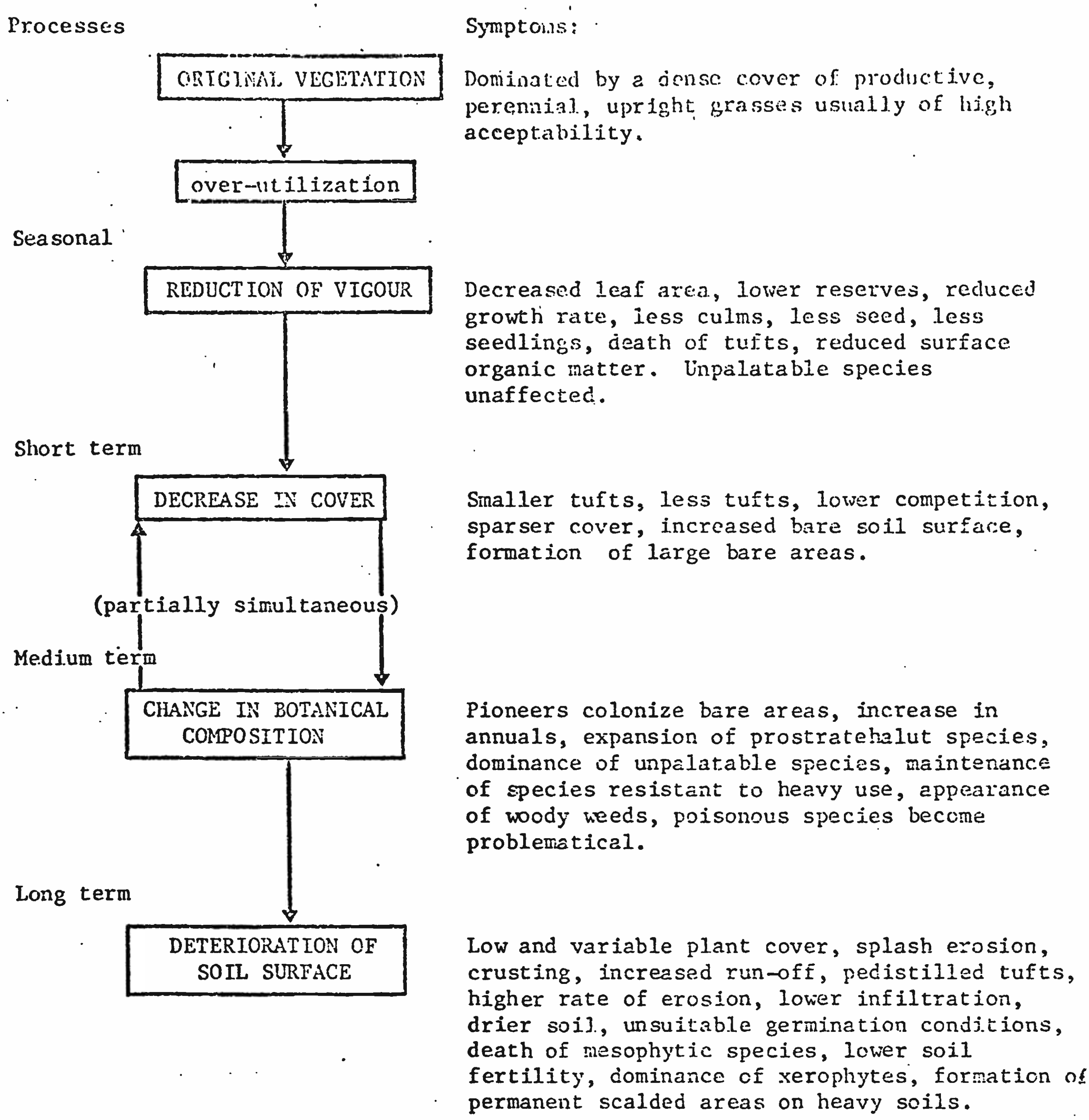


Figure 3: Theoretical sequence of processes in land degradation following continued over-utilization of the vegetation. (Roberts et al, 1975)

RANGELANDS USERS AND THEIR ABILITY TO CO-EXIST WITH UNIONS IN THE 1980'S.

By Geoff Rodda - "Nagaella", Broken Hill

Australian Rangelands users go into the 1980's in trepidation.

Firstly they are the victims of a vicious circle that has been with us since "indexation" was brought in. The escalating effects of world parity fuel pricing would be slightly easier to stomach if some of the "rake off" was put back into our road systems. The scramble by a variety of sections of the community - both inside and outside the normal indexation guidelines - for more and more wages and more and more leisure time and longer holidays (which they are unable to enjoy without yet more loadings) don't seem to take much account of rural industries' ability to meet their demands when the same rural industries are "tied" into the system but receive NONE of the benefits.

In the Rangelands where the good years are traditionally few and far between, surely we can be excused for wondering why in the hell we should foot the bill with a 17½% loading for an employee or a series of employees to enjoy his or her holiday, when in fact a great majority of us haven't been able to take a holiday in years.

Perhaps we may be regarded as renegades by trying to bring in improved shearing shed designs - with Roller matting, new shed lay outs, power wool presses and round wool tables - so that those of us who shear privately with our own labour can get some benefit at least.

Recently I read that 36% of wool income was taken in the harvesting of the wool clip. If this is so, how much longer can we go on before the sheep section of our Rangelands users again become unviable? Whilst the wool industry is currently enjoying stability of a kind (on a base that it funded itself) and while surplus sheep are in demand (thanks to the export meat industry that has provided a base in this regard, despite recent troubles with Unions over the live sheep export issue) those of us who are not drought affected MAY remain viable.

However, with a floating dollar and an even stronger Yen, the ACTUAL MONETARY VALUE of the return of our export products has, in "real" terms, been declining for years. What happens to the cattle industry when it has the next recession? That Land Cruiser that cost $6000 in 1975 now retails at $11,000. Freight, food, fuel, fodder and naturally rents, rates and taxes have all increased accordingly due, to a degree, to pressures from their respective Unions. When the cycle turns, as it has always done and no doubt will continue to do, WHERE ARE OUR RESERVES to be able to cope with it? Where are there any that have not been eroded by inflation? I would suggest that in large areas of our Rangelands - after years of drought and lean times - that they are at best minimal.

Some will naturally say "you can't blame the Unions for all that" and I agree. Of course we can't and don't, BUT a large degree of it IS attributable to their demands. The more muscle and the more organised that a Union is, the better paid the members are. As a rough instance, a shearer shearing 120 sheep a day would gross roughly $480 per week, whilst a mechanic (after a 4 year apprenticeship which includes 12 months at night-school) grosses around $180 per week and they BOTH provide their own tools to carry out their trade.

You could ask "Is there an answer?" and I could only reply "Frankly, I don't know". My only suggestion would be to opt for a greater degree of flexibility between employer and employee, perhaps with extra time off taken in lieu of overtime, especially relating to weekend work round shearing and crutching times. In relation to the shearing side of the industry, I can only suggest a more open attitude on BOTH sides. If innovations are made that make shed work easier - more comfortable and less tiring for all concerned - then surely IT IS OF BENEFIT TO ALL OF US. Don't tie any section to a specific requirement, as circumstances alter cases. You could have 3 shearers in one shed all shearing 200 sheep a day, and perhaps in another 5 shearers doing 95 each per day, so the ability, needs and manning levels of each shed team would differ greatly.

Lastly, look at the wine and grape industry, hardly a Rangelands topic, but relevant nevertheless. Costs, wages and the weather forced fruit growers to look for alternatives to their traditional harvesting methods and they were found in the form of the mobile harvester. Each year we see more of them operating up to 24 hours a day, picking blocks in hours that 5 years ago took weeks to harvest. One blockie told me that "It rarely has a sickie, never needs "Compo" and doesn't cost holiday pay". We realise that mechanical wool harvesting is presently in its infancy, but I would suggest that inevitably wage pressures and other industry related costs could accelerate research, perhaps with a financial input from wool growers. If such research is successful it could be deemed - by the Unions at least - to be detrimental to their members.

In closing my key words would be to all parties:

"BE FLEXIBLE IN YOUR APPROACH AND TRY AT ALL TIMES TO SEE THE OTHER PARTY'S POINT OF VIEW".

"DON'T KNOCK INNOVATIONS BECAUSE THEY SAVE LABOUR".

"DON'T PUSH RANGELANDS INDUSTRY TOO FAR BECAUSE THE NEXT JOB THAT'S PHASED OUT BY LACK OF FUNDS MAY WELL BE YOURS OR, WORSE STILL.....MINE".

THE USE OF LABOUR ON PASTORAL PROPERTIES

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ABSTRACT

The amount and type of labour used on pastoral properties in the north east of South Australia is examined. Two different strategies in the amount of labour employed to handle the same number of sheep were found. The high turnover of staff, the declining permanent work force, and the particular problems of hired managers are considered. Some implications for future property management are discussed.

INTRODUCTION

An interview survey of property management was conducted in the north east of South Australia late in 1980. The region surveyed (figure 1) comprised 30 management units south of the Dog Fence mainly running sheep. Each property manager was asked about the problems he faced in 1980. Labour was most often selected as the main problem at the time of the interview.

The amount and type of labour employed on a pastoral property is one of the major cost determining factors of the pastoral enterprise. Wages accounted for between 20 and 25 percent of total operating costs in a subsample of 16 properties for the years 1975 to 1980.

During the seventies most of the properties in the study area reduced the number of full time workers they employed. This reduction in the permanent workforce was an attempt to contain the cost of wages. The use of motor bikes, faster transport of stock to markets, innovations in sheep handling and the acceptance of a lower level of maintenance of fixed structures have facilitated this adjustment strategy.

This paper begins by describing the different types and amounts of labour employed on pastoral properties. The special problems of hired managers who control much of Australia's pastoral lands are considered in some detail and implications for the future are discussed.

TYPES OF LABOUR

Managers can choose to meet the labour needs of their properties by employing full time workers, part time or casual workers, family members or specialized contractors.

Part Time

Most managers are forced to employ extra labour at shearing (about 5 man weeks per property in 1980). At crutching more than half of the managers used some part time labour. One third of managers employed between 2 and 8 man weeks of part time labour in 1980 for other general station work. There appeared to be little trouble finding suitable part time labour.

Family

A great deal of family labour is used on pastoral properties. The average number of family members employed in 1980, including the manager, was 1.6. Sons and daughters are often stationhands and jilleroos, wives are frequently cooks, and other family members may be available to help in busy times. This flexibility in family labour was noted by Chudleigh (1971). Family labour is often unpaid which helps to keep the cost of wages down.

Contract

Specific tasks such as erecting new fences, sinking bores, fibreglassing tanks, and cleaning dams are being increasingly performed by contract labour. In this way the manager gets work completed but avoids many of the problems associated with full time employees.

Full Time

Most managers complained that there was a lack of reliable skilled full time workers. Station hands and jackeroos seemed to change jobs at least once a year. Good married station hands are one of the most valued resources on pastoral properties. Employers prefer married men because families are a stabilizing influence. The presence of a wife and family diminishes the isolation of life in the bush but introduces the problem of educating children and the potential loneliness and dissatisfaction of wives unaccustomed to an isolated life style.

THE AMOUNT OF LABOUR USED

An attempt was made to identify the level of labour usage on pastoral properties. The amount of part time labour used was positively related to property size but not related to the number of stock carried. Conversely the number of full time workers employed was positively correlated to the number of stock carried but not related to property size.

There appeared to be no relationship between the amount or type of labour used and any of the property structural variables such as paddock number, paddock size, ratio of small holding paddocks to large paddocks or number of permanent waters.

The number of stock carried can be used to predict the rate of labour usage on individual pastoral properties. Two significantly different labour strategies were found in the survey population (figure 2). Separate linear regressions were fitted for the two strategies and are reported below.

Strategy 1, n = 20

Total labour in man years = 0.45 + 0.00027 (no.sheep) $R^2 = 0.81$
(0.26) (0.000030)

Strategy 2, n = 7

Total labour in man years = 2.18 + 0.00033 (no.sheep) $R^2 = 0.98$
(0.19) (0.000018)

The main difference between the two strategies is the base rate of labour usage. Those practicing strategy 2 as opposed to strategy 1 employ 2 more man years of labour for the same number of sheep carried. No recorded reason can be found for the difference between managers practicing the 2 strategies (factors such as total area, paddock size, number of small paddocks, number of unpaid workers, proportion of work done by part time employees, number of sheep carried, managers's experience, hired verus lessee managers etc. were not related to the strategy used). This suggests that the two strategies represent different stages in the adjustment process.

About three quarters of managers, those employing strategy 1, have already reduced their work force to a minimum. Managers currently practicing strategy 2 could probably run their properties with 2 less man years of labour. The amount of labour used in the north-east is likely to decline until all managers are practicing strategy 1.

Both strategies embody a marginal rate of labour usage of 1 man per 3,300 sheep. Alexander and Williams (1973) noted for the pastoral zone that one man could handle 2,500 sheep in 1969. Each unit of labour in the study region was handling an average of 30% more stock than the 1969 average.

HIRED MANAGERS

Thirteen of the thirty properties in the study region were run by hired managers. Each hired manager was responsible for about twice the area controlled by an owner manager. The hired managers tended to be younger, to work longer hours, to be in charge of more men and to have less experience on their current property than the owner managers (Table 1).

Hired managers rarely stay in one job for more than a few years. New managers usually have little knowledge of the properties they are employed to run. Consequently the majority of absentee lessees set rather rigid calendars and reserve all major managerial decisions for themselves. As one astute manager remarked "if hired managers do not have average years they are in trouble, and whoever heard of an average year?"

Lessees who do not live on their properties have little chance of understanding what is happening to the country (more than half either manage other properties or are retired). Very few lessees appear prepared to change their plans in response to comments and suggestions made by their managers. In some cases lessees insist on doing all the purchasing and frequently do not send exactly what the managers require.

Several hired managers complained that they were receiving only $5 to $10 above the award wage for an adult station hand which was $154 per week ($8000 per annum). Although hired managers have a lower cost of living than urban workers, in South Australia they are faced with huge educational expenses. Parents must either send their secondary school children to boarding school and pay between $4000 and $5000 per year per child, or move close to a secondary school.

All these things leave little room for any job satisfaction for most hired managers.

IMPLICATIONS

Low wages, unreliable communication and isolation from social, medical and educational facilities make employment on pastoral properties relatively unattractive. The high rate of staff turnover means that managers must put a lot of time into hiring and training new employees. The best way to keep permanent employees is to treat them well. "It may cost a little more but the loyalty gained is worth the extra cost" (Pick and Alldis 1944).

"It takes time to learn the particular aspects of stocking levels, care of stock and waters, and what stock to run where, on any particular property" (Childs 1978). Every time an experienced station worker leaves his current position there is a loss of valuable expertise. Unfortunately there is little effective formal training available and consequently workers new to the area are likely to make mistakes which could be detrimental to the land. There is a need to collect and record the experiences and advice of people who have worked on pastoral properties and who understand the country in both its good seasons and its droughts.

As a result of the declining labour force, the condition of fixed structures on most properties has deteriorated. But, there is a limit to the extent to which labour can be reduced. Given the current level of technology, most managers in the north east consider that they have already reached this limit. Managers must look to new methods of sheep handling and evaluate different types of fencing, shed design, water catchment etc., if they are to remain economically viable.

In 1980 only four out of 30 managers reported having problems with unions or strikes, although several other managers had experienced delays in the handling of their wool clip. Pastoralists have few direct industrial problems; most of their troubles with unions are associated with bans on the export, handling or transport of wool and live sheep. Such bans are not usually directed at disrupting agriculture but rather are motivated by political reasons or by the demands of urban workers in secondary industries. With the recent demise of automatic wage indexation, these problems will probably escalate.

Currently the agricultural labour market is unstructured and characterized by relatively primitive working conditions, labour relations and personnel practices. If agricultural workers were to unionize in the future, pastoralists would have many more direct union problems.

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Table 1. Median values of selected characteristics of hired managers and owner managers

	Owner Managers (17)	Hired Managers (13)	All Managers (30)
Property area (km^2)	394	709	474
Number of full time employees in 1980 (including the managers)	2	4	2.5
Total weeks of part time labour used per property in 1980	10	12	10.5
Years manager has worked on the property	14	2.5	10
Manager's age	42	36	38

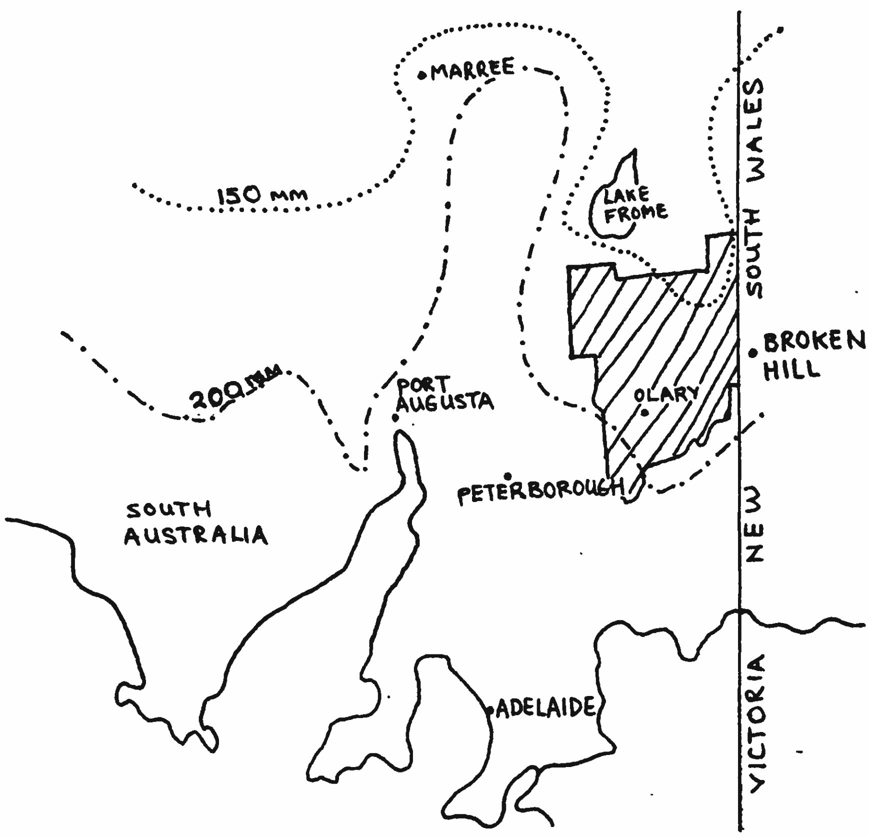

Figure 1. Sketch plan of survey study region

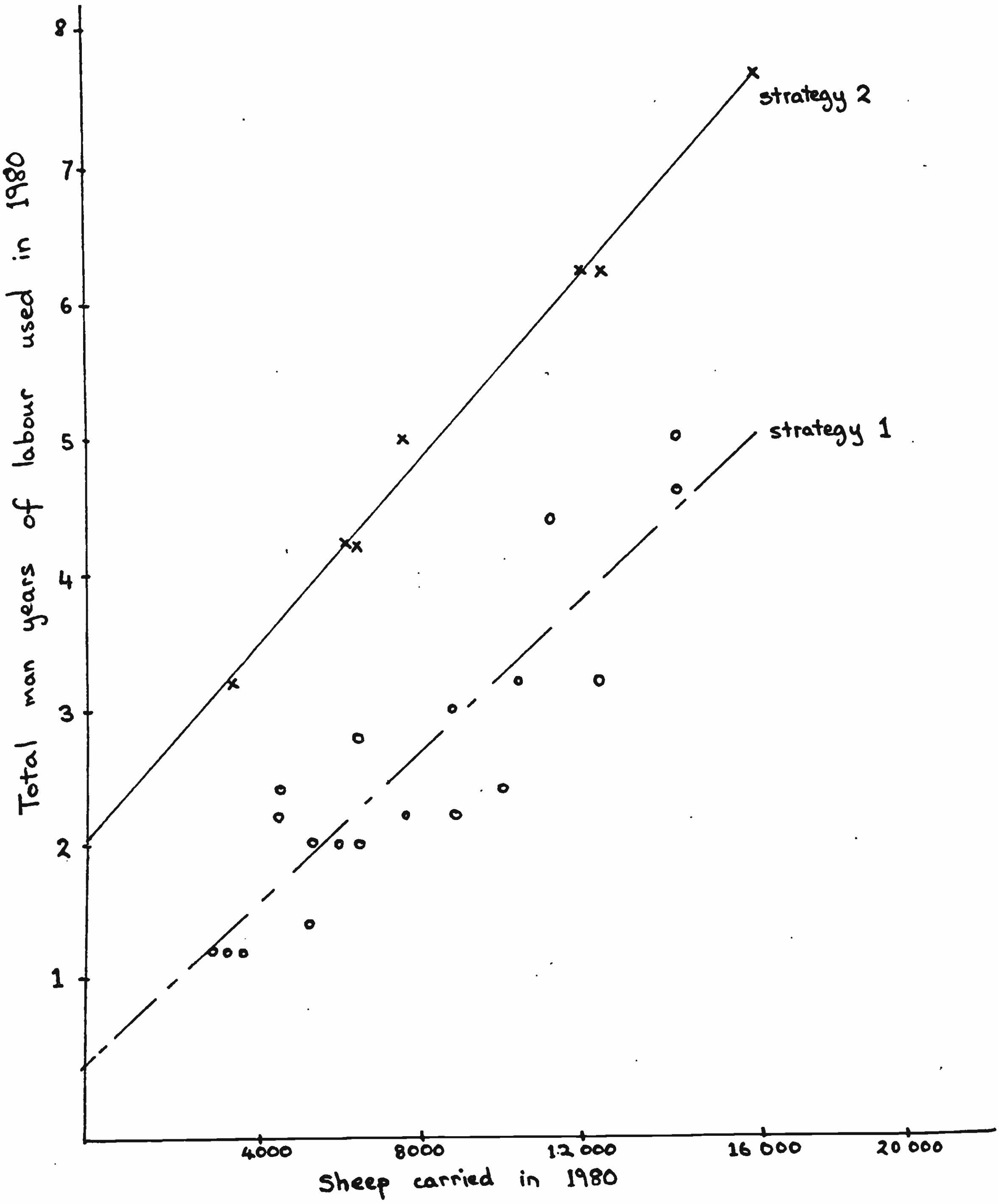

Figure 2. Relationship between total man years of labour used on the property and total sheep carried in 1980.

(Three properties have been excluded from this figure. Two failed to provide adequate information on labour usage. The third was in a phase of highly labour intensive development.)

POTENTIAL PROBLEMS WITH TREE AND SHRUB REGENERATION IN CENTRAL AUSTRALIA

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Abstract

Several pasture types in central Australia are undergoing important changes. Trees and shrubs are increasing on some alluvial soils. *Acacia, Cassia, Eremophila* and *Eucalyptus* species form locally dense stands. *Acacia aneura* (mulga) is increasing on red earth plains where run-on is favourable. Changed fire patterns appear to be an important cause of change.

Absence of regeneration of trees and shrubs is apparent in other parts of central Australia, particularly in association with calcareous soils, salt pans and some river frontages. It is likely that seedlings and juvenile plants are destroyed chiefly by rabbits, but that grazing by cattle will also cause losses at times.

Pasture production may be suppressed as woody plants increase; the use of fire is recommended to control the increase.

Landscape stability and topfeed resources may be lost as woody plant populations decline. Control of rabbits and cattle are recommended to allow regeneration.

Introduction

Substantial changes in woody plant populations on some arid rangelands since the advent of European man have been reported in

Australia and the U.S.A. (e.g. Humphrey 1958, Moore 1969).

No measurements are available of tree and shrub populations in central Australia, prior to 1980. However, anecdotal information and direct observation suggest that growth and recruitment has been extensive in some areas but largely absent in others. Problem species are often similar to those recorded elsewhere in Australia (e.g. Hall *et al.* 1964, Anon. 1969).

This paper presents evidence of increase and loss of woody plants in central Australia. The likely causes and effects of change and the management implications are discussed.

Increase in Woody Plants

Informants from cattle stations both north and south of the MacDonnell Ranges have reported increases in trees and shrubs since a period of exceptionally high rainfall from 1973 to 1978. In the northern Alice Springs region, where the average rainfall is up to 300 mm per annum, *Acacia*, *Eremophila* and *Cassia* species have all increased. A station owner who has lived in the northeast since 1924 has seen "nothing like it before".

On some stations in both the northwest and northeast of the region, the increase in *Acacia aneura* (mulga) is of great concern to the owners/managers. Mulga appears not to be invading land beyond its previous boundaries to any great extent, but rather to be thickening up wherever run-on is favourable. Where the problem occurs, the density of mulga 0.1 - 0.5 m in height can exceed 1000 individuals ha^{-1}, while the density of all height classes together can exceed 3000 individuals ha^{-1} (unpubl. data). Thickets of juvenile *Acacia estrophiolata* (ironwood) are apparent on many alluvial soils and extensive regeneration of *Acacia kempeana* (witchetty) is occurring on others. *Acacia victoriae* and *Acacia murrayana* also form locally dense stands on alluvial soils wherever rainfall or run-on are favourable.

Eremophila species, particularly *E. duttoni*, *E. maculata* and *E. sturtii* now cover considerable areas of alluvial soils bordering creeklines and on floodouts and plains. The predominance of young plants in areas which would otherwise be treeless floodouts implies a recent invasion by these species.

The *Cassia nemophila* - *C. artemisioides* - *C. sturtii* group and *C. oligophylla* are increasing markedly on many alluvial soils. Areas reported to have been shrubless or nearly so prior to the 1970s have a dense cover of these species. The *C. desolata* - *C. helmsii* group has also increased but is generally limited to soils either on or close to ranges. On open woodland sites where excessive increase in woody plants has been detected (methodology adapted from Tennant and White 1959), the density of woody plants of 0.1 - 0.5 m height is greater than 1000 individuals ha^{-1} and can exceed 3000 individuals ha^{-1}; the equivalent values for woody plants of 0.5 - 1.0 m height are 400 individuals ha^{-1} and 1500 individuals ha^{-1} respectively. *Cassia* spp. may constitute 80% or more of these plants (unpubl. data).

In waterways and areas subject to inundation throughout the Alice Springs region, *Eucalyptus camaldulensis* (river gum) and *E. microtheca* (coolibah) have formed dense stands in some instances. In the northwest region of saltlakes and limestone subsoils, *Melaleuca glomerata* (tea-tree) seedlings have invaded some alluvial plains and largely suppressed pasture species.

Opinion is divided amongst local pastoralists as to whether or not increasing trees and shrubs constitute a serious threat to pasture production. One owner/manager with long experience in the northeast reported similar increases in *Cassia* following big rains in 1921, 1926 and 1947 but that all populations were diminished by ensuing drought. Another, quoted above, said that the increase during the 1970s was unique. Several informants, while acknowledging a major increase in woody plants, believed that either pasture production would not be disadvantaged or that any disadvantage would be counteracted by the introduction of buffel grass. Other informants were concerned that mulga and *Cassia* in particular would suppress valuable pasture. Many found that mustering was made considerably more difficult where woody plants had increased.

Causes of increase

It is unlikely that increases in woody plants have a single cause. Since the advent of European man to the arid rangelands, several factors which influence plant populations have changed, although one may have had the predominant effect. Changed fire practices and/or grazing by introduced livestock are considered to be major causes by authors both in Australia and the U.S.A. (Humphrey 1958, Anon. 1969, Moore 1969, Barney and Frischknecht 1974, Harrington *et al.* 1979, Shinn 1980). Other causes include water redistribution, clearing, and ringbarking (Batianoff and Burrows 1973, Beeston and Webb 1977). A common feature of many Australian reports is that increase or invasion followed periods of above average rainfall (Anon. 1969, Moore 1969, Beeston and Webb 1977, Booth and Barker 1979, Harrington *et al.* 1979, R.W. Condon pers. comm.).

In central Australia, the existence of a "woody weed problem" has not been widely recognised, but the case for its likely expansion can be supported.

Fire is a feature of Australia's environments and species are adapted to survive particular fire regimes (Gill 1975). Prior to the arrival of European man, there were two important sources of ignition - lightning and Aboriginal man. Lightning may have been an indiscriminate fire lighter, but Aborigines were skilful users of fire and their fires had a critical impact on much of Australia's vegetation (Jackson 1968, Jones 1969, Hallam 1975, Hodgkinson and Griffin in press). There is considerable evidence for the widespread use of fire in central Australia by Aborigines, prior to European man's arrival (e.g. Basedow 1915, Carnegie 1973, Giles 1979, Griffin and Friedel 1981) and for continued Aboriginal use of fire in recent times (Griffin and Friedel 1981, R.G. Kimber pers. comm.). The use of fire by pastoralists was more common prior to a severe drought (1958-65) than at present, but some pastoralists continue to fire their spinifex country. However, the alluvial landscapes are now only burnt by wildfires ignited accidentally or by lightning. In general, such fires are less frequent, hotter and more extensive than pre-European fire regimes, and their season of occurrence may be different.

Consequently, there is good evidence for changed fire usage in the landscapes where trees and shrubs are increasing. On the other hand available evidence does not suggest that grazing is a major cause of woody plant increase, but studies are continuing. Disturbance by clearing, ringbarking or water redistribution has not occurred.

The process of woody plant increase appears to take the following course in central Australia. Extended above average rainfall stimulates massive germination and survival of all plant species. Failure of fire to occur as soon as the vegetation will burn enables woody plant seedlings to become established (probably within one year of germination). Juvenile woody plants can withstand fire from an early age; up to 84% of ironwood juveniles 0.1 - 1.0 m in height and probably between one and five years old survived fires of different intensities at Alice Springs (G.F. Griffin pers. comm.). Wildfire may occur after fuel has accumulated to a dangerous level over several years and may kill some young and mature woody plants. However, many species have the capacity to produce basal shoots, and seed germination will be stimulated by fire (Hodgkinson and Griffin in press). With favourable seasons, these new seedlings will also become established. A sequence of years of high rainfall, without fire in the first and subsequent years will almost certainly lead to a significant increase in trees and shrubs. Such sequences have occurred at about 20 year intervals in central Australia since the 1860s.

It appears that the central Australian landscapes on alluvial soils (footslopes, plains and levees) are probably "anthropogenic grasslands" (Vogl 1974). In other words, the climax vegetation which is possible with the present climate is a shrubland, and the open grasslands which presently exist are a "fire subclimax", maintained only by the deliberate application of fire. Drought, disease and herbivores must always have reduced woody plants from time to time, but fire at critical periods has been the major agent for maintaining tree and shrub populations at a relatively low level.

Decrease in woody plants - and its causes

Lack of regeneration is apparent in other areas of central Australia, particularly where they are more arid. Rainfall is lower in the south than in the north, so that suitable conditions for germination occur less often. However, exceptionally high rainfall occurred throughout the region during the 1970s, so that it might be expected that extensive regeneration of woody plants would follow. There are at least three possible reasons for the absence of regeneration. Firstly, germination and establishment failed due to locally unfavourable conditions; this is most unlikely. Secondly, seedlings established but were eaten and, thirdly, seed supply was totally depleted by previous germination and consumption. Of these two alternatives the former is most likely, as sufficient mature trees still exist in most areas to replenish the seed supply.

A significant feature of the southern region, in addition to greater aridity, is the greater proportion of calcareous soils and salt pans. These, and river frontages, are favoured habitats for rabbits. Thus, much of the better cattle grazing country in the south is also infested with rabbits.

No measurements are available of woody plant populations in the southern Alice Springs region. In the north, rabbits are far less common. However, during measurement of open woodland sites in the north, one area was encountered where rabbit warrens were extensive. Table 1 shows that no juvenile trees and shrubs to 1 m high were present, there were two individuals ha^{-1} between 1 and 2 m high, and 13 trees ha^{-1} above 2 m in height. These latter presumably predate the arrival of rabbits in the area. Informants indicated that rabbits were present in the area by 1910 and probably earlier.

Table 1

Number of trees and shrubs per hectare in open woodland in the northern Alice Springs region

	Height Class				Total
	0.1-0.5m	0.5-1.0m	1.0-2.0m	2.0m & Above	
Median of 22 sites without rabbits	639	169	97	59	1060
Range of 22 sites without rabbits	33-3254	32-1687	11-869	3-233	105-5844
Rabbit site	0	0	2	13	15

Informants from cattle stations in the southern region have said that large scale death of mature trees and shrubs was uncommon during drought. However, in country inhabited by rabbits, young trees and shrubs were either eaten or ringbarked. Many species were affected including mulga, witchetty, *Eucalyptus* spp., *Atriplex vesicaria* (bladder saltbush), *Maireana astrotricha* and *Chenopodium auricomum* (both called bluebush in central Australia). Saltbush and bluebush were utilised by cattle during drought but were not preferred. Cattle ate *Eucalyptus* spp. and *Acacia* spp. when available. Thus, it appears that grazing by rabbits is the primary cause of decrease in woody plants, although cattle grazing probably exacerbates the problem at times. Studies to be undertaken in the southern region should clarify the situation.

The problem of failing regeneration of woody plants has been reported in other parts of arid southern Australia. Grazing by livestock and/or rabbits has been the major cause (e.g. Hall *et al.* 1964, Cunningham and Walker 1973, Henzell and Lay 1981); seasonal fluctuations are not responsible for long term failure. Widespread death of mulga during drought or following fire is normal in arid Australia (e.g. Beard

1968, Condon 1969, Fox 1979), as is regeneration after occasional highly favourable seasons (e.g. Everist 1949, Hall *et al.* 1964, this paper). The absence of regeneration is not simply due to unfavourable seasons; grazing causes a reduction in the mulga population despite seasonal fluctuations (e.g. Cunningham and Walker 1973).

Implications for management

The invasion of an area by trees and shrubs or a major increase in pre-existing populations is not in itself an undesirable process. However, when invasion or increase occurs, the ground storey species may be reduced or eliminated (e.g. Humphrey 1958, Anon. 1969). In pasture lands, where palatable ground storey species are replaced by less palatable or unpalatable trees and shrubs, a serious loss of animal production will follow.

Excessive regeneration of woody plants should be controlled, to maintain pasture production. Fire is the most economical tool available to land managers for control, but it should be used before shrub density increases so much that adequate fuel levels can never be achieved. Control burning is probably necessary within one year of germination. A subsequent burn, given sufficient fuel, may be needed to destroy new seedlings and resprouting rootstocks (Ralph 1980).

The failure of trees and shrubs to regenerate in favourable seasons will eventually lead to their disappearance. When they are long lived, the absence of recruitment may not be apparent because the mature plants will continue to dominate the visual landscape for many years. Since woody plants may be valuable for maintaining landscape stability, as habitat for native animals, as browse and shelter for livestock, for providing construction materials, firewood and so on, the potential loss of the resource is important. If the resource is to be maintained, control of rabbits is essential at all times; grazing by cattle probably needs to be restricted following substantial rains, to aid the survival of newly established seedlings.

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A PRELIMINARY ASSESSMENT OF DISTRIBUTION AND ABUNDANCE OF RABBITS IN LAND SYSTEMS IN THE NORTHERN TERRITORY

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The European rabbit, *Oryctolagus cuniculus,* was the last of the feral mammals to reach Central Australia. The rabbit had reached the N.T. border from NW South Australia in small numbers by 1901 (Murray, 1904a). At the same time it had reached Lake Amadeus and was close to the Cleland Hills (Murray, 1904b). By 1915 it was well established on the Hale River near Arltunga (Day, 1916) and by the mid-1920s it had reached the Tanami Desert area (Terry, 1927). In the eastern N.T. the rabbit had probably reached the N.T. along the Georgina River by 1920 (Myers, 1970). There can be little doubt that the distribution of the rabbit was aided by human transport, but the establishment and spread could only have occurred during good seasons (Griffin and Friedel in prep.).

In our study we are attempting to provide an accurate map of the distribution and density of rabbit warrens in Central Australia. This project is part of a larger project to examine the biology of the rabbit in Central Australia and to assess the cost and effectiveness of various control techniques. Accurate determination of the distribution will also enable the suggestion that rabbits are still spreading north to be assessed.

METHODS

Historical distributions have been determined from writings of early explorers and surveyors. These have been summarised by Kimber (in lit. 1981) and Griffin and Friedel (in prep.).

Preliminary assessment of the present distribution of warrens has been made from ground surveys covering over 1300 km through 35 of the 88 Land Systems in the Alice Springs District, aerial photographs ranging from a scale of 1:3000 to 1:25000, occasional aerial surveys and reports from various sources including initial response to a postal survey of property managers.

An index of abundance was determined by counting warrens along road transects through each Land System. Transect width varied from 50 to 200 m on each side of the road.

RESULTS

The present known distribution of rabbits in the N.T. is concentrated in the southern third of the Territory (Fig. 1). The main distribution is south of the MacDonnell Ranges through the pastoral areas centred between the Finke River and the western desert areas. The major concentrations are on Owen Springs, Palmer Valley, Mt. Ebenezer, Erldunda, Kulgera, Umbeara and Mt. Cavenagh. Areas of high population are also present east and west of this central region wherever habitat is suitable such as in the Petermann Range. Isolated populations also extend out into the sand dunes of the Simpson and western deserts.

Several populations are found north of the MacDonnells. These are on the Titra Land System on New Haven and Central Mt. Wedge Stations, the Hale River area of The Garden and Ambalindum, and in the adjacent limestone areas of Bond Springs and Yambah Stations. A diffuse population occurs throughout the salt lakes on Central Mt. Wedge, Napperby and Narwietooma. Several isolated populations occur as far north as Tanami, Wave Hill, Rockhampton Downs and Lake Nash. These populations occur mainly in limestone or hilly areas.

Abundance of warrens is related to Land Systems in Table 1. Three of the Land Systems have more than 10 warrens per km of transect, equivalent to about 25 warrens per km^2. Only two Land Systems have been surveyed that have no warrens. There is considerable variation in the abundance through the Land Systems as shown by the coefficient of variation.

DISCUSSION

The distribution we have shown is a preliminary estimate of the present distribution. Differences between the distribution we have summarised and that shown by Petty et al (1979) reflect more accurate mapping rather than a change in distribution.

Despite recurring fears by some, rabbits probably reached their greatest and most northerly distribution shortly after 1920 (Griffin and Friedel, in prep.). As Ratcliffe (1959) suggests, the initial invasion of rabbits probably advanced into environments with which they could not cope during stress periods. Following large-scale die-offs during droughts such as the 1920s in the Bundey River area (R. Holt, pers. comm.) and following invasion of myxomatosis in 1951 at Central Mt. Wedge (W. Waudby, pers. comm.) rabbits in some of the northern reaches of the distribution have never regained the densities reached during the initial invasion. Evidence of the earlier distributions still exists in the form of extinct-warren mounds on properties such as Atula, Tobermory, the Bundey River area NE of Alice Springs and Central Mt. Wedge NW of Alice Springs. Reports by A. E. Newsome (in lit. 1979) indicate rabbits existed on Newcastle Ck, Wave Hill and in the Tanami desert in the late 1950s. Small isolated populations still exist in some of these areas (Corbett, pers. comm., Johnson, pers. comm.) but have not moved further north. Typical of these northern populations is the one at Mosquito Ck on McLaren Ck Station which was present in 1940 (W. Waudby, pers. comm.) and still exists in small numbers (Stock Insp. pers. comm.).

In the southern part of the N.T. populations have exploded and crashed on average once a decade since the turn of the century, but distribution has not changed much since about 1920. A possible exception may be in the Simpson Desert where rabbits may have moved down the Hale R. floodout during or after the heavy rains of the 1970s. However, a cursory aerial survey of these populations indicates these may have died back as a result of the incipient drought of 1980. Sand dunes leave no permanent record of rabbit warrens, so historical information is difficult to obtain.

Distribution of warrens within Land Systems (L.S.) is quite variable, not surprisingly, since rabbits choose the most suitable habitat for warrens while Land System mapping is done on a scale suitable for mapping manageable units. The most variable densities are in the highly variable Ambalindum L.S. where warrens are concentrated along the Hale River and in a few isolated limestone terraces. Warrens in all Land Systems tend to concentrate in restricted sub-units making up only a small portion of the L.S. However, in Muller, Outounya, Finke, Cavenagh and Ebenezer Land Systems, the preferred sub-units make up a large part of the L.S. and warren distribution tends to be more regular.

Rabbit warrens are most closely associated with limestone soils and outcrops, sandy soils, particularly with limestone at depth, salt lake fringes and alluvial fringes of hills, and along stream banks where soils are suitable for digging. The association between limestone areas and warrens is particularly marked in the north-western fringe of the distribution where most known isolated populations are associated with an outcrop of limestone. The fringes of the salt lake Amadeus Land System also carries rabbits over the extent of its range, e.g. Napperby Lakes, western desert salt lakes, and Karinga Ck. This is probably due to the permanent vegetation, *Melaleuca* sp. or samphire, and friable soils around these lakes. Sandy areas are favoured habitat in the southern part of the N.T. During good seasons high populations have been present in the Simpson Desert dune systems well down the Hale R. and scattered locations in the western deserts (Fig. 1). River front L.S. such as the Finke support high densities of rabbit warrens. However, north of the MacDonnells the Sandover, McGrath and McDills L.S.s carry none or few rabbits. This appears to be a result of the associated complex of Land Systems and lack of suitable soils. An additional factor may be the relative unsuitability of temperature and humidity which may inhibit establishment through reproductive failure (Cooke, 1977).

In conclusion, distribution of rabbits in the N.T. has reached a stable state. However, drought and disease cause populations to die back, sometimes to the point of localised extinction. During good seasons the populations expand to reoccupy suitable habitat. In general, rabbits are concentrated in a moderately small portion of the N.T. although small populations are widely scattered in the southern third of the N.T.

TABLE 1

FREQUENCY OF RABBIT WARRENS ALONG TRANSECTS
THROUGH LAND SYSTEMS OF THE NORTHERN TERRITORY, 1980/81

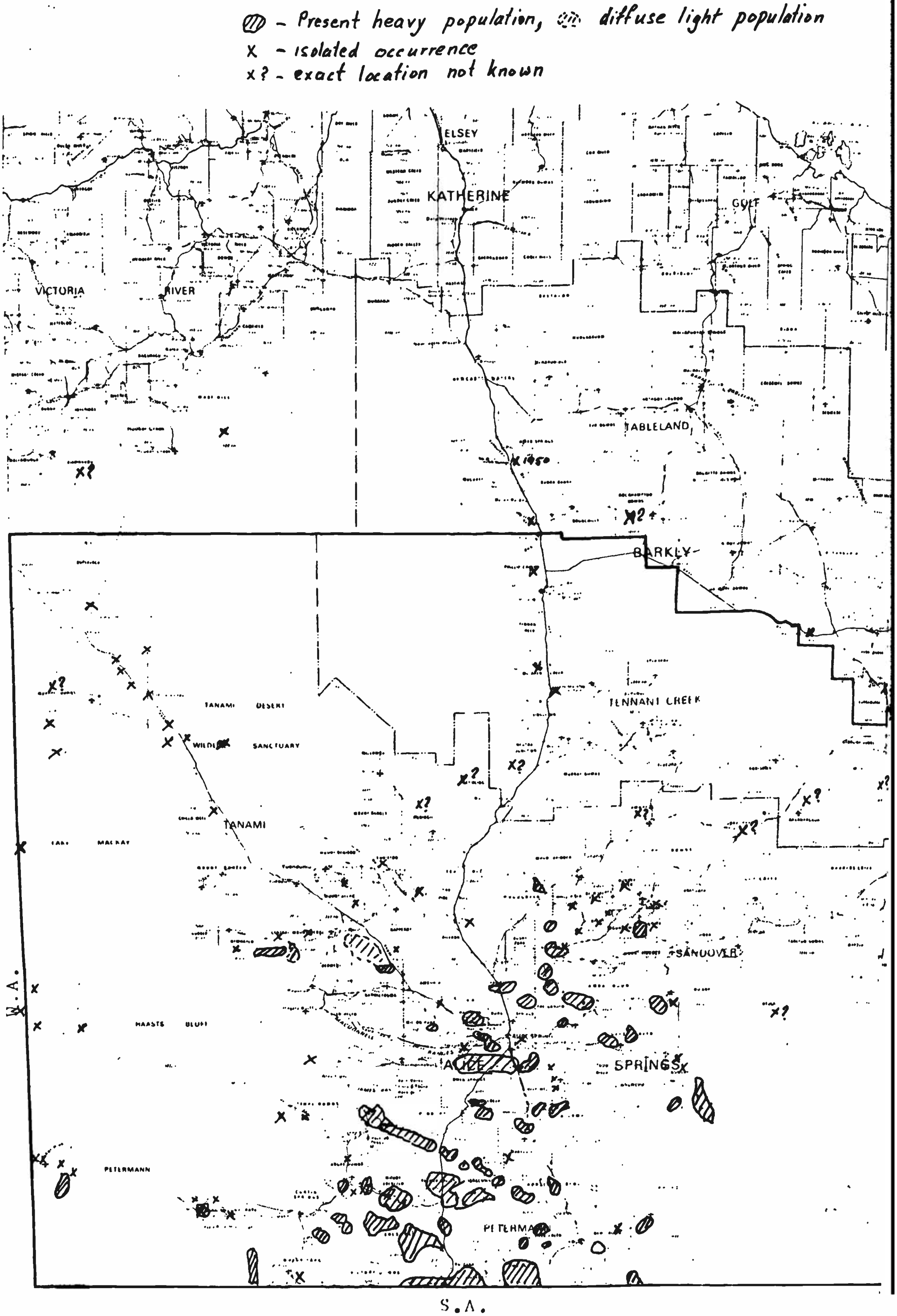
Land System		No. Transects	Total Distance (km)	Warren/km	S.D.	C.V.
Outounya	(Ou)	3	20.0	14.1	10.1	.7
Finke	(Fi)	7	24.1	13.2	7.9	0.6
Cavenagh	(Cv)	4	44.3	10.1	7.4	.7
Muller	(Mu)	17	26.6	8.6	6.9	.8
Ebenezer	(Eb)	4	15.6	8.5	4.3	.5
Kalamerta	(Kl)	2	6.4	7.8	-	-
BondSprings	(Bs)	11	86.2	6.8	5.0	.7
Chisholm	(Ch)	16	52.6	6.7	5.2	.8
Ambalindum	(Ab)	22	42.2	6.2	22.5	3.6
Alcoota	(Ac)	9	32.2	5.7	6.9	1.2
Lindavale	(Li)	17	90.9	5.3	3.3	0.6
Britten Jones Ck	(Si)	2	33.1	4.3	-	-
Harts	(Ha)	8	27.4	4.2	2.9	0.7
Amadeus	(Aa)	7	37.4	3.9	4.0	1.0
Huckitta	(Hu)	5	28.0	3.7	1.9	0.5
Coughlin	(Co)	2	12.4	2.5	1.3	0.5
Ewaninga	(Ew)	1	6.3	2.1	-	-
Titra	(Ti)	39	149.9	2.0	3.3	1.7
Rumbalara	(Ru)	5	19.5	1.8	1.5	0.8
Hamilton	(Hm)	6	18.3	1.5	1.4	0.9
Chandler	(Cn)	1	10.0	1.3	-	-
McGrath	(Mg)	5	8.8	1.3	0.9	0.7
Renners	(Rn)	1	8.3	1.2	-	-
Simpson	(Si)	26	223.9	1.1	2.3	2.1
Kanandra	(Kn)	5	19.0	0.9	0.7	0.8
Gillen	(Gi)	10	52.2	0.7	1.2	1.7
Todd	(Td)	5	49.6	0.5	0.7	1.4
Pulya	(Py)	3	19.7	0.5	0.6	1.2

TABLE 1 (Cont'd)

Land System		No. Transects	Total Distance (km)	Warren/km	S.D.	C.V.
Boen	(Bo)	5	21.5	0.4	1.0	2.5
Indiana	(In)	2	4.8	0.2	-	-
Ringwood	(Ri)	5	32.6	0.2	0.4	2.0
Endinda	(Ed)	13	88.5	0.1	0.2	2.0
Singleton	(Sn)	6	30.5	0.1	0.2	2.0
Sandover	(Sa)	4	16.9	0	0	0
Sonder	(So)	1	2.0	0	-	-

Note: S.D. = Standard deviation
C.V. - Coefficient of variation = $\frac{SD}{Mean}$

Fig. 1 Location of Rabbit populations in the Northern Territory



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FIRE IN MULGA COMMUNITIES OF EASTERN RANGELANDS - FRIEND OR FOE?

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INTRODUCTION

Fire occurs infrequently in Australia's most extensive plant community, the mulga lands (see map 3, Moore 1970). Under present management, the average interval between fires would be in the order of 20 to 50 years, that is, a once in a lifetime event for a manager. Before white settlement, fires occurred more frequently because of greater fuel buildup and deliberate lighting of fires by Aborigines. The community and its plant species have therefore evolved with fire as a major environmental factor shaping its characteristics (Hodgkinson and Griffin 1981).

Currently the value of fire, both wild and controlled, in mulga lands is a controversial issue. Everyone accepts that uncontrolled fires are undesirable because they may destroy stock, fences, buildings and forage, but are there any benefits accruing from fire in terms of enhanced carrying capacity resulting from a desirable change in community composition? In the mulga lands of N.S.W. and Queensland our experience leads us to advocate that there are benefits from controlled burning areas where shrubs have become or are likely to become a problem.

Endemic shrub species (belonging to the genera Acacia, Cassia, Dodonaea and Eremophila) have increased substantially in many parts of the eastern mulga lands to the stage of depressing forage production and making stock management very difficult. This reduction in grazing value of the land has been insidious but in some areas pronounced shrub increases occurred after the wet periods of the mid-1950s and 1970s. Interest in fire as a management for shrub control began in the late 1960s (Moore 1969, 1973) and further developed when the results of the 1974/75 wildfires were assessed (Walker and Green 1979; Wilson and Mulham 1979).

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LESSONS FROM THE 1974/75 WILDFIRES

During the summer of 1974/75 wildfires were rampant through the arid zone. Total area burned has been conservatively estimated at 120 million hectares with 5 million hectares being burnt in western N.S.W. Much of the area burnt were mulga lands. As an example of the effects of these wildfires we consider "Tundulya" station in western N.S.W. between Cobar and Louth.

The shrub problem on this station is acute. Shrubs regenerated after the wildfire of 1921 (which burnt a large area of western N.S.W.) and a further dramatic increase was experienced following the wet period 1950-56 (Anon. 1969). Many areas today are so shrub dominated that there is insufficient grass to carry fire except after very wet periods. The problem species are mulga (Acacia aneura), punty (Cassia nemophila), narrow-leaf hopbush (Dodonaea attenuata) and turpentine (Eremophila sturtii).

Another exceptionally wet period occurred during 1973/74 and there was excellent growth of annual and perennial grasses on most of the property. Common grasses were woollybutt (Eragrostis eriopoda), kerosene grass (Aristida contorta), no.9 wiregrass (A. jerichoensis) and speargrass (Stipa variabilis). By the late spring of 1974 the grass cover was up to 1 m high and yielding 14 000 kg/ha in many places.

Lightning started a wildfire several properties away on December 16, 1974 in the late afternoon. Every effort was made to halt the wildfire by local volunteer bush fire brigades because of likely damage to fences, stock and buildings. However several years later it became apparent to the owner and neighbouring managers that a high proportion of the shrubs over wide areas had been killed by the fire. However, in some restricted areas regeneration of the shrub species had been high.

The general experience of managers in other areas of the mulga lands was also similar with fire causing a general decrease in adult shrub populations whilst causing increased regeneration from seed and by suckering in some localities. The reasons for these differential effects are the subject of current research.

RESULTS FROM CSIRO EXPERIMENTAL BURNS

Over the last decade CSIRO has conducted a number of experimental burns in mulga lands in western N.S.W. The short term objective has been to study the effect of a single fire on the vegetation. In the longer term (10-15 years) the study of the effect of repeated fires (at different frequencies) is planned.

(a) The Efficacy of Fire in Killing Shrubs

The first attempt to study fire effects commenced in 1968 when an area of pulled mulga was fenced on "Tundulya" (between Cobar and Louth). The objective of this study was to burn the area whenever possible and record the effects on both the shrubs and the grass. To date there have been three occasions when sufficient fuel (mainly speargrass, *Stipa variabilis* and wiregrass, *Aristida* spp.) has built up to carry fire (1970, 1975 and 1977). Although two of the fires were quite patchy the result to date has been very encouraging. Overall the height and density of shrubs has been reduced at the site when compared with the unburnt surrounding areas. The density of all shrub species has been reduced except for emu-bush (*Eremophila longifolia*), which has suckered from the roots. Such an effect would not occur where stock were present as it is palatable and well controlled by stock.

More recently, further sites have been established; on "Tundulya", "Euroli" (between Wanaaring and the N.S.W./Qld border) and "Nil Desperandum" (near Yantabulla) where woollybutt (*Eragrostis eriopoda*) and wiregrass provided most of the fuel.

Single burns have killed from 45 to 80% of narrow-leaf hopbush and 80 to 90% of mulga (Fig. 1). Included in Fig. 1 is the proportion of shrubs that died in areas set aside as controls which were not burnt. Shrub death by natural causes was quite high (up to 30% in the case of mulga). This mortality mainly occurred amongst the recently established seedlings. Natural mortality was not high enough to prevent the shrub problem worsening at these sites during the last three years because the remaining shrubs have increased in size.

There was a strong tendency for young and old shrubs to be more susceptible to fire than middle aged shrubs (see Fig. 2 where age is assumed to be equivalent to height). At "Tundulya", where drought stress was greater, this characteristic was not in evidence and this is an indication that soil moisture conditions both before and after any fire are likely to greatly affect the response of the shrubs.

(b) Fire-promoted germination of seed

When good rains follow a fire more shrub seedlings may appear on burnt areas than where it was unburnt. Such an occurrence resulted from summer rains in 1980-81 after the experimental burns at "Euroli" and "Nil Desperandum" in 1979 more than a year beforehand. Such occurrences are not known to be widespread and therefore the problem is minor, but a second burn as soon as possible would be advisable on affected areas.

(c) Resistance of grasses to fire

The 10 year study of the effect of three fires at "Tundulya" has provided a good opportunity to study changes in the density of a range of grass species that occur at the site. The short lived perennials, kerosene grass (Aristida contorta), speargrass, and purple love grass (Eragrostis lacunaria) have fluctuated in numbers but with no apparent long term change. New populations of all species have been regularly born. The long-lived wiregrass (Aristida jerichoensis var. subspinulifera), woollybutt, bandicoot grass (Monachather paradoxa) and finger panic grass (Digitaria coenicola) have generally survived the fires well. Droughts (especially during 1978-81) resulted in death of many plants and appear to be a greater cause of death of grass plants than fire damage.

The same may be concluded from studies of individual grass plants at "Euroli" and "Nil Desperandum". Most woollybutt plants survived the fires (Fig. 1) but they were always reduced in basal area with only one or a few tillers of the many original tillers being still alive. These surviving tillers grow back to their former stature when good rains occur. In contrast all the wiregrasses died on both burnt and unburnt sites but considerable germination from seed occurred after the summer rains in 1980-81.

Kangaroo grazing after the large scale paddock burns in 1979 totally suppressed the regrowth of woollybutt and the seedlings of bandicoot grass and wiregrass, which amounted to approximately 200 kg/ha on protected areas. The effects of such heavy grazing are bound to affect soil erosion, the subsequent grazing value of the area and the possibilities of follow-up burns. Control of kangaroo grazing will probably be a vital part of any property fire management in the future.

CONCLUSIONS

The results of wildfires and controlled burns clearly indicate that fire is effective in reducing shrubs in mulga lands, whilst the grasses have shown their ability to recover after a fire. However the precise effect of a fire on shrubs and grasses in any particular area cannot be forecast because of two factors which are not under the control of the land-manager, namely post-burn rainfall and grazing by wildlife. It is the differential experience of these two factors, which is responsible for the disparity in opinions on whether fire is a useful management tool or not.

Opportunities to burn in the mulga lands are few and far between and only follow extremely wet periods. By the time the grass is dry enough to burn it is of extremely low grazing quality. Despite the hazards associated with uncontrolled grazing by wildlife and the possibility of a drought after the burn, it seems desirable for managers to burn shrub-invaded areas when they can, particularly if very young shrubs are present (which may not be apparent for some years after their establishment). Current studies on the interaction of the effects of rain and fire on shrubs and grasses and the movement of kangaroos to burnt areas should help to improve managerial control in the future.

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Fig. 1. Mortality and survival of dominant shrubs and grasses after controlled burns at four sites. Mortality of unburnt plants (controls) is also indicated on the pie diagrams.

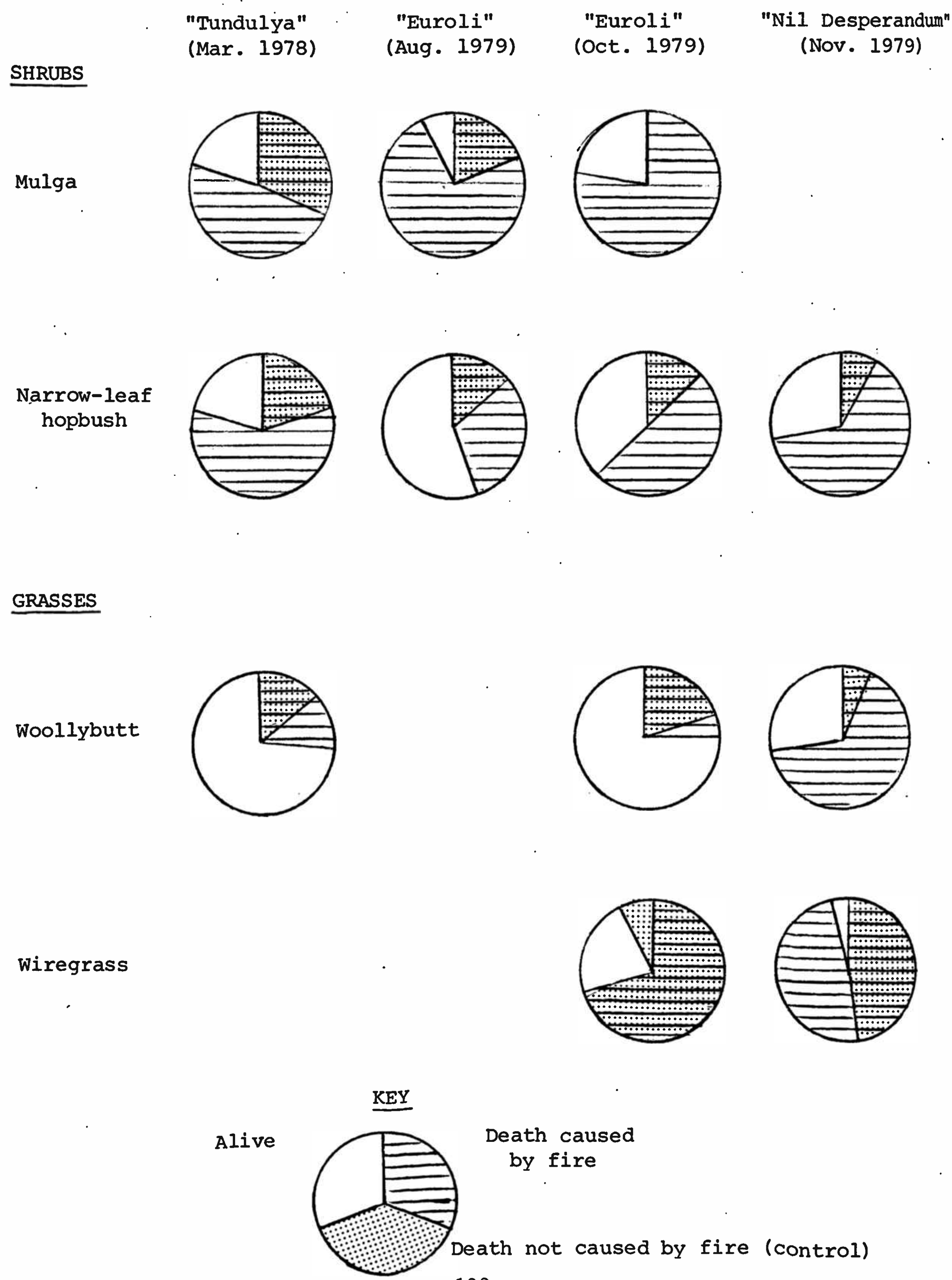
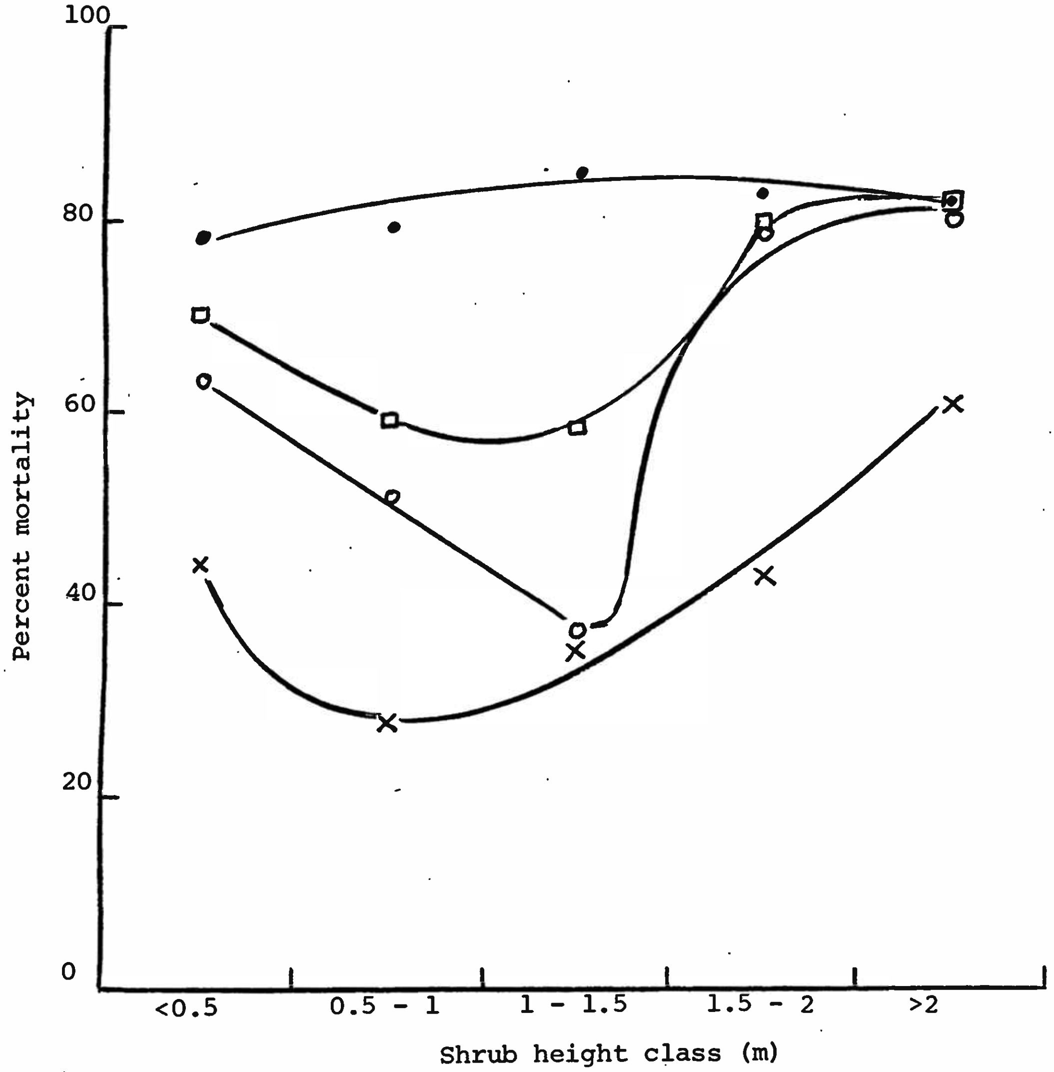


Fig. 2. Mortality of narrow-leaf hopbush shrubs of different heights after controlled burns at four sites.



Legend

- ● "Tundulya" (March 1978)
- × "Euroli" (August 1979)
- o "Euroli" (October 1979)
- □ "Nil Desperandum" (November 1979)

CONTROL OF WILDFIRES AND PRESCRIBED BURNS IN WESTERN NEW SOUTH WALES.

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ABSTRACT

The pre-settlement fire regime had a major influence on vegetation. Pastoral activities significantly modified the fire regime by altering the vegetation, the suppression of wildfires and deliberate burning.

Except for the mallee country, significant fuel accumulation is ephemeral and occurs infrequently. However, high fuel loads can develop rapidly. Most fires in the area involve tall grass fuel.

Major fires in 1974-75 have resulted in the development of highly organised and equipped brigades.

There is a great deal of interest in prescribed burns to control scrub regrowth and improve pasture production. This activity results in hazard reduction and preparedness of brigades.

The logistics of fire control in arid areas revolve around the paucity of resources, particularly man-power. Thorough organisation is essential in such situations for all fire control.

Landscape has a major influence on the fuel type and fuel quantity which, in turn, affect fire behaviour. Landscape also affects access. The three main landscape factors are topography, soil type and the presence of timber

and scrub.

Fuel type factors that affect fire behaviour and fire fighting strategies are flammability, flame height, spotting and fuel moisture.

The weather influences fire behaviour and fire fighting strategies by the factors of temperature and humidity, cloud cover, wind velocity and direction and atmospheric instability.

Fire control techniques mainly involve dry fire fighting with earth moving equipment. Aircraft are very valuable in these areas.

CONTROL OF WILDFIRES AND PRESCRIBED BURNS IN WESTERN NEW SOUTH WALES

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1. History of Wild Fire Occurrence

1.1 Prepastoral settlement

The records of the early explorers note the existence of fire started by Aborigines, who used fire extensively - this would have added significantly to the occurrence of fires caused by lightning alone. The frequency and distribution of fires caused by lightning and Aborigines meant that fire was an important factor in developing the landscape vegetation of western N.S.W.

1.2 Pastoral settlement

Pastoral settlement brought significant changes to the landscape, including changes to the fire regime, mainly as a result of livestock altering the vegetation and the direct suppression and control of fires by landholders. The spread of lightning ignited fires was significantly affected after settlement.

The decline in the number of Aborigines living off the land from the mid-1800's onwards meant that fires caused by their activities also decreased. The grazing of livestock reduced the vegetation which would otherwise have formed fuel for wildfires. Grazing also resulted in some vegetation types becoming more grass and herbage dominant and this resulted in a greater fire hazard. The reduced incidence of fire and the overgrazing by both livestock and rabbits have been contributing factors in the increase of scrub density in some areas. Where the scrub has depleted the pasture cover the fire hazard has generally been reduced.

Another factor in the change of the fire regime was the use of fire by graziers. Some were keen to use fire to produce a "green pick" or open up mallee-porcupine grass county. On the other hand, many landholders made every effort to reduce the risk of fire and to suppress any that did start.

1.3 Contemporary situation

Significant fuel loads develop infrequently because of the relatively low and variable rainfall in the area. Except for the accumulation of litter under mallee trees most fuel loads in western N.S.W. consist of annual or weakly perennial grass and herbage which accumulate over one or two seasons. However, in years of extended rainfall periods, high fuel loads can build up in a relatively short period, resulting in a very high fire hazard. Major fires in western N.S.W. mainly occur in such seasons (e.g., 1957, 1969, 1974-75). The probability of fire is naturally increased if, in seasons producing a high fuel load, dry lightning storms are common.

The infrequent occurrence of fires in western N.S.W. resulted in a lack of preparedness for the major fire outbreaks that occurred in 1974-75. Since that time brigades have been organised to cover the whole region. There is generally good liaison with interstate brigades when the need arises.

2. Prescribed Burns

Until quite recently, very few landholders would deliberately use fire as part of their management. However, studies into the causes and possible solutions to the major scrub and timber regrowth problem in western N.S.W. have resulted in a large amount of interest in using fire in the management of these rangelands (Leigh *et al*, 1981; Ralph, 1980). Organisations involved in research and co-operative programmes with landholders are CSIRO, Soil Conservation Service and the Western Lands Commission with strong support from the Bush Fire Council and the Forestry Commission. As a result of this, it is anticipated that fire will become increasingly used by landholders as part of their regular management programme.

The increased use of controlled fire will have an obvious direct effect on the wildfire situation by hazard reduction and maintaining preparedness of brigades.

3. Fire Suppression and Control

Fire suppression in western N.S.W. is concerned mainly with grassland fires. However, many of the principles involved are common to grassland fires in other areas and to fire fighting in most situations.

In general, most large operations involve dry fire fighting techniques, i.e., burning back from fire breaks formed with earth moving equipment. Water is mainly used for protecting property improvements, small fires, 'mopping up' operations and personal safety.

The problems associated with fire fighting in the area can be divided into three categories: - logistics, landscape - fuel type and weather.

3.1 Logistics

In sparsely populated areas, such as western N.S.W., it requires thorough organisation and adequate pre-fire season preparation to ensure that available resources are deployed to best advantage.

The combination of lightning-caused ignitions and sparseness of population often means that fires may start to run either before brigades can attend or even before they are detected. In some seasons the large number of lightning-caused fires can place a great strain on fire fighting resources.

In a severe wildfire situation it may be necessary to set up a forward emergency control centre at a significant distance from any town.

3.2 Landscape and fuel type

Landscape has a large bearing on the type and quantity of fuel present. Fuel type and fuel quantity are the main factors affecting fire behaviour. The seasonal conditions preceding and during the fire season are the most important factors determining the fuel build-up. Tall grass, up to 60 to 90 cm high and sometimes up to 1.2 m high is by far the most abundant fuel type in western N.S.W. Landscape also has a significant effect on access for fire fighting equipment. There are 7 major landscape-fuel type categories in the Western Division (Condon 1975; Condon *et al*, 1980). Each category has its own particular problems in relation to fire fighting.

3.2.1 Landscape factors affecting fire behaviour and fire fighting strategies.

Experience with fires in the Western Division in recent years has shown that there are many landscape factors which influence fire behaviour and fire fighting strategy. These factors can be considered under topography, soil type and the presence of timber and scrub.

Topography

The rate of spread of a fire usually accelerates with increasing slope. However, in the arid areas, fuel volume usually decreases markedly with increasing slope above about 10^{o} and such areas would be unlikely to carry a fire - especially at night or if there are steep scarps or rocky areas present.

Once slopes become greater than 2 to 3^{o}, access becomes difficult because the country is often broken up by gullies. In the fire fighting situation air photo-maps or an aerial inspection will often reveal broad valley areas with gentle slopes which have a high proportion of bare areas which may be used to hold a fire.

Soil Type

Soil type has its main influence on the fuel type that develops. However, soil type, particularly in relation to topography, can also affect access for fire fighting equipment.

Timber and scrub

Timber and scrub affect fire behaviour and fire fighting strategies in several direct and indirect ways. These include effects on fuel type, access, visibility and fire behaviour.

In western N.S.W., increasing density of timber cover usually results in a reduction in fire hazard because grass fuels are usually absent or dominated by copperburrs of low flammability. In most cases dense timber cover, particularly belah and rosewood, make an effective firebreak. However, mulga does not compete strongly with grass for moisture and, if the trees are close enough and there is a heavy grass understory, mulga may carry a crown fire under extreme conditions.

In the more open areas timber and scrub cover creates an access problem because of logs and stumps hidden in tall grass areas. Visibility is often limited in timber and scrub areas.

3.2.2 Fuel type factors affecting fire behaviour and fire fighting strategies

Flammability

Western Division pastures will burn quite readily when only 60-70% cured, provided that there is sufficient dried material around the base of the grass tufts. Under mild conditions with winds of 5 km per hour or less, fire will only run through pasture stands where the plants are separated by no more than half the distance of the maximum diameter of the plant. Under higher fire danger conditions and with an increase in wind, fires can run more easily through sparser grass pastures.

A modified grasslands fire danger meter has been developed for measuring fire danger index and rate of spread for arid areas. The main modification to the conventional (McArthur) meter is that the "degree of curing" scale is substituted with a pasture height scale. (Condon, 1979; Condon *et al*, 1979).

Flame height

Flame height will increase with increase in pasture height which, in turn, brings about an increase in the Fire Danger Index.

Spotting

Some fuel types are prone to spotting, the process whereby burning embers are transported in updraughts ahead of the main fire front. Species and circumstances in which spotting may occur in western N.S.W. fuel types are:

Mallee country

Mallee country is characterised by closely spaced, low , many-stemmed Eucalypts, 3-5 metres in height, each with an accumulation of leaf and bark litter and fallen stems around the base of each, and with ribbon bark hanging from the upper branches. Normally there is little or no ground cover between the mallee clumps and it will not carry a fire. However, prolonged and heavy winter rains promote a tall dense growth of spear grass. Under these conditions, as has happened in 1957-58, 1969-70 and again in 1974-75, the mallee country becomes a major fire hazard with a high potential for spotting as the accumulation of leaf and bark litter on the ground can flare up into the hanging ribbon bark and carry burning embers off in the up-draft. The development of massive, thunderous convection columns is also a major problem in mallee fires. Because of its propensity for spotting, back burning becomes a very hazardous operation in mallee country.

Wildlife

Rabbits and kangaroos fleeing out of the flames with fur alight can be a means of the fire being carried across otherwise safe breaks.

Other

Other species and circumstance where spotting may occur include pine trees, old lignum plants, saffron thistle and recently fallen trees.

Fuel moisture

Fuel moisture for a particular pasture type is governed by two processes - (a) the curing pattern as determined by a combination of seasonal conditions and the particular curing process for the dominant pasture species; and (b) the diurnal variation in fuel moisture content.

The arrangements of fuel in a tall arid zone grassland is such that, once 60% of the plant material is cured, most species will burn quite readily. Some species, notably nigger heads or summer grass, woolly butt and spinifex, are more flammable at 70-80% cured than when fully cured.

In the fully cured state there is a marked variation in fuel moisture content as temperature and humidity changes throughout the day.

3.3 Weather

3.3.1 Temperature and humidity

Relative humidity has a much greater influence on fuel moisture content and hence flammability than air temperature. Fast spreading grass fires can occur under conditions of low temperature providing the air is dry and a strong wind is blowing.

3.3.2 Cloud cover

The presence of cloud tends to lower surface temperatures and raise fuel moisture contents, hence lowering the flammability of fuel. However, cumulus clouds can also indicate the presence of atmospheric instability.

3.3.3 Wind velocity and direction

Wind has the effect of leaning the flame into the unburnt fuel and pre-heating it (Luke, 1978). Grassland fuels are usually open to the full force of the wind and, what might be a slow fire, can become a raging inferno under the influence of a strong wind. The higher the wind speed the greater the risk of spotting.

Rates of spread varies approximately as the square of the wind velocity. Thus the rate of spread under a 30 km/h wind is four times the spread under a 15 km/h wind. (Luke, 1978).

Wind does not blow at a steady velocity and direction may vary by about 60^{o}. A gusty wind causes a fire to be erratic and unpredictable. In light winds, the movement of convection cells can cause sudden changes in fire behaviour.

Wind direction normally moves anti-clockwise with the passage of high and low pressure systems. Cold fronts may cause a sudden marked change in direction. In view of the expected wind shifts it is imperative that the northern and eastern flanks of a fire be brought firmly under control to avoid a massive breakaway on a wide front.

3.3.4 Atmospheric instability

Under conditionsof high instability, convection columns may form over major grass fires increasing the chances of long distance spotting.

The lee side of a hill will often create instability and initiate massive whirlwinds which may carry flames to 20-25 metres in height. This is a particularly dangerous area.

4. Fire Fighting Techniques - Equipment and Support

The general principles and practice of direct fire fighting apply to fire control in western N.S.W.

Dry fire fighting involves the use of equipment such as bulldozers, graders, tracotr blades and the Brompton Fire Rat to prepare breaks to hold a fire or, more commonly, for back burning. The Brompton Fire Rat, a tractor-drawn implement, cuts a vee-shaped groove whilst a burner ignites grass on one side of the groove (Wedd, 1978). It can be used to make features such as roads or sandy creeks more effective as firebreaks and to create firebreaks in trackless country and protective areas around improvements. The "Rat" is ideally suited for control burn situations, but has also proved very valuable in wildfire suppression.

Direction finders which are very valuable in the rapid location of fires, are located at strategic points in some areas of the Western Division.

The scarceness of fire fighting resources means that "mopping up and patrol" operations are difficult to maintain but they are essential for efficient fire suppression.

The use of aircraft has always been of great value in the fire situation, particularly in reconaissance. In general, helicopters have proven more versatile than fixed-wing aircraft. However, the latter are usually more available. Aerial ignition, which has been used for control burns, may have potential for back-burning in a wildfire situation.

Experienced field officers from the State Government departments are available to assist brigade captains and fire control officers in the event of a serious fire situation.

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CHEMICAL CONTROL OF WOODY WEEDS IN WESTERN NEW SOUTH WALES -

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1. The Problem of Woody Weeds

Woody weeds ("scrub regrowth") are the main cause of reduced productivity over large areas of western N.S.W.

There are many genera and species involved in the woody weed invasion. The main ones are hopbushes (*Dodonaea* spp., particularly *D. attenuata*) turpentine (*Eremophila sturtii*), budda (*E. mitchellii*) and cassias (*Cassia* spp. particularly *C. eremophila*).

2. Use of Chemicals

There has been very limited use of spray-applied chemicals because of the high labour cost, time involved, tediousness and inconvenience of the work, cost of the chemical and the requirements for transporting and using relatively large quantities of water.

The development of the point-application technique for applying chemicals prompted the Western Lands Commission, in co-operation with Du Pont (Australia) Ltd., to commence trials in mid-1978. (Alchin *et al*, 1979; Alchin, 1981).

3. The Point-Application of Chemicals

Point-application involves the placement of a relatively small quantity of chemical on the soil surface above the maximum density of active roots of the plant being treated. When rain falls the chemical moves downward through the soil profile forming a highly concentrated "core" of material. Plant roots that pass through this "core" absorb the chemical.

4. The Chemical

The chemical used in the trials was hexazinone, manufactured by Du Pont, and with various formulation bearing the trade name "Velpar".

4.1 Formulations

4.1.1 Liquid (Velpar L (R) - registered trade name).

The equipment for point-application of the liquid is a hand-operated soil injection applicator (Spotgun (R) - registered trade name). A calibrated dose of several millitres is applied to the drip-line of the plant. One to four or more points, spaced at equal distances apart around the drip-line, are treated.

A particular advantage of the soil injection technique is the large number of shrubs which can be treated per unit volume (or weight) of chemical.

Where clumps of shrubs have plants closer than 2 to 3 times their height, the chemical can be applied on a square grid pattern through the stand. This pattern of treatment means that several plants can absorb chemical from the one point and each plant can absorb chemical from several points.

4.1.2 Pellets. (Velpar Gridball Brushkiller (R) - registered trade name).

These are hard elliptically-shaped pellets, weighing 1.0, 2.0 or 4.0 grammes and consisting of a clay matrix which carries the active ingredient. They are applied in the same pattern as for the liquid point application, i.e., equally spaced around the drip-line for individual plants or on a grid pattern for dense clumps.

4.2 Characteristics

Once absorbed into the plant, hexazinone is translocated to the leaf where it causes death by inhibiting photosynthesis. The plant often produces new leaf growth and a process of defoliation and refoliation may occur several times before the plant exhausts its regenerative reserves.

Its mode of action and the strong regenerative resilience of arid zone shrubs means that hexazinone is a slow acting chemical. Field trials have indicated it may take 3 to 18 months or more for a plant to die, mainly depending on rainfall.

Hexazinone is relatively resistant to degradation by ultra-violet light but can be digested and rendered inactive by mirco-organisms.

5. Factors Affecting Response

Trials have been carried out to determine the factors that affect response. The aim of the trials is to develop recommendations to obtain the maximum response at the least cost.

5.1 Comparison of Application Techniques

Soil injection on individual plants

The soil injection technique has been successful in most trials.

Pellet application on individual plants

This formulation was always the slowest to effect response, but has frequently produced higher percentage kills than any of the other application techniques - and often at lower rates of application per plant or per hectare. The reason for the relatively good response to pellet application is probably due to the chemical remaining intact until significant rain falls at which time there is a release of chemical and stimulation of both root absorption activity and plant growth. Also, the liquid formulation may be more subject to degradation and possibly up-take by non-target plants than the pellet.

Point-application on a grid-pattern - soil injection or pellet.

The rooting habits of arid zone shrubs appear conducive to high up-take under grid-pattern application.

It has been found that where the distance between shrubs is less than 2 to 3 times their height it is more efficient to use grid pattern rather than individual plant treatment.

Consideration is being given to achieving less than 100% death with grid pattern application and treating the remaining plants on an individual basis. This may be more economical in amount of chemical required than endeavouring to attain a 100% kill with grid pattern treatment alone.

5.2 Application rate

The effective application rate for either the soil injection or pellet application depends on the plant species, soil type, seasonal conditions (particularly rainfall) as they affect movement and absorption of the chemical, as well as plant growth and plant size. Plant size involves the existing biomass of leaves as well as the regenerative reserves in the root and stem portions. The amount of chemical applied must allow for sufficient up-take (presumably there would be some loss of chemical between application and absorption) to effect defoliation of all the existing leaves as well as any leaves the plant is able to produce in refoliation.

5.3 Timing of application

The chemical hexazinone is most effective when the plants are growing actively. Active growth usually occurs when soil moisture is available and temperatures are moderate to high. Spring to early summer appears to be the optimum time for application.

5.4 Placement of application in relation to shrub dimensions

Optimum placement of application in relation to distance out from the butt of the shrub is critical in terms of achieving maximum absorption of the chemical. For most situations it appears that application at the drip-line is adequate.

5.5 Number of points of application

Results to date indicate that increasing the number of points of application for the one application rate with soil injection increases the response. This would be related to the greater probability of roots intercepting the chemical with increasing number of points of application.

5.6 Dilution of liquid

Trials involving dilution of the liquid with the soil injection technique have indicated an increased response to increasing dilution. Dilution allows an increase in the volume of liquid applied per injection. This results in greater penetration of the chemical into the top of the soil profile and thus enhances its movement towards the plant roots.

5.7 On or below soil surface application for soil injection.

Nozzle attachments on the soil injector can be exchanged so that the liquid is applied to either the top of the soil surface or at any depth up to several centimetres below the soil surface. The below-surface application was developed mainly for sloping areas to prevent overland flow of the liquid. Trials were carried out to compare on-surface soil and below-soil surface application on level areas on the basis that below-surface application may lessen any loss of chemical from disturbance or break-down. However, results to date have not indicated any significant difference between the treatments.

5.8 Placement on bare soil, litter or pasture plants.

It was considered that point-application of chemicals would be affected by placement on bare soil, litter or pasture plants. Unexpectedly, trials to date have not indicated any significant difference between the three placements.

5.9 Soil type

Hexazinone is slightly adsorbed by clay particles and organic matter. However, its high solubility means that it is transported rapidly through soils of high sand content. The effect of soil type and characteristics is currently being studied.

5.10 Pasture growth

Trials have shown that each point of application affects pasture growth within a circular shape of 30 to 50 cm diameter around the point, depending on the rooting dimensions of the adjacent pasture plants. For a closely spaced grid of 1.4m square, there was a 50 cm diameter influence around each point, approximately 10% of the total area being affected.

Trials have indicated that any plant that germinates or has roots that grow into the concentration of chemical within 12 months of application would normally die. After about 12 months, depending mainly on rainfall, the chemical has been leached below the root zone of most pasture species as well as being reduced through degradation. The first pasture plants to recolonise the bare areas are medics (because of the symbiotic bacteria being able to degrade the chemical). Grasses, herbage and pasture shrubs follow the medics.

5.11 Residual and break-down characteristics

The residual and break-down characteristics of hexazinone are important in relation to the length of time the chemical remains active and available for absorption by both target and non-target species.

Results to date indicate that the chemical will remain available, awaiting movement by rainfall and absorption by the plant for several months to 2 years and possibly longer.

It has been noted in some trials that, as well as the initial target plant, shrubs which have germinated near the treated point several months after application have also died.

6. Application Rates and Costs

It will be some time before optimum application rates can be recommended for each species in every situation. However, sufficient data has been collected to provide a guideline. The following table provides a basis for probable general recommended application rates on individual plants.

6.1 Individual Plants

Table 1. Tentative estimates of rates and costs for application of "Velpar" to individual shrubs, saplings or suckers.

SITE	RATES AND COST PER PLANT			
	Active Ingredient* (grammes)	Volume Liquid** (ml)	No. of Pellets ø	Cost of Chemical øø
Shrubs, Suckers, Saplings Less than 1 metre high	0.5	2	1	4 cents
1 to 2 metres high	1.0	4	3	8 cents
Greater than 2 metres high	2.0	8	5	16 cents.

* Effective results have been obtained with less ingredient but the figures shown are the anticipated optimum amounts to effect death of the plant under most conditions.

** Applied through the "Spotgun".

ɸ Based on the 4.0 gramme pellet - the number shown contains the quantity of active ingredient closest to that indicated in the first column. There is no commercial price available for the pellets yet.

ɸɸ Based on price of $20.00 per litre for liquid (retail price varies from about $15 to $20 per litre).

The application rate for suckers may need to be higher than indicated, depending on how much regenerative reserve is present in the plant, particularly in the underground portions.

7. The Potential role of Chemical Control.

7.1 Treatment of encroaching scrub areas

Point-application of chemicals has the potential to provide significant economic control in encroaching scrub areas. The following table presents the estimated time and cost involved for treating stands of scrub regrowth at various densities:

Table 3. Tentative times and costs involved in treating stands of different density.

DENSITY (Plants /ha)	AVERAGE SPACING (Metres)	COST OF LIQUID (S/ha)	TIME INVOLVED (min/ha)	COST OF LABOUR (s/ha)	VEHICLE COST ($/ha)	TOTAL COST ($/ha)	TOTAL TRANSPORT COST ($/ha)
114	10	$9.12	25	$2.08	$0.06	$11.30	Motorbike at 5 k.p.h.
28	20	$2.24	5	$0.40	$0.03	$ 2.70	Motorbike at 10 k.p.h.
5	50	$0.40	1	$0.08	$0.01	$ 0.50	Motorbike at 15 k.p.h.
1	100	$0.08	0.5	$0.04	$0.01	$ 0.10	Motorbike at 20 k.p.h.

Notes

Cost of chemical - based on $20.00 litre (the assumption is that the shrubs are 1 to 2 metres high and application rates are as in Table 1.

Time involved - based on taking 5 seconds to treat each plant and travelling time on motorbike between plants at speed noted.
Cost of labour - based on $5.00/hour.
Vehicle cost - based on $0.05/kilometre (a 4-wheel drive vehicle could be used but this would increase costs).
Total cost - figures rounded to nearest 10 cents.

Assuming a typical area of scrub encroachment to have 1 to 2 metre high shrubs at 20 metres apart, this would cost approximately $3/ hectare ($1.00/acre).

The cost of chemical treatment increases at an accelerating rate with increasing plant size and stand density. The cost of treatment is significantly reduced on (a) a per hectare basis if encroaching regrowth is treated as early as possible and (b) an individual plant basis if the plants are treated when they are as small as possible.

7.1.1 Practical aspects

Treatment pattern

Maintaining a check on individual plants and areas already treated to ensure efficiency of travel can be facilitated by the use of a dye in the liquid (which remains visible for up to 2 months without rain) and simple markers tied to shrubs.

Use of soil injector

Observations indicate that best results are obtained by having the soil injector at an angle (a) as close to vertical and (b) as close to the soil, as possible.

7.1.2 Integrated control programme

It is proposed that an integrated control programme involving fire and chemical would greatly reduce the problem of scrub regrowth. CSIRO research has indicated that burning to control scrub is most effective in the autumn. A programme involving an autumn burn followed by chemical treatment in the spring appears a feasible proposition. (Trials are being carried out on comparative burnt and unburnt areas). It is presumed that shrubs that survive the fire will have largely exhausted their reserves for regeneration by spring and the chemical treatment may not require a very high application rate to effect death.

It has also been proposed that, where areas are suitable, chemical application to control scrub could be feasible following intensive goat grazing.

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CROPPING IN THE MARGINAL LANDS OF SOUTH-WEST NEW SOUTH WALES

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ABSTRACT

The expansion of cropping into pastoral country of south-west New South Wales is discussed, along with an examination of the types of country involved.

Bare fallowing is a practice necessary in cropping in this low rainfall area but it results in most of the problems encountered by both the landholder and the soil conservationist.

The roles of the soil conservationist in marginal cropping lands are threefold; advising the land administrators, assessing the relative erodibilities of different sites, and encouraging farmers to modify their clearing and cultivation practices so as to minimise erosion.

INTRODUCTION

Extensive cropping on grazing leases began in the early 1960's but the last ten years have seen the major thrust of expansion in the area sown to winter cereals, particularly wheat (See Figure 1). However, some areas have been cropped since the 1930's (Kyalite, Balranald and Euston areas) and these are considered locally to be traditional cropping areas.

These areas are within the Western Land Division of New South Wales, and properties are crown leases, usually leases in perpetuity.

Pressure to continue cropping resulted in an amendment to the Western Lands Act in 1980, which requires that lessees must obtain a cultivation licence, with an annual fee depending on the area cultivated. The issue of a licence is subject to advice from the Soil Conservation Service.

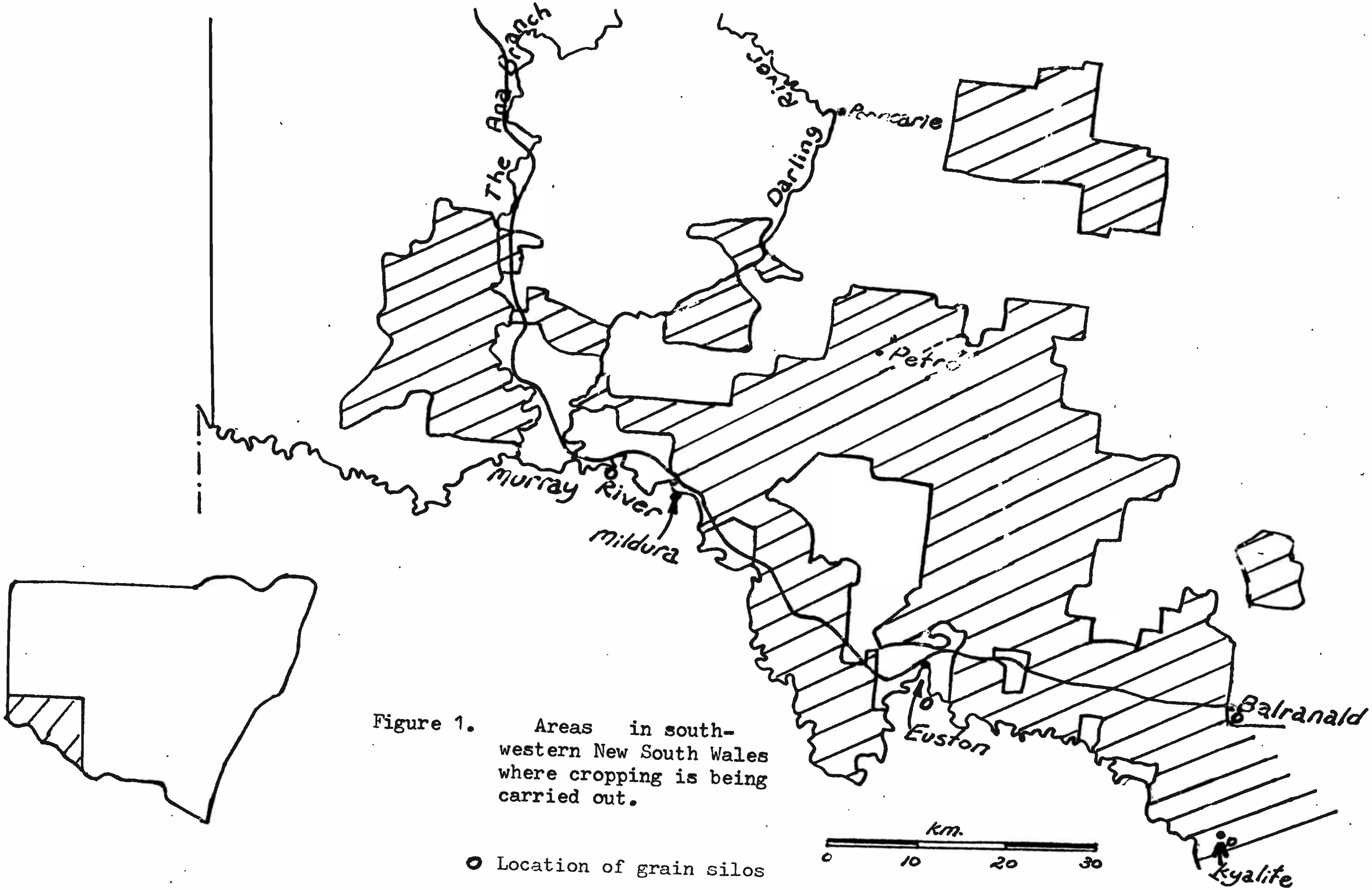

Figure 1. Areas in south-western New South Wales where cropping is being carried out.

o Location of grain silos

Property inspections associated with licence applications have revealed that 25 percent of the area shown on figure 1 has already been cropped or is proposed to be cropped.

Landholders involved in marginal area cropping fall into three main groups:

1. Full-time farmers mainly associated with the traditional cropping areas around Kyalite, Euston and Balranald.

2. Graziers who have taken an interest in farming but have run the majority of their holding as a grazing enterprise. This group includes the "opportunistic" farmers who undertake cropping only during favourable periods.

3. Graziers with sharefarmers handling the cropping, with the grazier carrying out little if any of the farming.

Description of the Area

Rainfall for the area is winter dominant, and this dominance increases from about 25%* in the north to 35% in the older cropping areas around Balranald. The annual rainfall and May to October rainfall are shown for "Petro" Station for the years 1945 to 1980 (Figure 2).

Cropping is being carried out on four main types of country:

1. Dunefields and plains with mallee *(Eucalyptus* spp.).
2. Plains (often calcareous) with dense belah *(Casuarina cristata)*.
3. Slightly undulating plains with open belah-rosewood *(Casuarina cristata)-Heterodendrum oleifolium)* often with bluebush *(Maireana sedifolia-Maireana pyramidata)*. Here cropping is largely confined to the more open areas where clearing costs are minimal.

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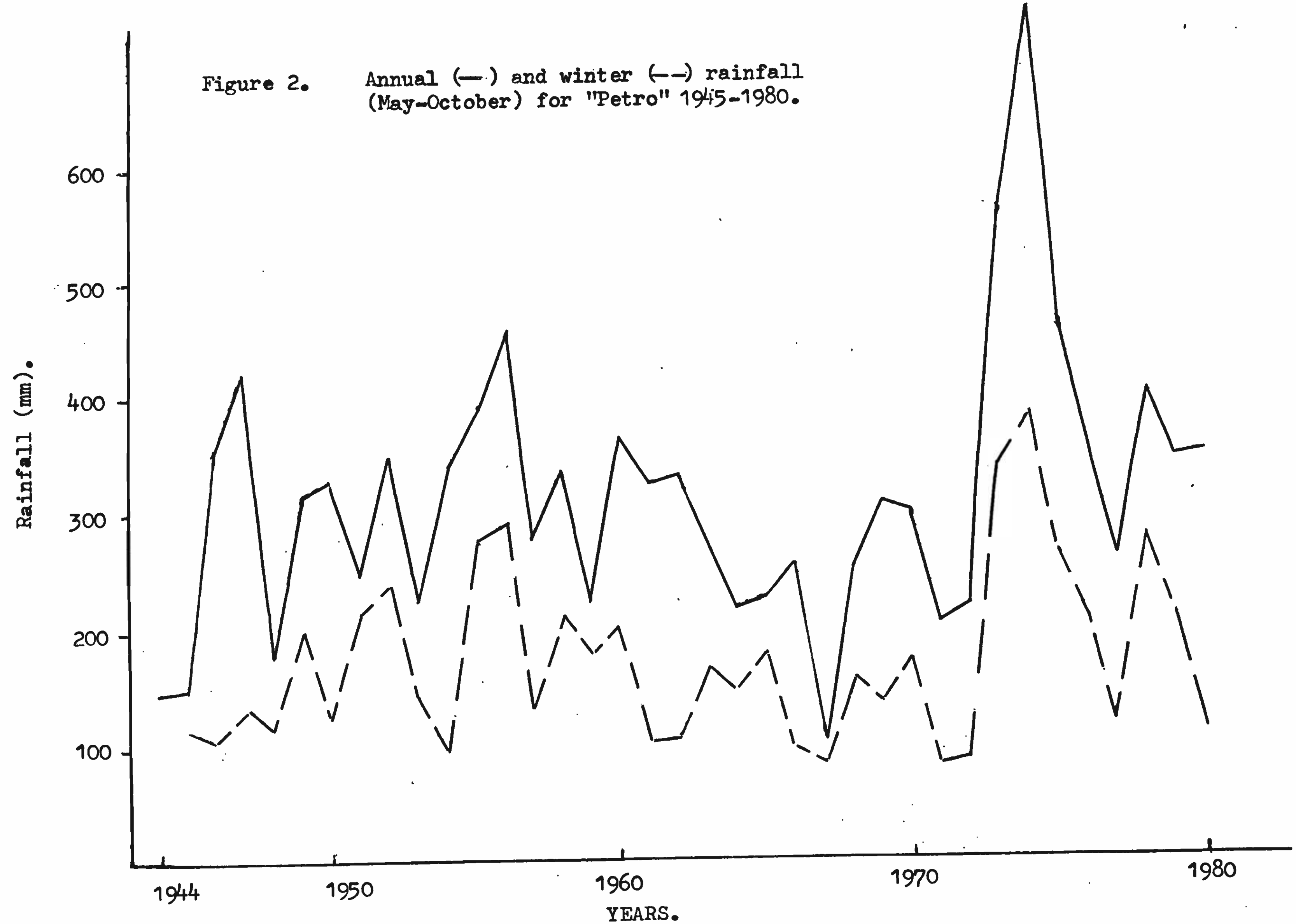
* 25% winter dominance means that 25% more rain falls in the six winter months compared with the six summer months.

Figure 2. Annual (—) and winter (– –) rainfall (May–October) for "Petro" 1945–1980.



4. Lakebeds with heavy clay soils. Cropping is usually carried out to take advantage of stored moisture on a receding waterline.

Soils of the cropping area are mainly solonised brown soils (Gc 1.12, Gc 1.22 - Northcote (1971)) with surface textures ranging from sands to loamy sands on dunes and to clay loams in the depressions between dunes. Siliceous and earthy sands (Uc 1, Uc 5) occur on the higher dunes and are particularly susceptible to wind erosion. Crusty, red duplex soils (Dr 1) often occur in the swales.

Problems for the Landholder

The biggest problem facing the marginal area farmer is the lack of sufficient rainfall during the growing season. Because of this low rainfall, bare fallowing* is necessary to achieve economic yields in most years. Long term studies at Walpeup Research Station in Victoria have shown that yields increase with the length of fallow (Sims, 1965). Fallowing is often carried out from August through to sowing in April/May. When compared with the normal grazing enterprise, grazing capacity during this period is considerably reduced.

Costs associated with delivery of grain to silos (see Figure 1) and farming equipment can be a deterrent to farming. The price of a reasonable second-hand four wheel drive tractor, wide-line scarifier, sowing equipment and header are in the vicinity of $350 000. The farmer can either:

(1) Buy modern equipment and be committed to farming for many years in order to pay it off, or,
(2) buy cheaper, second-hand equipment, eg. disc ploughs, which usually are not designed for conservation farming, or,
(3) enter into an agreement with a sharefarmer, who supplies his own plant.

Drought is likely to hit harder at the farmer than the grazier, especially if he is trying to pay off equipment.

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* Bare fallowing or simply "fallowing", is the practice designed to store subsoil moisture from one season to be used by a crop in the subsequent season.

Benefits to the Landholder

Crop returns can be used to finance the clearing of large areas of land in order to improve grazing country, create speargrass*-free areas, improve water supply and improve fencing.

A few landholders consider narrow-leaved hopbush *(Dodonaea attenuata)* control and vermin eradication as their primary reason for cropping. In some cases, previously cleared dunes have become infested by woody shrubs and cropping of these dunes may keep the shrub problem under control. Cropping may also be useful in making fire control in mallee and belah areas more effective by enabling easier access by fire control vehicles and by segregating areas of fuel.

Benefits to the Land

Specialized cropping can be used as a reclamation technique, especially in areas which were previously cropped and have since fallen out of production due to weed invasion or erosion.

Cropping can lead to an increase in the fertility level of the soil if fertilizers and legumes are used.

Adverse Effects on the Land

Wind erosion and drift are the most serious problems resulting from cropping in this area. Drift is evident on fallows in most summers and occurs when the following conditions are met (Woodruff et al, 1972):

* loose, dry and finely divided soil,
* smooth, bare surface,
* wind velocity in excess of 20 km per hour.

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* speargrass *(Stipa variabilis)* can cause sheep and lamb deaths due to skin penetration by seeds.

At the present time, most of the uncleared areas are stable and if erodibile sites (eg. dunes) are left uncleared, erosion is expected to be minimal. If dunes are cropped, moderate to severe drift is inevitable with the cropping techniques presently used in the area. Increased dust is already evident in the cropping areas.

Salinisation is a potential problem in some areas, both at local and regional levels. Soil salting on arable land is well documented for north-western Victoria (Rowan and Downes, 1963), but little is known of its potential hazard in New South Wales, particularly along the Murray River.

Introduction of weeds is also a problem as evidenced by the rapid spread of onion weed *(Asphodelus fistulosus)* into the cropping areas. It is likely that the spread of weeds will continue, particularly if sharefarmers from established cropping areas continue to operate in south-western New South Wales.

Loss of vegetation communities and their associated faunal habitats will result from uncontrolled clearing. At present two areas have been set aside as National Parks (Mallee Cliffs and Mungo National Parks) in which a number of the vegetation and landscape types are preserved.

Other Effects of Cropping

The increase in cropping has resulted in other effects:-

1. An increase in land values brought about by increasing demand for cropping land particularly by interstate farmers.

2. With more land being cropped and less used predominantly for grazing there is likely to be a loss of grazing management skills.

3. Should the present run of good seasons continue, pressure may be put on the Western Lands Commission to subdivide larger holdings. This happened in the Euston area some 40 years ago but farms were subsequently amalgamated.

The Soil Conservationist's Role

Although broad scale resource surveys on a land system (Christian 1958) and individual property basis are carried out by the Soil Conservation Service, they go only part of the way to solving present and potential problems in this area.

Two basic problems confronting the extension worker/researcher are:

(1) Assessing the relative erodibility of different sites; and
(2) Encourging farmers to modify their clearing and cultivation practices so as to minimise erosion.

Despite the fact that a large area of south-western New South Wales is being cleared and cropped there is little apparent erosion at present. However, erosive winds produce low to moderate amounts of drift on cropped dunes in most years. During the August to April fallow period, a study conducted on similar soils in north-western Victoria (Speedie, in press) found that 47% of fallows had been drifting. The soil conservationist and the community must decide on an acceptable level of erosion. Quantitative data on soil loss, soil erodibility, wind speed and wind direction are needed as a basis for more precise future recommendations for cropping rotations, fallowing practices and clearing limitations.

The Soil Conservation Service is responsible for inspecting individual holdings and reporting to the Western Lands Commission on possible hazards associated with cropping. Special conditions have been devised for different types of cropping country in the Western Division. The normal conditions applied to mallee-belah countryare given in Appendix I. Attached to this list of conditions is a set of recommendations designed to reduce or eliminate drift. These include:

1. Cultivation of soil when damp rather than dry.
2. Cultivation at slow speeds and across the direction of the prevailing winds.
3. Less frequent cultivations of the more erodible sites.
4. Use of tyned implements rather than disc implements.

5. Use of fertilizers and pasture legumes.

Written conditions and recommendations go only part of the way to getting the message across. Although many farmers seem prepared to modify their practices, there is a lack of local research data with which to quantify the problems of cropping light soils and for explaining the restrictions which are imposed. As cropping areas are widely scattered throughout this large area the establishment of a close working relationship with farmers is difficult to achieve.

Research work to overcome some of these difficulties has been planned by the Soil Conservation Service and is expected to commence before the next wheat-growing season.

ACKNOWLEDGEMENTS

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APPENDIX I

1. Uncleared (and uncultivated) ground must occupy at least 15% of the total area to be treated, which shall include a 100 metre perimeter strip uncleared and uncultivated.

2. The distance between any one uncleared area and the two nearest uncleared areas (of which one may be the perimeter) shall not exceed 1 kilometre.

3. Any clump of timber left (including any surrounding uncultivated ground) shall not be less than 2 hectares in area. Clumps of smaller area may be left but shall be disregarded for the purpose of conditions (1) and (2) above.

4. Uncleared and uncultivated strips at least 100 metres wide shall be left across level areas between parallel sandhills, at right angles to the direction of the hills, and at intervals not exceeding 2 kilometres.

5. As an alternative to (1) above, clearing and cultivation may be carried out in blocks not exceeding 120 hectares in area and each block shall be surrounded by a strip of uncleared country not less than 100 metres in width. Where there are no trees, each block shall be surrounded by a strip of uncultivated country not less than 100 metres in width.

6. Sandhills shall be left uncleared and uncultivated except as may be specified below.

7. Defined drainage lines which carry water after storms shall be left uncultivated in the channels and for a width of at least 20 metres on either side.

8. No cultivation shall be carried out on lands with a slope exceeding 2% unless and until such areas have been inspected by the Soil Conservation Service and necessary soil conservation measures installed at the expense of the lessee.

9. Any cultivated area which becomes affected by erosion will be subject to inspection by Soil Conservation Service and to implementation of remedial measures as appropriate, at the expense of the lessee.

10. Cultivation of bluebush stands shall be limited to areas where the average spacing between shrubs is greater than 30 metres.

11. There shall be no clearing or cultivation within 50 metres of any fence. Alternatively, there shall be no clearing or cultivation within 100 metres of any internal fence on the upwind side, with clearing and cultivation allowed up to the fence on the downwind side.

12. There shall be no clearing or cultivation within at least 100 metres of any public road.

13. No more than three (3) crops may be grown in any successive nine (9) years. For the purpose of this clause the term crop shall include the pre-sowing operations, a failed crop or a long fallow.

14. With every third crop, pasture seed (appropriately inoculated) shall be sown. The pastures shall include species in accord with Departmental recommendations. Alternatively, the pasture seed may be sown separately in the following year.

15. Stubble shall be retained except where burning is required to control scrub and timber regrowth or to reduce the buildup of plant disease. Burning operations may be carried out only with the approval of the Soil Conservation Service after consultation with the Western Lands Commission and/or Department of Agriculture respectively.

CULTIVATION OF MITCHELL GRASS *(ASTREBLA* F. Muell.)
RANGELANDS IN NORTHERN NEW SOUTH WALES

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SUMMARY

The mitchell grass pastures of northern New South Wales are economically important to the grazing industry and occur mainly in the 375 mm to 475 mm annual rainfall zone.

Expansion of the wheatbelt into traditional rangelands has led increasingly to the cultivation of these grasslands.

Legislation to regulate all cultivation in the Western Division of New South Wales has curtailed cultivation of the mitchell grass pastures. However, in the freehold country to the east, valuable mitchell grass stands have been, and continue to be, destroyed by cultivation.

INTRODUCTION

The grasslands of northern New South Wales are economically important to the grazing industry of the state. Among these, mitchell grass *(Astrebla* F. Muell.) pastures provide high quality and more reliable stock feed than other grassland pastures under comparable rainfall regime.

The curly mitchell grass *(Astrebla lappacea)* alliance (Beadle 1948) includes an area in New South Wales from a line from Brewarrina to Narrabri north to the Queensland-New South Wales border.

Rainfall in the area ranges from 375 mm to 475 mm per annum, of which 55% to 70% more falls in summer than in winter.

The mitchell grass alliance is characteristic of, and restricted to, alkaline self-mulching clay soils which are not subjected to flooding. The area falls entirely within the Darling River drainage system of northern New South Wales.

The mitchell grasses are perennial tussock grasses endemic to Australia. Curly mitchell grass is the dominant species in the area described although cow mitchell grass *(Astrebla pectinata)* also occurs in small areas. Cow mitchell grass is susceptible to heavy grazing.

Mitchell grass grows mainly during the summer months, provided sufficient moisture is available.

LAND TENURE

The area west of the Barwon River is part of the Western Division of New South Wales. Land tenure is by way of lease, in perpetuity, from the Crown.

Lessees have, for many years, been required to obtain a licence to destroy timber in order to prepare lands for cultivation. The expansion of the wheat belt into traditional rangelands with lower rainfalls and timber clearing costs, has led increasingly to the cultivation of the treeless grasslands.

The Western Lands Act (1901) was recently amended to prohibit cultivation of any lease country without the approval of the Western Lands Commissioner.

Country to the east of the Barwon River is freehold and is therefore not subject to Crown control.

GRAZING

Mitchell grass pastures are important in arid Australia in that they have a stock carrying capacity of three to four times greater than other arid grasslands under comparable rainfall (Jozwik et. al. 1970). The Soil Conservation Service of New South Wales estimates the long term grazing capacity of mitchell grass pastures as 1 sheep to 1.2 ha. This compares with a grazing rate of 1 sheep to 1.5 ha for a wire grass *(Aristida jerichoensis* var. *subspinulifera)*- variable spear grass *(Stipa variabilis)* pasture (with no trees or shrubs) and 1 sheep to 1.2 ha for a woolly butt *(Eragrostis eriopoda)* pasture.

Under good summer rainfall conditions mitchell grasses dominate the grass sward with a basal area of 4% or less (Everist 1964). Associated perennial species are uncommon unless the community has been modified by grazing or altered by cultivation. Neverfail *(Eragrostis setifolia)*, queensland bluegrass *(Dichanthium sericeum)* and fairy grass *(Sporobolus caroli)* are the most important summer growing perennials, together with rigid panic *(Panicum prolutum)* a winter growing perennial. Winter pasture species also include trefoils *(Medicago* spp.) barley grass *(Hordeum leporinum)* and australian carrot *(Daucus glochidiatus)*.

The mitchell grasses are well adapted to the hot arid climate.. Roe (1940) observed that mitchell grasses in southern Queensland shot, seeded and dried off within two months after summer rainfall. Jozwik et. al. (op. cit.) established that mitchell grass seeds germinated rapidly over a wide temperature range which indicates that germination is seldom prevented by low soil temperatures after adequate rain. Seedlings grow and mature rapidly at high temperatures with no evidence that extreme temperatures inhibit growth. Established plants respond quickly to light falls of rain by tillering prolifically from the lower nodes (Jozwik. et al, op. cit.).

TREND TOWARD CROPPING

The increase in the area under cultivation has accelerated during the late 1970's. In 1971/72 approximately 3% of the area under discussion was cultivated, mainly for wheat (Australian Bureau of Statistics Handbook 1971/72). By 1978/79 approximately 6.5% of the area was under cultivation (Australian Bureau fo Statistics Handbook 1978/79).

Applications for approval to cultivate Western Lands Lease country totalling 29,000 hectares of predominantly previously uncultivated country have been submitted in 1981. Much of this area includes mitchell grass and other valuable pasture species.

This increase in the rate of expansion of the wheat belt into traditional rangeland areas is due to five main factors:

1. The continuation of an orderly wheat marketing programme.
2. A run of favourable seasons in the 1970's.

3. Improved machinery and techniques.
4. Improved drought resistant varieties.
5. Favourable commodity prices.

SOIL CONSERVATION SERVICE OF NEW SOUTH WALES INVOLVEMENT

Prior to granting approval for cultivation of Western Lands Lease country the Western Lands Commissioner must seek the advice of the Soil Conservation Service on soil conservation aspects.

The Soil Conservation Service recommendations aim to preserve areas with viable and adequate native seed sources to permit natural regeneration should cultivation prove to be beyond the long term capability of the land. Recommendations also aim to prevent both wind and water erosion by retaining adequate areas of pasture and/or timber.

The high percentage of clay in the soil and the formation of stable aggregates upon drying, make the soils resistant to wind erosion. Water erosion is negligible due to the flatness of the land which precludes both concentration of flow and high water velocities.

The Soil Conservation Service also recommends against the cultivation of mitchell grass pastures due to apparent inability of the species to re-establish after cultivation.

Where cultivation is practised the Service recommends that stubble be retained to provide some vegetative cover during the summer months.

Recommendations made by the Soil Conservation Service for cultivation of heavy clay soils would include the following:

1. Permanently uncultivated ground must occupy at least 15% of the total area to be treated, and shall include a 100 metre perimeter strip.

2. The distance between any one uncultivated area and the two nearest areas (of which one may be the perimeter) shall not exceed 1 kilometre.

3. Any clump of timber or uncultivated area left shall not be less than 2 hectares in area. Smaller areas may also be left but shall be disregarded for the purpose of conditions (1) and (2).

4. Alternatively to the above, cultivation shall be carried out in blocks not exceeding 120 hectares in area and each block shall be surrounded by a strip of permanently uncultivated country not less than 100 metres in width.

5. Defined drainage lines which carry water after storms or high river flows shall be left uncultivated in the channels and for a width of at least 20 metres on either side.

6. No cultivation shall be carried out on lands with a slope exceeding 2% unless and until such areas have been inspected by the Soil Conservation Service and necessary soil conservation measures installed.

7. Areas carrying stands of perennial or bladder saltbush *(Atriplex vesicaria)*, old man saltbush *(A. nummularia)* or cotton bush *(Maireana aphylla)*, even though presently or apparently dead, shall be left untouched for a distance of at least 100 metres around any stand where the plants are spaced at 10 metres apart or closer.

8. Areas carrying stands of mitchell grass *(Astrebla* spp.),even though dead or apparently dead, shall be left untouched for a distance of at least 100 metres around any stand where plants are spaced closer than 10 metres apart.

CONCLUSION

There is a conflict of land use interests in this area at the present time, with some lessees and farmers wishing to grow sometimes highly profitable cereal crops, and the Crown wishing to retain valuable native pastures with the view that regular cropping cannot be sustained.

While control on cultivation is possible in the Crown administere Western Division, a problem in long term range management exists in the freehold country.

In mitchell grass areas rainfall is summer dominant thereby increasing the likelihood of unreliable crop yields. Mitchell grass, as a drought evading perennial, interspersed with highly productive annuals afte good rainfalls, is the system of production best suited to the area.

The inability of mitchell grass to re-establish after cultivation emphasises the importance of the Soil Conservation Service recommendations and the futility of destroying a well adapted grassland pasture unless regular and reliable cropping is possible.

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PHOSPHATE FERTILIZER COATS FOR BUFFEL GRASS SOWN IN INFERTILE SOILS

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Abstract

The use of a seed coating to supply buffel grass (Cenchrus ciliaris) seedlings with adequate phosphate for rapid growth on infertile, acid red earth appears practical. The concept may also apply to other phosphorus-demanding grasses such as Anthephora pubescens. Extensive field testing is now required to see if enhanced early seedling growth rate improves establishment reliability on infertile soils under natural conditions.

The potential advantages are:- (i) greater reliability of establishment (ii) more reliable seed placement (iii) easier handling and distribution (iv) less blowing of seed by wind (v) reduced ant predation (vi) introduction of buffel grass into a further 4M ha of Queensland and N.W. New South Wales.

The cost of coating may be $1.20/kg of pure seed. At current seed prices ($9/kg), the coating process would add 13% to the cost of seed. As compensation, the improved seed placement and reliability of establishment may allow sowing rates to be reduced by 25-50%.

Introduction

Buffel grass (Cenchrus ciliaris) is a successful introduction over a wide area of tropical and sub-tropical Australia. Greatest success has been achieved on the fertile gidyea and brigalow clay soils of central Queensland. Introduction has been less successful on sandier soils, particularly acid, infertile earths such as mulga soils.

The major non-climatic limitation to establishing buffel grass and Anthephora pubescens on sandy mulga soils is phosphate deficiency in the seedling stage (Silcock et al. 1976). Once established buffel particularly persists and yields well at Charleville. The amount of extra phosphorus needed could theoretically be as little as 0.5 mg/seed. Early studies into the P nutrition of grass seedlings on mulga soils involved either deep incorporation of the fertilizer into the soil (Christie 1975) or broadcasting. We set about to determine more critically the amount required per plant and the most efficient means of supplying the fertilizer. In the early trials, Anthephora pubescens was used as the test species because its growth habit is more suited to pot trials. Buffel grass was grown in later studies because of its greater foreseeable pasture potential.

(i) Timing of P application

A water soluble fertilizer $NaH_2PO_4.2H_2O$ was applied, at rates equivalent to 25 kg P/ha, on 1 of 6 occasions, either 3 weeks or 1 week before sowing, at sowing or at the time of emergence of the coleoptile, or leaf 2 or leaf 3 of *A. pubescens*. Subsequent seedling growth was measured for nearly 3 weeks. Within the time scale used, application at any time up until the emergence of leaf 2 was equally satisfactory for stimulating early seedling growth.

(ii) Amount and placement of phosphate

In this experiment the same fertilizer was either applied at the same rate (25 kg P/ha) to different proportions of the soil surface (centred on the seed buried 1 cm beneath) or placed in solid form above the seed (at either 0.6, 2.4 or 9.6 mg P). The pots were then watered to field capacity with a spray. Subsequent seedling growth showed that most treatments were effective, provided the P was placed close to the seed (Table 1). Placing 75 mg of P in a ring more than 5 cm from the seed had no effect on seedling growth.

Table 1. Effect of different phosphate fertilizer rates and positioning on the growth of *Anthephora pubescens* seedlings on mulga soil.

Treatment	Days to leaf 5 appearance	Tiller number after 30 days	Shoot DM yield (mg)after 30 d
no fertilizer	23.2c*	0a	72a
45 mg P, 5 cm from seed	23.8c	0a	84a
0.6 mg P, spot application	17.3ab	0.8ab	264b
2.4 mg P, spot application	16.5ab	2.5bc	435c
15 mg P, 10 cm dia. circle	17.2ab	3.5c	588c
9.6 mg P, spot application	15.3a	5.0d	943d

* Values followed by the same letter are not significantly different ($P < 0.05$).

Thus the P fertilizer requirement per seed is small provided it is supplied close to the seedling and prior to the emergence of leaf three.

Are all forms of phosphorus equally available to buffel grass seedlings? Christie (1975) used insoluble Aerophos (Monocalcium phosphate). Silcock *et al.* (1976) used soluble mono-sodium phosphate while double superphosphate (19.2%P) has been successfully used in field trials at Charleville.

(iii) Sources of phosphorus

A pot trial was conducted with 20 mg of each of eleven phosphorus sources placed 0.5 cm below each buffel seed. Only pyrophosphates were deleterious to germination. All phosphorus sources stimulated seedling growth - soluble phosphates of Ca, K, NH_4 and Na, insoluble phosphates of Ca, soluble metaphosphate ('Calgon'), commercial superphosphates and pyrophosphate.

(iv) Method of coating the seed

The application of a coherent coating to a buffel grass fascicle is difficult to achieve. However without the protection of the fascicle and its seed valves, all soluble fertilizers are very toxic to germinating seeds. If the fascicle is left intact, large quantities of fertilizer can be applied, 20-30 mg if necessary. To date we do not have a proven method applying a consistent amount of soluble phosphate to buffel facicles, but we have been able to produce enough experimentally to continue our studies.

(v) Pot trials with coated seeds

Several pot trials showing the benefits of certain coatings under well-watered conditions have been conducted (Table 2). What is the optimum amount of coating needed?

Table 2. Effect of various phosphate fertilizer coatings on the emergence and growth of buffel grass seedlings in pots of mulga soil.

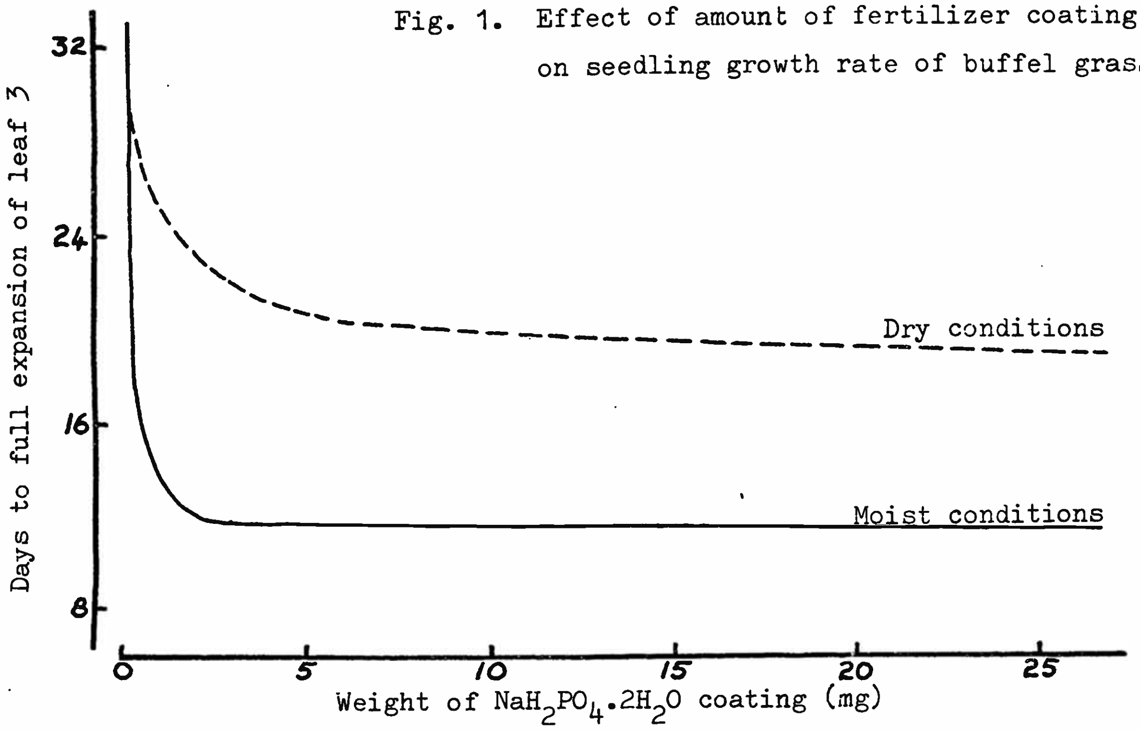
Coating	% emergence after 65 hr	Days to full expansion (F.E.) of leaf 3	Seedlings with 5 F.E. leaves after 41 days (%)
Nil	47b*	30.2d	0a
$CaHPO_4$ (insol.)	56b	21.3c	9a
$CaH_4(PO_4)_2$(sol.)	25ab	15.1ab	100b
'Citraphos'	53b	32.4d	0a
Superphosphate	14ab	16.7ab	87b
Double super	6ab	16.3ab	100b
M.A.P.	25ab	13.2a	100b
$Na_6(PO_3)_3$(sol.)	0a	17.2b	96b
$NH_4H_2PO_4$ (sol.)	33b	13.7a	100b
KH_2PO_4 (sol.)	28ab	16.0ab	100b
$NaH_2PO_4 \cdot 2H_2O$ (sol.)	39b	14.6ab	97b

* Values followed by the same letter are not significantly different ($P < 0.05$).

(vi) Rate of coating trials

Mono-sodium phosphate was used as a coating material because its very high solubility in water allowed a wide range of coat weights to be produced. Seeds and coatings were individually weighed after drying in a desiccator. Two trials were conducted in pots, the second experiencing a much drier moisture regime. Seedling growth was monitored until the fourth or fifth leaf expanded. The response curves produced are shown in Figure 1.

Fig. 1. Effect of amount of fertilizer coating on seedling growth rate of buffel grass



Under moist conditions very little P was needed to give maximum stimulation to seedling growth. Where soil surface conditions were dry the optimum coating rate lay between 1 and 2 mg of P per seed.

(vii) Field trials

Two field trials were conducted in the late summer of 1980/81 to test the efficiency of phosphate seed coatings on buffel seedling growth and survival. Because of the drought, artificial watering was needed to germinate the seed in both cases. In the first trial, coatings produced by Coated Seed Ltd., New Zealand were compared against a 30 mg coating of 'Monofos' (monosodium phosphate) applied by ourselves and an uncoated control (CON). The commercial coatings CS_0, CS_1, CS_2 and CS_3 weighed between 30 and 50 mg and contained an added 0, 1, 2 or 3 mg of mono ammonium phosphate (M.A.P.) respectively.

Figure 2 summarizes the results over the first month. Emergence was slightly reduced by coating the seed. No coating was effective in reducing the rate of seedling death during the ensuing 10 days. Continuing dry weather made more watering necessary to salvage the trial. After the 2 leaf stage, seedling growth was much better from pelleted seeds and best from 'Monofos' (MON). Survival of seedlings to mid-May (98 days) was 18-38% for seedlings receiving

M.A.P. or 'Monofos' compared to 8-12% for the others.

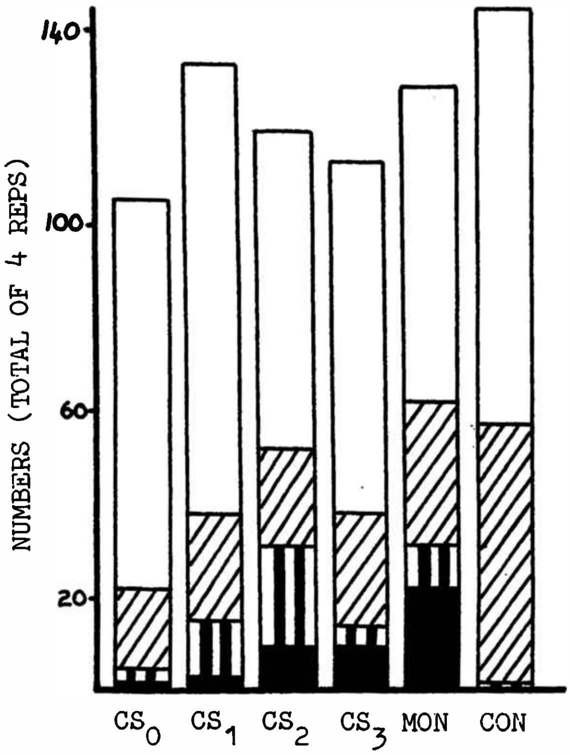


Fig. 2. Emergence, survival and early growth rate of buffel grass seedlings from seed coated with a range of fertilizers.

Table 3. Effect of 3 seed coatings on buffel seedling emergence, growth and survival on mulga soil in the field.

Treatment	Coat Wt. (mg)	% Emergence 4 days	% Emergence Total	Percentage of emergent seedlings with 3 leaves after 15 days	with 5 leaves after 35 days	surviving after 70days
CON	Nil	59	85	2	4	72
CS_2	40.0	9	87	43	53	83
MON	8.2	46	81	68	52	86
M.A.P.	14.2	39	89	52	67	79

The second field trial tested 3 coatings, M.A.P., 'Monofos' and CS_2. The results were similar to the first field trial (Table 3). All three coatings were effective but the weight of coating was much less for 'Monofos' and M.A.P. The commercial coatings are, however, very robust and durable while ours are brittle and easily removed.

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DROUGHT FREIGHT SUBSIDIES IN THE NORTHERN TERRITORY AND THEIR IMPLICATION FOR PRESERVATION OF RANGELANDS

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INTRODUCTION

In arid and semi-arid pastoral areas, if permanent damage to rangelands in the form of accelerated erosion and pasture degradation is to be avoided early in drought periods, it is necessary to rapidly reduce stocking pressure in accordance with forage availability. After drought has broken, pastures should only be lightly stocked until palatable annual and perennial species have established and attained normal vigour.

In the Northern Territory two drought assistance schemes have operated to assist the cattle industry which, by provision of subsidies, could be expected to affect the management of rangelands during drought periods. In 1961, following three successive years of drought throughout most of central Australia, the Commonwealth Government introduced a drought relief scheme in the Northern Territory which subsidised above normal turnoff of cattle. This policy was last applied during 1971.

Following a run of above average seasons from 1972-78 and the collapse of beef cattle markets during the period 1974-77, cattle numbers grew to record levels. In these circumstances the Commonwealth policy was deemed inappropriate. The Northern Territory Government adopted a new drought assistance scheme in January 1981

This paper summarises the provisions of each policy, comments on the effectiveness of the former Commonwealth Policy and raises a number of questions concerning the newly adopted Northern Territory Government Policy.

THE COMMONWEALTH DROUGHT RELIEF SCHEME

The policy was determined by the Minister for Territories in 1961 as "*our objective is to prevent cattle from dying on the run and we should keep clearly in mind that this is the only objective we are trying to serve in drought relief*". (Anon, 1961). The policy applied to all properties in the Northern Territory.

Assistance in the form of drought relief freight concessions were:-

(a) 50% of the cost of road or rail transport of fodder for starving stock,

(b) 50% of the cost of road or rail transport and droving charges of starving stock moved off the property.

(c) 50% of the cost of road or rail transport and droving charges of stock returning to the property from agistment.

In general, drought relief concessions only applied to stock being moved which would not normally be moved off the property. As a general rule concessions were only payable for breeders but occasionally subsidies were paid on movement of store stock where these are not normally part of station turnoff.

Properties were declared droughted when available feed was inadequate to support the cattle being carried. As the objective was to prevent cattle dying, very little consideration was given to previous rainfall and pasture growth response, total stock numbers or the assessed grazing capacity of the property. When rain fell the drought status of the property was immediately reviewed.

THE 1981 NORTHERN TERRITORY DROUGHT ASSISTANCE SCHEME

This scheme defines drought as *"summer rain insufficient to produce adequate pasture growth"*. The objectives of the policy are to provide an incentive for adoption of management strategies which will alleviate the effects of drought, to reward good rather than poor management of stock and land and to allay hardship. Furthermore the scheme had to comply with *Natural Disasters Assistance Arrangements* between the Commonwealth and States and not be an excessive burden on taxpayers. (Anon, 1980).

Although the new policy defines drought on the basis of rainfall and pasture growth, assistance from the Northern Territory Government is only available immediately to properties in the dry monsoonal area (Barkly Tablelands and Victoria River Districts). For properties in the semi-arid area (Alice Springs District) where summer rainfall occurs less frequently, relief is not provided until after the failure of two successive summer rainfall, and therefore, growth periods.

Properties declared droughted are able to claim:-

(a) a 50% fodder freight subsidy to operate from the point of purchase to the property.

(b) a destocking freight subsidy on road transport (but not droving) of

    (i) 75% on all turnoff in excess of the previous 10 year average turnoff in the first qualifying year,

    (ii) 60% on all turnoff in the second year (provided the average turnoff is met in the first year),

(iii) 40% on all turnoff in the third year,

(iv) 20% on all turnoff in the fourth and subsequent years.

(c) the destocking freight subsidy is limited to the distance to the nearest railhead for properties in the Alice Springs and Barkly Tablelands districts or to Wyndham or Darwin for properties in the Victoria River District.

(d) a slaughter subsidy of $15 per head on all helpless and unsaleable stock slaughtered.

(e) a restocking freight subsidy during the year following the revocation of drought of

(i) 50% on agisted breeding stock to operate from the property of origin to the property of agistment and return,

(ii) 50% on breeder replacement stock to operate from the point of purchase to the cattle station.

The total restocking freight subsidy payable to individual properties is limited to the equivalent number of breeders turned off or agisted during the drought to a maximum of 3,000 head of adult stock.

DISCUSSION

Under the former Commonwealth Policy, assistance measures were provided only when cattle were in danger of dying on the property.

During the period in which the policy operated, cattle movement restrictions due to diseases were less rigid enabling most pastoralists to sell store cattle for fattening mainly in Queensland and South Australia and to a lesser degree, Victoria and New South Wales. Although the freight subsidy was limited to the equivalent of the distance from the property to Adelaide, it still provided a significant financial incentive to all Territory producers to reduce breeder numbers. The net effect was reduction in the number of deaths on the run because a greater number of breeders less able to survive drought were turned off. It is also probable that a greater number of male cattle were retained. As cattle were in poor condition when they were turned off, many deaths occurred during droving and transit.

As forage availability had to be inadequate before the producer was eligible for subsidy payments, the policy did not encourage early reduction of stock numbers when it was evident that summer rains had failed. It was probable that many pastoralists would have held cattle hoping for relief rains, or in anticipation of receiving freight subsidies. The consistent pressure on pastures resulted in accelerated pasture degeneration and erosion. (Condon, Newman and Cunningham, 1969; Parts I & IV). Furthermore the policy did not consider the management ability of the producer. Pastoralists who reduced numbers while cattle were in a saleable condition and those who continued to turnoff a reduced number of fat cattle by better management of stock and pastures received less assistance than poor managers.

Subsidy payments on stock returning from agistment were only payable if the property had been inspected to determine whether adequate feed was available.

Restocking without approval made the producer ineligible for further assistance for a minimum period of six months if drought conditions continued. This procedure discouraged over-optimistic restocking following small falls of rain and gave some pastures increased time to recover following the break of drought.

In the late 1970's when cattle numbers had risen to record levels, access to store markets was no longer available to many producers due to the brucellosis or tuberculosis disease status of their herds. The establishment of export abattoirs at Alice Springs and Tennant Creek meant that only prime cattle would normally be shipped to Adelaide or Brisbane.

Furthermore, in circumstances where many properties were over-stocked, the probability thatcattle would die on the run was an inappropriate criteria for being eligible for drought assistance. Both the pastoral industry and the Department of Primary Production were aware that considerable stock losses and severe environmental degradation would occur with the onset of drought conditions. It was evident that the policy was not relevant to the prevailing circumstances and a new Northern Territory policy was developed in an attempt to overcome the above difficulties.

The new Territory policy was adopted in early 1981 and the full implications of the subsidy provisions for management of rangelands are not yet evident. Already questions have arisen:-

- Will the annually reducing rate of freight subsidies during the period of a drought effectively encourage early turnoff?

- The policy takes account of climatic differences by distinquishing between the semi-arid and dry monsoonal pastoral areas but will pastoralists accept the implied onus to manage their stations according to climate and seasonal conditions?

- By requiring that two successive rainfall failures be experienced in the semi-arid area before assistance is available, does the policy provide an incentive to turnoff cattle before feed reserves are depleted?

- To what degree will restrictions on distance over which freight subsidies apply influence turnoff strategy of a pastoralist close to the railhead or abattoir compared to the pastoralist a considerable distance from the abattoir?

- Will the provisions governing restocking sufficiently restrict stocking pressure after drought to enable pastures to recover?

- Are subsidy levels adequate to achieve the objective of rewarding good management of cattle and land and allaying hardship?

- If use of subsidies is ineffective in achieving adoption of ecologically judicious drought strategies, are there acceptable alternative methods?

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LAND DEGRADATION AND DROUGHT RELIEF MEASURES IN THE MULGA LANDS OF WESTERN QUEENSLAND

by

J.R. Mills*

Abstract

Land degradation in the mulga lands of far south-west Queensland is discussed in relation to the extended drought periods which occur in this area. The use of drought relief measures to provide incentives for more conservative utilisation of these lands during drought periods is outlined. Property sizes are examined, and costs of a property build-up program estimated.

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History shows that following the introduction by man of domestic livestock, the productivity and carrying capacity of many arid areas (< 500 mm rainfall) of the world (such as North Africa, the Middle East, the south-west states of America, South Africa and Western New South Wales) have been drastically reduced by the invasion of unpalatable plants or soil erosion.

Increased knowledge of the land resources and ecosystem processes in the mulga lands of Western Queensland has focused attention on the land degradation effects which persist following drought periods. The cost-price squeeze in the pastoral industry, combined with high interest rates, has also accentuated the adverse effects of loss of income during drought periods. In practical terms, this means that smaller producers with marginal profitability are forced to operate their properties at maximum stocking rates at all times to service debt repayments and provide some surplus for living and family expenses.

Figure 1 shows the periods of drought declaration for various shires in the far south-west of Queensland over the last 17 years. The data do not include individual droughted property declarations, which would add further to the overall area and time of drought incidence. Silcock (this Conf.) has indicated that the present drought relief scheme caters for 'normal' dry seasons as well as severe drought periods.

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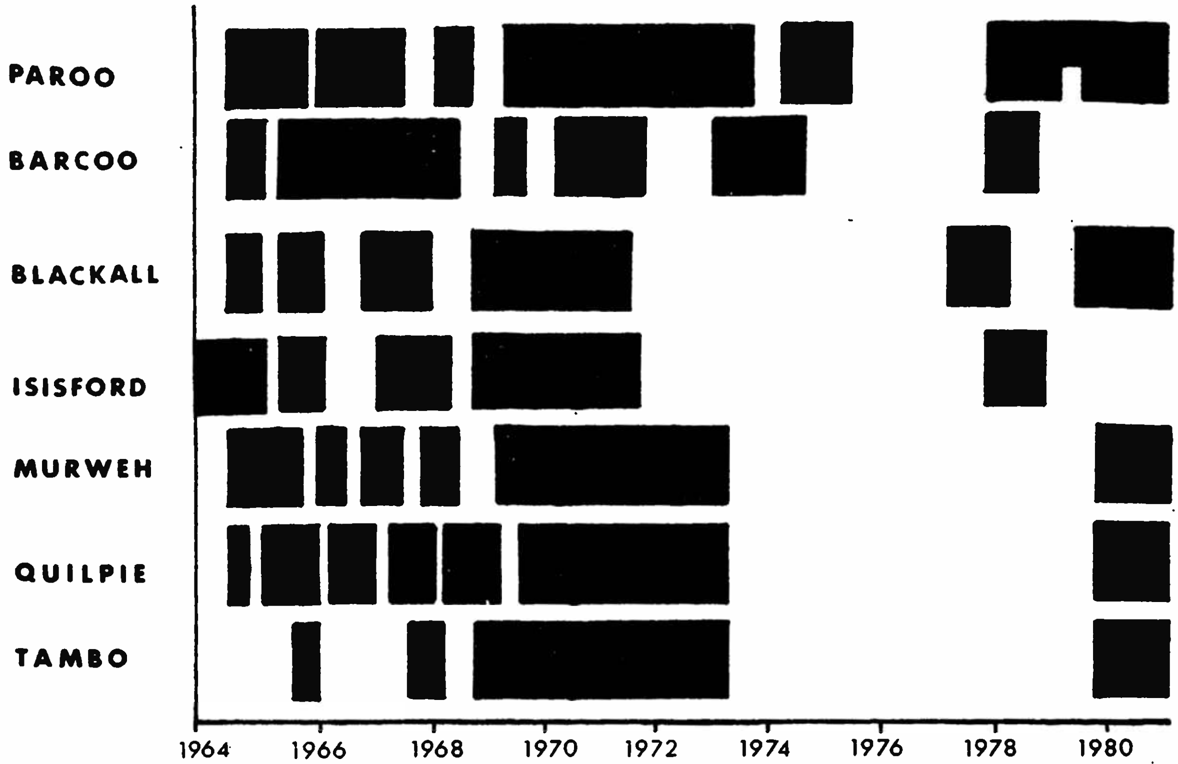

FIGURE 1. Periods of drought declaration for some south-western Queensland shires.

The extent of these periods of drought declaration, when viewed in the light of the significant woody weed populations recorded in the Western Mulga lands by Burrows and Beale (1969), and subsequent increases in these populations (Charleville Pastoral Laboratory, unpublished data), indicates that the long term productivity of the mulga lands may have been substantially overestimated. The Commonwealth and State Government Collaborative Soil Conservation Study (1978) (S.C.S.) indicated that 52% of the Queensland arid zone was suffering damage ranging from vegetation degradation to severe erosion and/or dryland salinity.

The mulga lands and frontage country in far south-west Queensland have been defined by land systems surveys (Dawson and Boyland, 1974), to be susceptible to land degradation. Major emphasis is placed on preventing the initial establishment of woody weeds or erosion surfaces in these lands because of the cost of conventional land rehabilitation measures.

The maintenance of adequate ground cover in the form of mulga trees, litter and pasture during drought periods is essential to prevent the start of the degradation cycle in mulga lands. This ground cover can only be maintained by relatively low levels of utilisation (or stocking rates) by both domestic and native animals during and immediately before the dry period.

Given the high frequency of dry periods in the area, a grazing system is needed in which the number of stock appropriate to a dry season is normally carried, and any build-up in stock numbers which occurs during runs of good seasons is rapidly reduced to the basic dry season number as soon as dry seasons recommence. Rainfall data for Charleville shows 62% of years have below average rainfall (487 mm), indicating the need to cater for low rainfall years in land and stock management (Silcock, this Conf.).

Under the present system relatively high stock numbers are often maintained over dry seasons and through severe drought periods by felling mulga. The adverse consequences of such a stocking policy in destabilising the sensitive mulga lands, particularly during the recovery phase following drought, have been referred to by Pressland (this Conf.), and Brown (this Conf.), whose data shows that even at conservative utilisation levels, c. 80% or more of the grass population at a site in the Eastern Mulga resource region died during a two year drought, and was replaced by seedling recruitment following the drought.

The concept of using the more conservative 'dry' season stocking rate as a basis would necessitate an adjustment in the area required to maintain a family unit and provide some return to capital and management. The remainder of this paper looks at existing drought relief measures, and compares the cost of these measures with that of a property build-up program.

Drought Relief

Existing drought relief schemes, which apply to individual droughted properties and properties in drought declared shires, provide freight rebates of 50-75% for stock, fodder and water movements, as well as carry-on and restocking loans at concessional interest rates. Income tax arrangements which allow the use of Income Equalisation Deposits (of questionable value) and the spreading or carrying forward of income from forced stock sales during periods of drought declaration are provided by the Commonwealth. Expenditure on relief measures is significant and loans and freight rebates are understood to amount to at least $90M in Queensland (Robinson, this Conf.) in the period from the 1965 drought to the present time.

There has been some criticism of existing drought relief measures on the grounds that they do not benefit the better managers who take action to reduce stock numbers before the drought reaches a stage where a declaration is made (Mawson 1979). Existing measures are generally based on the condition of the stock in question, which may not properly reflect the condition of the pasture, particularly where topfeed is available. The S.C.S. has stated that 'Soil conservation objectives need to be inserted in relief measures as soon as they start. They (these objectives) should also help to determine when relief measures start. This particularly applies to destocking policies during droughts and in the early recovery phase'.

Positive and constructive drought relief measures are desirable from a resource management point of view. Such measures should contribute to amelioration of drought and land degradation problems in the long term by encouraging sound management practices and the restructuring of living areas where necessary. Mawson (1979) has said that though managers must accept responsibility for their management and consequent personal loss or gain, it is in the interest of the community at large that incentive be provided to encourage conservative management in order to maintain productivity.

The continuing flow of funds into short-term, 'relief' or 'welfare' measures every time a season falls short of expectations must be looked at closely in the light of increasing pressure on Government to justify fully all avenues of expenditure. Money spent on these measures also has some potentially adverse effects. It may allow small, marginally economic units to survive, when without aid, natural market forces would have caused these units to come on the market. This, theoretically, would have made them available for other landholders to increase their property size. On the other hand tariff protection of the manufacturing sector was estimated to have cost the sheep and cattle industries $616M per annum as long ago as 1975/76 (A.W.G.C. 1977). In view of this, and because of the considerable disadvantages in respect to 'normal' community services suffered by country dwellers, there may be a strong case for providing welfare type assistance to owner-operator type enterprises.

The adjustment of living areas to facilitate lower utilisation levels in the mulga lands, together with the provision of incentives for the early reduction of stock numbers following failure of the growing season, are the principal modifications necessary to incorporate land conservation objectives in current drought relief measures. Changes of this nature should eventually reduce expenditure on emergency drought aid, such as carry-on loans and restocking loans. More conservative stocking rates will reduce both the stock numbers which have to be moved and the corresponding freight rebates.

Proposals that stock movements made in anticipation of drought should attract freight rebates if a drought declaration is subsequently made, should remove an existing anomaly. At present graziers who reduce stock numbers early are not eligible for freight rebates, while those who move animals only when their condition has begun to decline qualify for rebates.

The adjustment of living areas has been slowly occurring through the Rural Reconstruction Board and through private trading. Historically the concept of property build-up leading to increased viability and better management of the land is unsubstantiated. However in recent years the work of Holmes (1980) in the Murweh Shire, which is composed mainly of mulga lands, revealed that graziers surveyed regarded property enlargement as the adjustment which best satisfied the goal of future income (by off-setting anticipated future cost increases and income declines). Holmes also found that other important motives for buying more land were to buy better country for sheep breeding or cattle fattening, and to enable stock to be spread out during drought periods. He concluded that property enlargement offers considerable scope for more efficient labour use.

Childs (1974) found that in the Western Mulga resource area, properties with larger areas had a significantly higher degree of financial success than smaller properties. He concluded that in this area a certain minimum property size may be necessary to allow flexibility for management to respond to variations in climate, pasture conditions and product prices.

Financial data collected by Mills, (1981) in the Paroo Resource Region showed that larger properties had lower debt levels, higher per property and per family unit incomes, and ran marginally lower stocking rates. Ninety percent of properties had plans for further expansion.

The enlargement of living areas or property size by the acquisition of additional land, or trading up to a larger property, is a desirable move for increasing graziers' returns. It also provides them with the flexibility and the opportunity to manage sensitive lands in a conservative manner where this is necessary to maintain the productivity of these lands.

In 1971 the Land Administration Commission's guidelines for mulga country west of Charleville nominated a minimum of 8750 sheep. Survey data of Mills (1981) from this area indicates that properties with $<$10 000 sheep had considerably lower returns than properties with $>$10 000 sheep.

If we assume 9000 sheep as the very minimum desirable size, then of the 451 aggregates listed in Table 1, 298 are below this size. Deletion of aggregates with less than 3000 sheep on the grounds that they are 'hobby farms' or non-commercial units supported by off-farm income, leaves 263 properties below the recommended size.

Table 1. Carrying capacity assessments for properties in the far south-west of Queensland, which contains c. 90% of the 500 mm rainfall mulga lands in the state.

Stock Numbers*	No. of properties or aggregates
<3000	35
3000-5000	62
5000-7000	123
7000-9000	78
9000-12 000	73
12 000-15 000	36
15 000+	44

* Department of Lands assessed carrying capacity (sheep).

These 263 undersized properties run 1 607 000 sheep. At an average property size of 9000 sheep this would be reduced to 178 properties. So 85 properties, in theory carrying the average of the range 3000 to 9000, (i.e. 6000 sheep), need to be reallocated amongst the remaining 178 properties. Thus 510 000 sheep areas need reallocating. Valuing sheep areas at $40 overall for the mulga lands, country worth $20 400 000 will have to be bought by the remaining properties. Taking a value of $21M being required for the build-up, one possible course of events is as follows.

One third of the build-up occurs unaided over the next 10 years. This reduces finance required to $14M. Of this amount assume the Government has to fund one half ($7M), with the remaining $7M being forthcoming from banks and buyers themselves. A typical buyer's package would be made up as follows, 50% Government money, 25% private trading bank or Commonwealth Development Bank, 25% own funds.

An input of $7M over a period of 10 years is only 2.7% of the estimated expenditure on drought measures of $258M* over the next 20 year period,

* Based on the same expenditure of c. $90M (loans and freight rebates) as for the period 1961-1981, projected forward at 10% yearly inflation rate.

1981-2001. Repayment of early loans could provide capital for later loans, so an amount of less than $7M is likely to suffice.

Real cost of the scheme if the money was raised at 13½% interest and re-lent at the same rate of 5% as present carry-on loans, would be $595 000 (difference between 13.5% and 5%) each year, even if the whole $7M was lent out at once. This represents 5% of the expenditure (to April 1981) of c. $11M on loans and freight rebates made to the far south Queensland area during the 1979-81 drought.

Mawson (1979) and Holmes (1980) have referred to difficulties in property build-up, mainly related to finding suitable additional areas. It is evident that the increasing acquisition and use of aeroplanes may allow blocks which had previously been considered unsuitable because of distance or labour requirements, to become a practical proposition. While acknowledging some administrative and spatial difficulties it is proposed that:

- property build-up can be hastened by channelling a proportion of drought relief expenditure in this direction, and this will be instrumental in providing the opportunity for conservation management of the mulga lands to maintain their productivity.
- the cost is not excessive and should be recouped through a reduction in the need for emergency drought assistance in future droughts.
- high land prices at the present time mean sellers are comparatively easy to find. This provides a good opportunity for considerable property build-up to take place, particularly while the memories of the present extended drought period are fresh in graziers' and administrators' minds.

Acknowledgement

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ARE DROUGHT RELIEF SCHEMES DESIRABLE?

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Abstract

In the last two decades hundreds of millions of dollars have been spent by Governments in Australia on drought relief schemes. In some cases the droughts were simply periods of below average rainfall - part of the normal cycle of seasons which semi-arid Australia experiences. Too many people expect more of our climate than is realistic. Consequently we are doing serious damage to the pasture and soils (which do not receive drought relief) by running excessive numbers of animals during dry seasons.

In the interest of long term stability and productivity of our rangelands, the amount of money spent on drought relief should be reduced. Any money outlayed should help reduce the likelihood of future claims e.g. by incentives for early destocking and late restocking in dry years and by facilitating the sale or size increase of uneconomic holdings.

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The definition of a 'drought' is infinite in its variety but could broadly be described from 2 viewpoints in Australia -

(i) the socio-political one i.e. dry conditions which temporarily prevent a primary producer from growing animals or crops as well as he would hope for his environment, resulting in animal deaths or crop failures and a low financial return

and (ii) the biological one - a deficit of rainfall such that pasture growth is severely restricted during the normal growing season and abnormally high rates of perennial plant death occur.

In the Murweh shire of S.W. Queensland, there have been category (i) droughts i.e. shire drought declarations in force for nearly 50% of the last 17 years. There have been 4 very dry summers i.e. < 200 mm summer rain, over the same period (summer being the growing season - Christie 1978) and 5 other dry summers. Thus it would appear that present schemes in Queensland are catering for dry seasons rather than severe droughts. I believe a similar situation exists in many parts of Australia.

Dry summers are the rule rather than the exception at Charleville (Fig. 1), so one would assume that farmers, graziers and Government officers in the area would manage the land with this in mind. Biologically this makes sense. However, if a man sees other depressed industries getting Government assistance then he wants even-handed treatment. Dairy farmers on the coast have had large sums of money injected into their industry in Queensland in the last 13 years

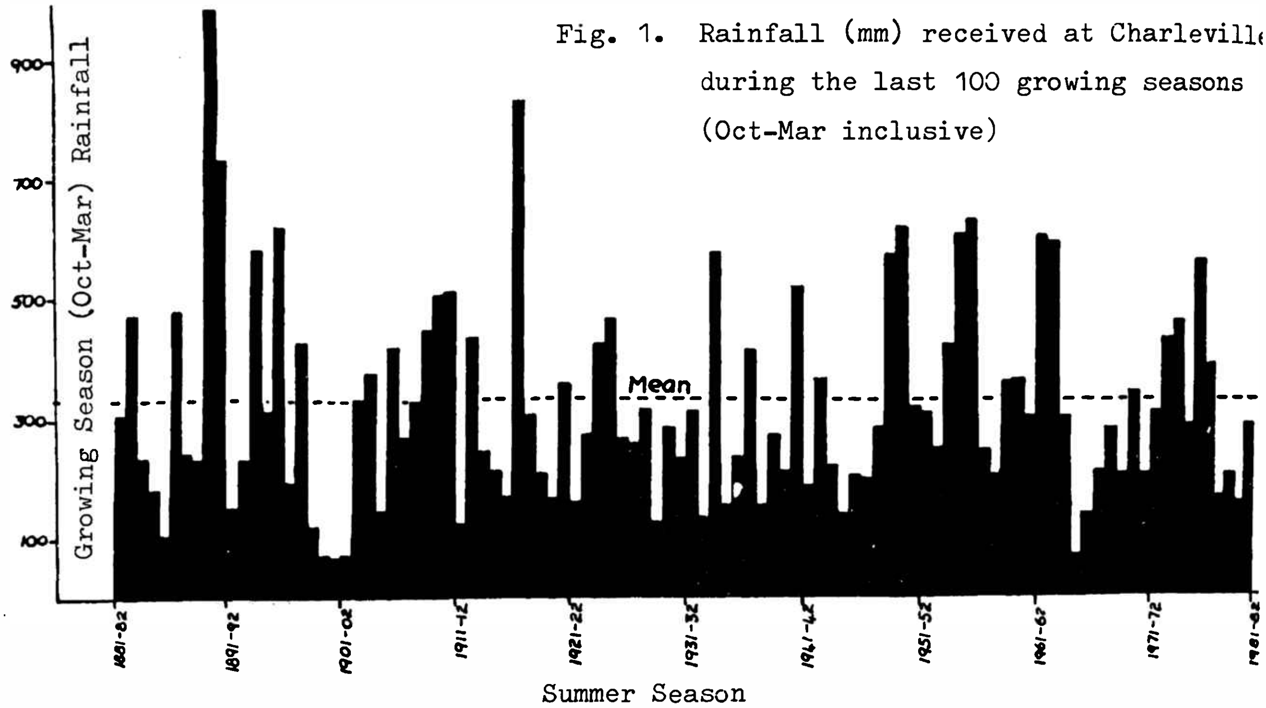

Fig. 1. Rainfall (mm) received at Charleville during the last 100 growing seasons (Oct-Mar inclusive)

to improve efficiency. Ex gratia payments have also been made to wool and cattle growers in the last decade during times of low prices. In secondary industry, trade and tariff barriers protect vulnerable industries such as textiles and car manufacturing. Such protection was reported to cost graziers $11,600 each in 1975/76 (A.W.G.C. 1977). In this light, drought relief measures for primary producers seem completely fair and reasonable.

In recent years it has also seemed Government policy, both State and Federal, to give aid to victims following natural disasters such as cyclones and floods. Clearly, it is socially and politically acceptable to give this aid. Overall there seems to be a general trend towards direct Government financial aid to the disadvantaged e.g. grants, rail rebates etc. rather than indirect aid such as long term loans and restructuring of inefficient enterprises. The total cost of such indirect schemes may be no greater than the present system of direct payments and could also assist in minimising land degradation by reducing grazing pressure in dry times.

Who benefits from the present drought relief schemes? Obviously the owners of stock and the transport industries would benefit most. Who owns the stock,- breeders, dealers, doctors, pastoral companies, solicitors, hobby farmers etc? The proportions are very difficult to determine. Who owns the transports,- the Government, small local carriers, accountants, other investors? The transport industry assistance also benefits the community and towns in the drought affected areas via the employment it generates. However the local benefits from assistance to the stock owners may not be as great. Highly paid professionals and pastoral companies should be able to weather a typical dry season without Government help. Bear in mind that they have the capital and assets to purchase or raise the necessary finance for purchasing large or expensive properties, often at currently inflated values with which the local graziers cannot compete. In the recent drought the Diamantina Shire, where the owners are almost all large pastoral companies, received almost 80% as much road transport subsidy as did the Murweh Shire. Murweh has about 20 times as many properties and 2.6 times as many cattle equivalents.

Where should most assistance be going - to the land, the vegetation, the nucleus herds, the rural workforce or the coastal bank accounts? Surely the fragile natural resources should be the first beneficiaries in the face of the unnatural onslaught made upon them by human exploitation. Without the resources there can be little net local contribution to primary production. Without rural industries and a habitable environment there can be no significant population or monetary economy. The next most important concern would probably be for the welfare of the nucleus of local stock and then for the graziers' direct welfare. With the relatively good stock water supplies available in inland Austalia, nearly every grazier should be able to maintain his nucleus of breeders through most Queensland droughts provided he reduces stock numbers early in a dry period. As Figure 1 shows, only rarely are there summers where rainfall is negligible (1899/1900, 1900/01, 1901/02 and 1964/65). Naturally there can be disasters (fire, flood, insects and extreme droughts) which would have to be given special consideration, but these are normally very localised. Remember, in the very wet years and following any very heavy rains, floods smash fences, while flies and other pests are rife. Individual properties can suffer huge losses in these circumstances but that does not attract Government handouts on a large scale. However a township, recreation facility or tourist attraction badly damaged by high winds or floods will usually receive rapid and direct Government assistance.

Government assistance to rural industries is a fact of life. In 1977-78 Australian agriculture received $308M from the Commonwealth Government and $241M from State and Local Government (Hawke 1980). This amounts to 6.25% of the gross sources of agricultural income in that year. In return, total payments to Government from the agricultural industries was $910M, so it was far from a one-way traffic in funds. However, is Government assistance in the form of drought relief being directed to the right places? For example, has the $21.3M spent in Queensland by State and Commonwealth authorities in the 1979-81 drought (up to 30.4.81) assisted in maintaining the long term stability and viability of our agricultural industries or has it been a satisfactory political undertaking that has kept Governments from facing hard facts about the way semi-arid Australia is being exploited by certain agricultural enterprises?

I turn now to south western Queensland again as an example because the area is known best to me, but others could be found throughout Australia. The two major vegetation types are the mulga and the mitchell grass country. Dawson and Boyland (1974) and others have highlighted the relative fragility of the mulga land and its continuing degradation biologically, compared to the relative stability of the mitchell grass downs (Turner 1978). Economic surveys by Childs (1973), Holmes and Mills (1978) and Mills (1981) indicate that increased property sizes are often needed for financial viability, provided extra labour is not required also. However, the combination of high current debt levels and an inability to obtain early financial assistance to increase their property size when the opportunity arises (Holmes 1980), leaves these producers in a chronic state of marginal profitability. The result is that the country is continuously overstocked, being steadily overrun by woody weeds and grasses of little value, while sheet and gully erosion are increasing.

What graziers and the mulga vegetation need most is property build-up, not drought relief. They need to be able to run sufficient stock so that in dry times they can sell excess stock, invest the proceeds of the sale and wait for better seasons to return. Cutting the readily available mulga scrub may keep their animals alive but the country is being hammered at the time when it is most vulnerable. The pastures get no chance to recover afterwards either, because stock are still there when the relief rains come. By comparison, mitchell grass country has no top feed to allow animals to stay after the grass has been eaten and owners are then forced to move or sell their stock.

Mills' (1981) figures for one type of mulga country indicate that 15 000 dry sheep equivalents would earn a healthy average net income (about $34 000 p.a.) for a family but a low return to capital. At the recommended stocking rates for that country (1 sheep per 3.5 ha) 52 000 ha are needed to run these stock. Management units of this size are not common in that district, half this being the more common size, often despite the aggregation of several leases to acquire even that size. The Lands Department in Queensland has been assigning additional areas in recent years to landholders with small areas. Generally this has only had the effect of raising living standards from 'economic famine' to 'drought stricken conditions'.

Recently, land values in S.W. Queensland have increased enormously, with values up to $40-50 per sheep area being paid. Classical economics would indicate a very low return to capital on such an investment. So why are people buying this land? It could be partly naiveness or optimism about capital gains for some buyers. It is partly an exercise in property build-up by many longer-term residents and this can be attractive economically (Holmes 1980). Profitability may not be important to certain buyers. Nevertheless buyers also know that they can stock heavily and when things get a bit dry, drought relief will be forthcoming. Government authorities must be made aware of the long term damage which is being done to much of the mulga country be continued heavy stocking. Otherwise the options in 50 years time could be either (i) to turn the area into nature reserves or military training areas or (ii) the inclusion of mandatory, expensive scrub control or clearing clauses into tenure agreements or (iii) massive Government subsidies for rehabilitation measures. World wide experience shows that rehabilitation of degraded (i.e. overexploited rangelands) is often a very slow and/or a very expensive process. With Australia's low population density we have no excuse for overexploiting marginal land for some short term political or social gain. I believe that a healthy grazing industry, based on large properties in good condition with moderate stocking rates, will support at least as large a rural population in the future as at present and without the need for regular drought relief.

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Drought and the mulga lands of Queensland

by

A.J. Pressland*

Abstract. A comparison in western Queensland of pasture yields and stocking rates indicate that the latter are similar on mulga (*Acacia aneura*) rangelands to those on the Mitchell grass (*Astrebla* spp.) rangelands despite large differences in pasture biomass. The theme is developed that the maintenance of stock numbers on mulga country during extended dry periods, and restocking too rapidly at the end of a drought is biologically unsound. An alternative approach outlines the need for financial incentives to encourage sound biological practices and for government assistance in the search for, and finance of, additional areas for small land-holders.

Introduction

Drought is a frequent occurrence in the mulga (*Acacia aneura*) rangelands of south west Queensland. The shires of Murweh, Paroo and Quilpie for example have been declared drought striken for 40 to 48% of the time between September 1964 and March 1981. Since the commencement of the most recent drought in 1979, road transport subsidies of $1.98 million have been paid to graziers in the south west while loans totalling $7.33 million and rail transport concessions of *c.* $2 million have been made statewide.

Droughts are expensive, but not only in terms of hard cash. They are also at the expense of the natural resources - soil and vegetation. In this paper, I look briefly at some biological consequences of maintaining stock on drought affected property in south western Queensland by feeding pushed mulga.

Stocking rates and pasture production

Stocking rates in a pastoral area with a substantial amount of shrub or tree cover would be expected to be considerably lower than on an open grassland with a similar climate because of the lower pasture production (Beale 1973). A further reduction in stocking rate could be expected where the potential pasture production is lowered due to a combination of low soil fertility and poor soil-water holding capacity. The number of stock which could be carried in a mulga community would be expected to be less than one

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half that in a Mitchell grass (Astrebla spp.) community, On the basis of forage yields (Figure 1) and assuming that the nutritional value of the two pasture types and their utilization levels are similar. In practice, this is not the case. The mean stocking rates employed in western Shires over a period of thirty years are shown in Table 1. Stocking rates of two of the shires dominated by mulga are in fact similar to those of the two shires dominated by open Mitchell grass downs. Quilpie shire, the most western of those with mulga, has the lowest rainfall and the least mulga, so stocking rates employed there are considerably lower than in the more eastern shires.

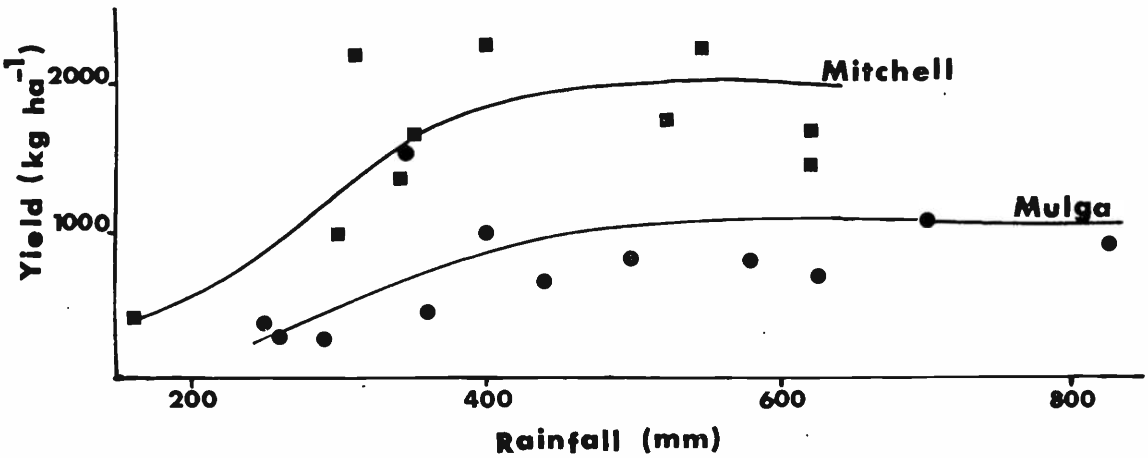

Figure 1. Mitchell grass and mulga pasture yields related to annual rainfall. Mean yields were 1600 ± 190 kg ha^{-1} and 740 ± 110 kg ha^{-1} for the former and latter respectively. An additional 50 kg ha^{-1} of mulga leaf maybe available to stock grazing mulga pastures. (Source of data: Ebersohn 1970, Orr 1975, Christie 1978, unpublished data of staff at the Charleville Pastoral Laboratory.).

The apparent ability of mulga country to support many more stock than would be indicated by the pasture yields is probably due to underestimating the quantity of mulga available to stock on standing trees, or on trees cut or pushed by the grazier. It is unlikely that the pasture yield data are greatly in error as they came from a range of sources. Further, the mean rainfall which produced the mulga pasture yields (460 mm ± 50 mm) was slightly higher than the geometric mean* (GM) of the long term annual rainfall for Charleville (446 mm) but almost identical to the GM for the period over which the stocking rates were calculated (465 mm). Thus these yields are probably representative of those which could be expected in these rangelands.

Table 1

Stocking rates[1] on 11 western Queensland shires together with the dominant vegetation

Shire	Vegetation[2]	Stocking Rates		
		Sheep ha/sheep	Cattle ha/cattle	Sheep & Cattle ha/DSU
Murweh	M	4.4 ± 0.2	40.1 ± 0.3	2.2 ± 0.3
Paroo	M	3.2 ± 0.1	126.8 ± 9.8	2.6 ± 0.4
Quilpie	M	6.7 ± 0.2	100.1 ± 5.4	4.3 ± 0.7
Bulloo	S	33.7 ± 1.1	91.4 ± 4.0	8.5 ± 1.8
Barcoo	MG/H	16.5 ± 0.6	76.3 ± 4.7	5.9 ± 1.3
Diamantina	H	0	103.5 ± 5.2	12.9 ± 3.6
Barcaldine	D/G/MG	2.0 ± 0.1	104.0 ± 17.1	1.6 ± 0.3
Blackall	WMG/BG	2.2 ± 0.3	86.2 ± 12.1	1.7 ± 0.3
Tambo	WMG/G/BG	2.5 ± 0.6	36.5 ± 2.2	1.5 ± 0.2
Isisford	MG	2.7 ± 0.1	153.7 ± 15.7	2.2 ± 0.7
Longreach	MG	2.6 ± 0.1	99.7 ± 8.2	2.0 ± 0.4

1 Mean ± S.E. for the years 1945, and 1952 to 1980 inclusive. These are the only records available for these shires.

2 M mulga; S spinifex sandplains, channel country and herbfields; MG Mitchell grass; H herblands; D desert country - *Eucalyptus* spp. woodland; G gidyea; BG buffel grass; WMG wooded Mitchell grass.

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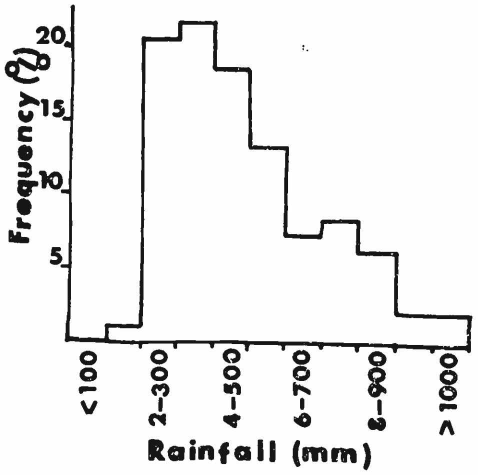
* The geometric mean is a more useful statistic than the arithmetic mean rainfall (e.g. 486 ± 21 mm for Charleville) because of the skewed nature of the data (see figure below).



Frequency of six classes of annual rainfall for Charleville.

Consequences of high stocking rates in mulga during drought

The implication of maintaining stock on mulga country when there is little ground flora on offer is that not only is mulga pushing or cutting necessary for stock survival, but any response to rain of the ground flora will be rapidly consumed by the stock. Thus, there will be little decomposition of detritus or subsequent release of nutrients for further growth. But, the stability of these rangelands largely depends on the maintenance of surface litter, and the first few centimeters of soil (Charley and Cowling 1968). Further, in an area in which light falls of rain predominate, and where annual rainfall is low and has no clear pattern of seasonal distribution, the opportunity for biological activity is slight. This is exacerbated by the small nutrient pool of the soils, and the concentration of nutrients in the surface soil.

Thus, when the opportunity for pasture regeneration does arise, stocking rates should be reduced so that individual plants have the chance to seed, and seedlings have the chance to establish. But, how often do we hear the comment 'due to rain this week stock have been withdrawn from today's sale'? In other words, the decision has been made not to decrease stock numbers just at the time when, biologically, this would be the best action.

Post-drought strategies

One further aspect of stock numbers, biology and drought in south western Queensland is the debilitating impact on the natural resource of re-stocking too soon after a drought is broken. Before 1960, restocking following drought was a gradual process. For example, the dry years from 1898 to 1903 caused a massive reduction in stock numbers in south western Queensland (Mawson _et_ al. 1974). Sheep and cattle numbers were reduced from 1.56 million and 424500 respectively in 1897 to 0.51 million and 33100 respectively in 1902. It was not until seven years later in 1909 that sheep numbers recovered to the pre-drought numbers (1.47 million), but cattle numbers have not since reached the high figures of 1897. Similarly, it was not until 1956 that sheep numbers recovered completely from the dry years 1943 to 1947.

The 1965 drought saw a change in stocking policy in the mulga country of south west Queensland. The number of sheep held in 1964 in the shires of Murweh, Paroo and Quilpie has not been exceeded in the ensuing 16 years. On the other hand, the number of beef cattle in these shires is now double that before 1965. The speed at which restocking took place following the 1965 drought also increased and may be assessed from the sheep numbers for the combined shires of Murweh, Paroo and Quilpie: predrought 1963/64: 4.35 million; mid-drought 1965/66: 2.73 million; post-drought 1967/68: 3.54 million. The latter figure has not since been exceeded. Cattle restocking occurred at a similar rate. There is no reason to expect that restocking following the present drought will be less rapid. What then is the answer?

Rather than ceasing mulga pushing/cutting as soon as reasonable rains occur, graziers should be encouraged to keep it up for an extra four to six weeks so that stock have access not only to the regenerating ground flora but also to the mulga. It may also be practical to move stock to one paddock where mulga is pushed for them so that plants in other paddocks may have a chance to recover from the drought. After four to six weeks stock are spread more evenly over the property while the 'sacrifice' paddock is destocked for at least one summer period.

Future options

The object of management in the mulga lands should be to reduce to the absolute minimum the necessity to push mulga for stock feed. This can only be done by either decreasing the number of stock per unit area, or increasing the reliability of summer rainfall, or increasing pasture productivity. While the latter aspect has received considerable attention in the mulga lands (e.g. O'Donnell et al. 1973) only small areas have been improved and the effects are insignificant overall. We can do little about the unreliable rainfall despite considerable expenditure by various national governments. We can, however, manipulate stock numbers.

Large properties have a greater ability to have a flexible stocking policy than do smaller ones, and it seems that from a biological viewpoint, amalgamation of small properties, or the purchase of additional areas, should be actively encouraged. In addition, survey work of Childs (1974), Holmes and Mills (1978) and Holmes (1980) indicate that returns and management efficiency are higher on larger properties in the Queensland mulga lands, and expansion from small areas should be encouraged providing additional areas can be purchased at reasonable cost.

In terms of a government drought policy for the mulga lands there are three main points which require consideration. Firstly, graziers who reduce stock numbers in response to deteriorating seasonal conditions could be rewarded financially. Secondly, restocking in the first post-drought growing season could be made financially unattractive to the grazier. Thirdly, graziers could be assisted more in their search for, and ability to finance, additional areas. This may however, require some degree of government supervision to ensure that stocking rates are not increased. Biologically, these three proposals are sound. The evidence available suggests that they are also economically viable.

Acknowledgements

The views expressed in this paper have been formed during many discussions with colleagues at Charleville whose help is gratefully acknowledged.

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PRELIMINARY RESULTS FROM AN EXPERIMENT TO EVALUATE GRAZING IMPACTS OF RABBITS AND LARGER ANIMALS IN AN ARID-ZONE NATIONAL PARK

*R.P. Henzell and *B.G. Lay

SUMMARY

An experiment to assess the relative importance of rabbits and larger native or feral animals (mainly goats) on the vegetation of the Gammon Ranges National Park is described.

The experiment consists of six sets of exclosures with unfenced controls in three vegetation types typical of foothills of the Northern Flinders Ranges in a 200 mm rainfall area. The results, after 4 years of observation, show that despite the visual evidence of goat grazing activity in the area it is the rabbit which is preventing regeneration of most perennial plant species present there.

INTRODUCTION - BACKGROUND

In 1976, about the time that the Gammon Ranges National Park was dedicated, concern was expressed about the apparent damage being inflicted on the vegetation there by large numbers of feral goats. The local National Parks and Wildlife Service ranger at that time, Brenton Arnold, proposed a study of the effects goats were having on the vegetation of areas where they were in high numbers, by fencing off one or two small plots. Siting these within a national park would eliminate the complicating effect of sheep or cattle.

This proposal was eventually formalized as a joint project between the National Parks and Wildlife service and our Department, with the present authors being responsible for design and implementation of the project.

The immediate problem we encountered was the extreme heterogeneity of the vegetation in the country we selected, which was the foothills and watercourses most preferred by the goats and showing most visible

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damage. Following biometrical advice, two sets of exclosures were erected in August 1977 in each of three readily recognisable vegetation types. These are:

(a) Callitris columellaris - Heterodendrum oleaefolium associated with watercourse and run-on country.

(b) Acacia aneura with Dodonaea and Eremophila spp. of skeletal hill slopes over shales.

(c) Casuarina cristata with Cassia nemophila var coriacea of skeletal hill slopes over quartzites.

Each set consists of one plot fenced to exclude all animals rabbit-sized and above, another plot fenced to allow entry of rabbits but to exclude all animals goat sized and above, while a third plot is an unfenced (pegged) control. All plots are 25 m x 25 m in size and gridded for mapping purposes into 5 m x 5 m quadrats. All perennial plants have been mapped and scored for height class each year, and particular regard has been paid to seedling input and survival. A Pluviometer has been established since 1978 by courtesy of the Meteorological Bureau. The exclosures form part of our programme of reference areas within the arid-zone.

DATA COLLECTION

In March each year the exclosures are re-mapped, with particular attention being given to the fate of perennial plant seedlings recorded the previous year. A number of mature plants are photographed each year using a background gridded screen (as in Wilson et al 1976), to determine grazing effects or regrowth behaviour of these plants. At least one permanent photopoint has been established at each set of exclosures, as well as at vantage points nearby and further up the watercourse.

In addition to the above work, new dung accumulations along several 25 m x 0.4 m transects are identified and weighed, and the type and extent of rabbit damage to a number of mapped mulga seedlings which had established themselves before the exclosures were erected are recorded annually.

RESULTS

The results, summarized below, cannot be considered conclusive as they cover only 4 years of record.

1. Rabbits. The most important finding from this experiment is the degree to which rabbits are suppressing regeneration of important perennial plants in this area. This is particularly significant in that at the time the exclosures were set up, casual observations indicated that rabbits were not particularly numerous, compared with some localities nearby. The mapped seedling inputs of *Acacia aneura* (Mulga) on one set of exclosures serves to illustrate this point (Fig. 1).

   Germination recorded in Fig. 1 probably occurred after 122 mm of rain in February 1979 and was mapped in March, 1979, 1980 and 1981.

   The observations of damage to young "established" plants of Mulga predictably shows a marked cyclical pattern, with damage by ring-barking and stem severing corresponding to the onset of dry conditions after a period favourable to rabbit population increase.

2. Goats etc. There is no apparent effect of the combined grazing by goats, donkeys and euros on seedling survival. However, as very few seedlings have survived in exclosures subject to rabbit grazing, it is not possible to define their effect with any degree of certainty. What we need here is the mythical fence which allows free and unrestricted entry by goats etc. but precludes rabbits.

3. Germination of *Callitris* has not been observed in any plots, despite the abundance of mature plants. Presumably the climatic events enabling this have not occurred during the study.

4. *Santalum spicatum* (Sandalwood), a rare and protected species in South Australia, was seen to be regenerating near the plots and a special rabbit-proof exclosure was erected around a mature individual and two young plants. An unprotected young plant adjacent to this plot has now been grazed off and possibly has died, while 2 out of 5 mature plants in the same area have also died after being repeatedly defoliated by goats.

5. *Eremophila alternifolia*

   Germinations occurred subsequent to exclosure and the seedlings we observed are shown in Figure 1(b). These seedlings occur in the vicinity of two mature bushes. The only other mature plants occur outside the exclosures and controls. Germination probably occurred there also, but no seedlings were observed despite searches for them. The low number of seedlings mapped within the rabbit proof exclosure in March 1979 probably reflects our inability to identify them in the very young stages.

6. Annual herbage. In addition to the regeneration now present in the rabbit-proof plots, there is now a large accumulation of dead ephemeral plants which is not present in either goat-proof or control areas. This further attests to the impact of rabbits here; such growth would have a marked effect in improving rainfall effectiveness by slowing run-off after heavy rain.

DISCUSSION

The trends evident from this experiment, though tentative, are very disturbing from a resource manager's point of view. At this site we have an area exposed to grazing by apparently high numbers of goats, and yet it is the rabbit which is having what seems to be the most serious long-term impact. These results re-inforce trends already evident from similar exclosures we have established for a longer period in other parts of the arid-zone where rabbits occur.

The chief reason for creating a national park in the arid-zone or elsewhere is to enable the preservation of the flora and fauna in a natural state free from the degrading effects of introduced animals and plants.

If it were only goats, donkeys or sheep which were doing the damage, then with the aid of suitable mustering and trapping techniques, it is quite practical to control or eliminate them from large areas at a relatively low cost. But the very animal which is preventing the natural plant community from maintaining itself is also the one which is difficult to control on a large scale even in accessible country. The use of the rabbit flea to enhance the value of myxomatosis offers some hope but the effect it will have in the arid zone is yet to be determined. With increasing labour and fuel costs, and the low effectiveness of myxomatosis in arid areas the prognosis is not good.

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FIGURE 1

Survival of seedlings of Acacia aneura and Eremophila alternifolia germinating subsequent to the establishment of the exclosures. Results for one of the six sets of exclosures in the Gammon Ranges National Park are illustrated.

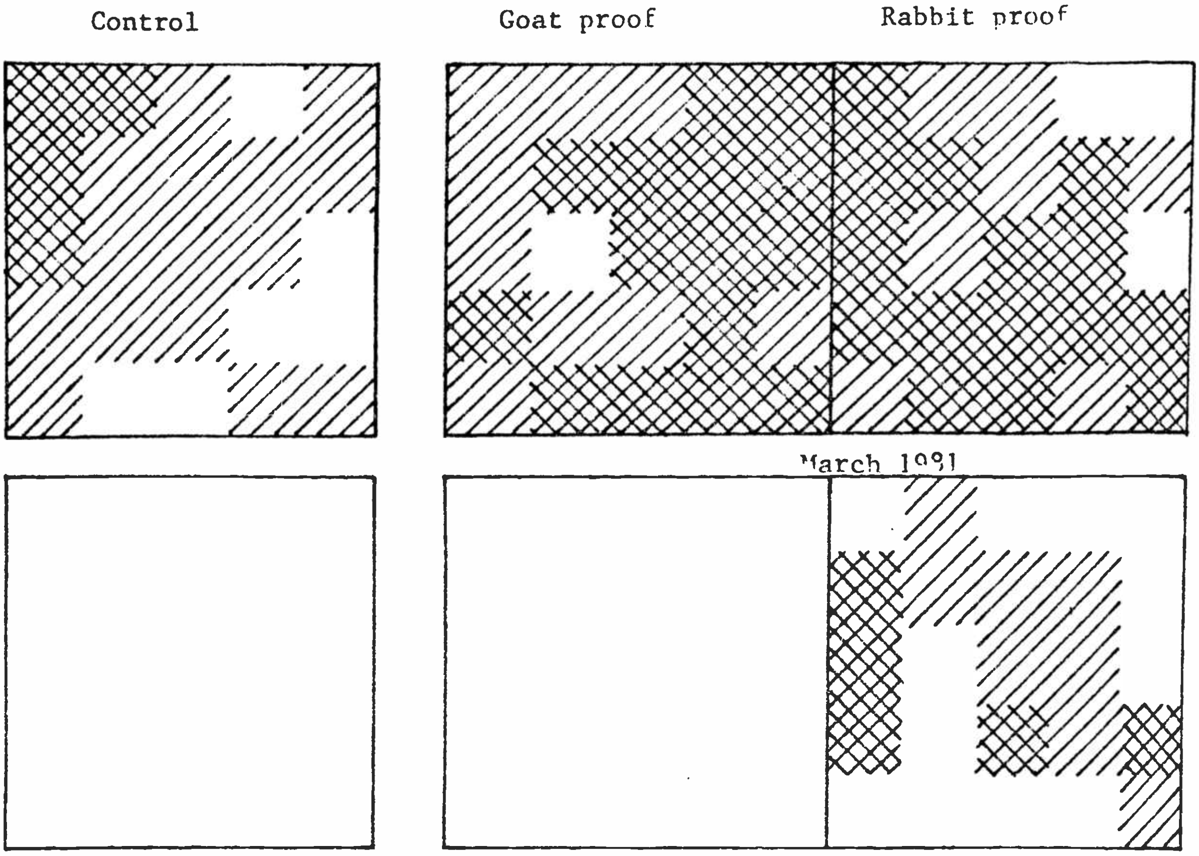
Seedings are shown which have appeared since exclosure on each 5 x 5 m quadrat mapped firstly in March 1979 (after a period of good rainfall) and again in March 1981 (after a dry period).

LEGEND

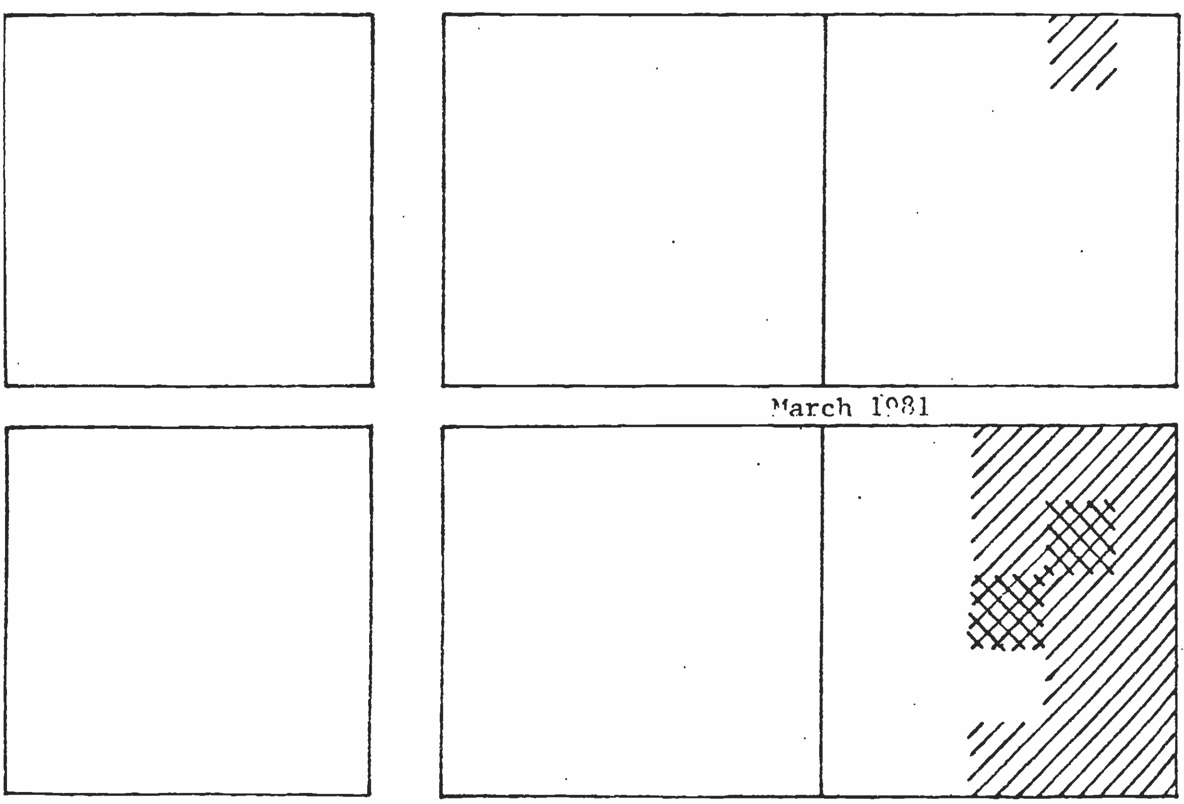
1 - 10 seedlings recorded.

More than 10 seedlings recorded.

(a) Acacia aneura March 1979



(b) Eremophila alternifolia March 1979



The response to season, exclosure and distance from water of three central Australian pasture types grazed by cattle.

B.D. Foran [1] and G. Bastin [2].

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ABSTRACT

In two Mulga pasture types and in a Sandy Open Woodland, the effect of exclosure from grazing cattle during seven years,and distance from water were studied. Standing biomass levels fluctuated more in response to season and wildfire than to the treatments of exclosure and distance from water, and grazing pressures did not produce any marked deleterious effects. However, it is likely that in an extended period of low rainfall when cattle are making greater use of this country, exclosure may change species composition and benefit landscape stability. Due to the lack of change to date, grazing could continue at present stocking levels and under similar management.

INTRODUCTION

Exclosure is a recognised technique for partitioning the effects of season and the impact of livestock. Grazing pressure around a permanent watering point produces zones of influence which are dynamic rather than static. When a long exclosure radial to a watering point is erected, the effects of exclosure can be compared to the zones of grazing influence around the watering point.

Three extensive pasture types widely used by the grazing industry were studied. In the Mulga (*Acacia aneura*) lands, mixed pasture types of Mulga with an understorey of perennial grasses (Mulga Perennial), and annual and biennial grasses (Mulga Annual), occur. The Sandy Open Woodland pasture type is characterized by widely scattered trees and shrubs over biennial grasses on deep sandy soils at the base of ranges. Exclosures 3.2km long and 0.8km wide were erected adjacent to permanent watering points in Mulga country on Central Mount Wedge Station and in a Sandy Open Woodland on Mount Riddock Station in 1968. In addition to the effects of exclosure and season, wildfires burnt through the Mulga study area in 1975 and 1976 and through the Sandy Open Woodland site in late 1976. Standing biomass levels collected over the period 1972 to 1979 are presented in this paper.

RESULTS

1. Rainfall

The average annual rainfall at the Mulga site over the period 1968 to 1979 was 411mm, with a range between 181mm and 964mm while average rainfall over the same period at the Sandy Open Woodland study area was 422mm with a range between 72mm and 1,035mm.

The lowest annual rainfall measured is comparable with the driest year recorded at Alice Springs in 100 years (to 1973) while the January 1974 rainfall of 669mm in the Sandy Open Woodland nearly equalled the "wettest" year on record (to 1973) at Alice Springs. This period then has seen the extremes of precipitation for which an arid climate is known.

2. Standing Biomass

Standing biomass of the herbage layer in the Mulga Annual and Mulga Perennial varied from 217 kg ha^{-1} in 1973 to 2,377 kg ha^{-1} in 1976 (Fig. 1) in response to rainfall prior to each harvest. Total biomass in Mulga Annual did not vary appreciably from levels in Mulga Perennial in each year. Fires in February, 1975 and August, 1976 may have been responsible for the reduced standing biomass levels at the next harvest. No consistent significant effects were measured for either exclosure or distance from water.

Standing biomass in the Sandy Open Woodland varied from 551 kg ha^{-1} in 1973 to 1,870 kg ha^{-1} in 1975. The fire in late 1976 may have contributed to the significantly lower total yield in 1977, but this is also a period of lower rainfall in comparison with the previous three years. *Aristida browniana* was the dominant component in the wetter years between 1974 and 1978 comprising up to 86% of total standing biomass. In an analysis combining all years, forbs yielded less in the exclosed treatment (Exclosed: 147 kg^{-1}; Not Exclosed: 200 kg ha^{-1}). A higher biomass level of *Aristida browniana* at 3.2 kms was the only consistent effect shown with distance from water.

DISCUSSION

Exclosure and distance from water produced very few consistent significant trends in standing biomass in the seven years of data collection apart from less forb in the exclosed area and greater *Aristida browniana* at 3.2 km in the Sandy Open Woodland. In comparison with the main treatments, season produced very large fluctuations in all pasture types, e.g. there was a tenfold difference in standing biomass due to season over the period, while in any one year exclosure and distance from water produced less than two-fold differences. Better forb growth under grazing in the Sandy Open Woodland offers a marked nutritional advantage as forbs consistently had higher digestibilities and nitrogen contents than the dominant grass, *Aristida browniana* (Foran, unpublished data). Siebert, Squires and Hunter (1978) have shown a direct relationship between liveweight gain and dietary nitrogen in central Australia and a higher forb component in the diet should produce better liveweight gain. However, there must be a balance between landscape stability afforded by the grass component, and better animal nutrition from forbs on the Sandy Open Woodland pasture type.

The lack of treatment effects may not be unexpected as exclosure experiments in both Australia and the United States often report the effect of thirty or more years retirement (e.g. Hall, Specht and Eardley, 1964: Robertson, 1971). In addition, the middle nineteen seventies produced a flux in vegetation growth that masked grazing effects. Animal behaviour studies during this period showed that cattle spent a large proportion of their time on smaller, highly preferred land units such as floodplains and foothill fans (Hodder and Low, 1978: Low, Muller and Dudzinski, 1980). The grazing pressure expected during periods of average and lower rainfall was not experienced at either study site during these high rainfall years.

The resultant high fuel loads carried wildfires, the effects of which were difficult to differentiate from season and treatment effects.

Future studies should be located on more preferred pasture types where grazing pressure is high and controlled. The study of presumed gradients of grazing intensity with distance from water is possible with a range of grazing pressure treatments or with a number of exclosures in a paddock where animal numbers are monitored.

Although these studies were not designed to compare the productivity of pasture types, basic models were developed for standing biomass and rainfall (Fig. 2). The relationships for the mulga pasture types in central Australia had steeper slopes than that developed from the data of Christie (1978) at Charleville. These differences may be related to soil fertility status, plant composition and previous grazing history. The relationship derived for the Sandy Open Woodland indicates a more productive biomass-rainfall relationship than that developed from the data of Lendon and Ross (1978) which may be due to greater soil moisture availability or to higher accumulated biomass levels which increases the standing biomass intercept. The relationships are unlikely to be linear throughout the full range of rainfalls as we would expect a rapid decline in standing biomass below 50mm and a plateau above 500 to 600mm. Simple growth models of this type can find wide application in rangeland management, particularly in the areas of stocking rate assessment and drought declaration policy.

On three pasture types in central Australia, grazing pressures have not produced any marked deleterious effects during the study period.

It is likely, that in an extended period of low rainfall when cattle are making greater use of this country, exclosure may change species composition and benefit landscape stability. However, due to the lack of change to date, grazing may as well continue at present stocking levels and under similar management.

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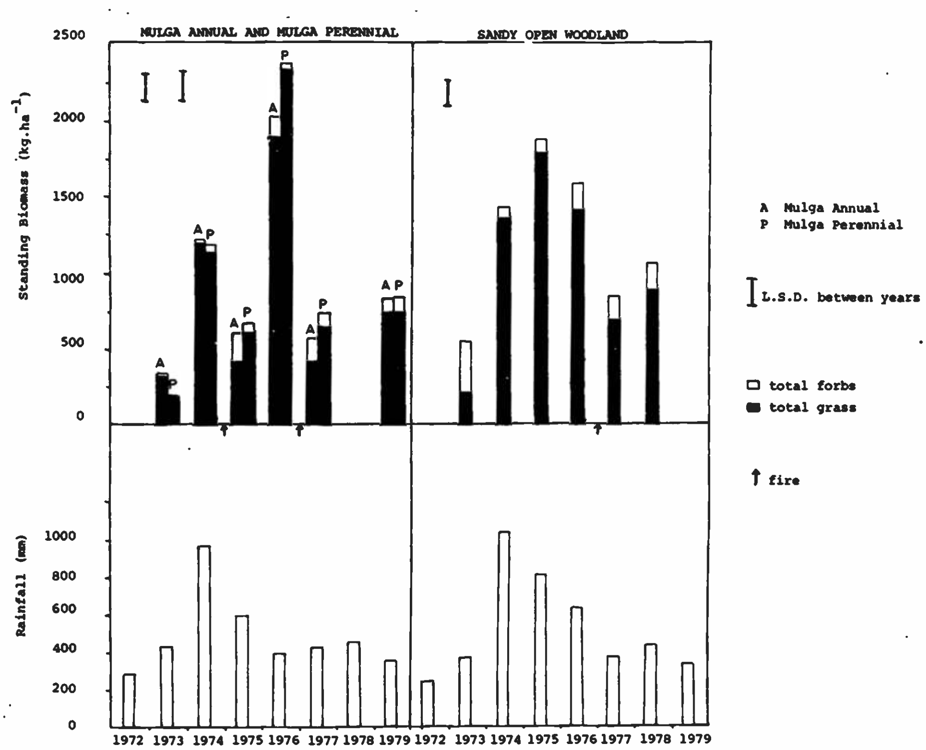

Fig. 1 Standing biomass levels (kg. ha^{-1}) and annual rainfall (mm).

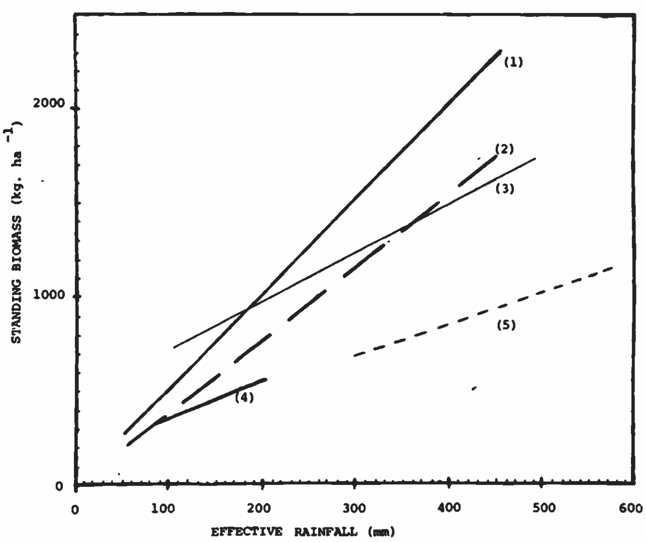

Fig. 2. Regression relationships between effective rainfall and dry matter production for four sites in Australian rangelands.

(1) Mulga Perennial, Central Mt. Wedge, central Australia, 1972-1979 y= -4.0 + 5.1x (r^2.9)

(2) Mulga Annual, Central Mt. Wedge, central Australia, 1972-1979 y= -1.4 + 3.9x (r^2.8)

(3) Sandy Open Woodland, Mt. Riddock, central Australia, 1972-1978 y= 462.8 + 2.6x (r^2.8)

(4) Kunoth Paddock, central Australia, 1970-1972, (from Lendon and Ross, 1978) y= 137.5 + 2.1x (r^2.9)

(5) Charleville, Queensland 1974-1977 (from Christie 1978). y= 183.5 + 1.7x (r^2.9)

EFFECT OF GRAZING ON AN AREA OF SEMI-ARID LAND AT MORKALLA IN THE NORTH-WEST VICTORIAN MALLEE

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Abstract

The effect of sheep and rabbits grazing on the vegetation and its regeneration measured in the 275 mm annual rainfall zone on three overgrazed sites between 1968 and 1980.

It was found that where the grazing pressure was reduced the natural revegetation slowly developed with the healing of the bare surface in enclosures. In areas where grazing continued the regeneration of herbs and forbs was insignificant or did not occur at all.

The vegetation growth is governed by rainfall, consequently the best management for both animal production and vegetation maintenance is a stocking rate that never completely defoliates the groundcover.

Introduction

Morkalla is situated in the semi-arid north-west section of the Mallee region of Victoria, near the South Australian border. The area is part of the Raak land-system where the land was taken up for grazing long before wheat-growing on the surrounding land-systems (Rowan and Downes, 1963). Here, interference with the native vegetation by introduced sheep and rabbit grazing resulted in changes and deterioration of the plant communities.

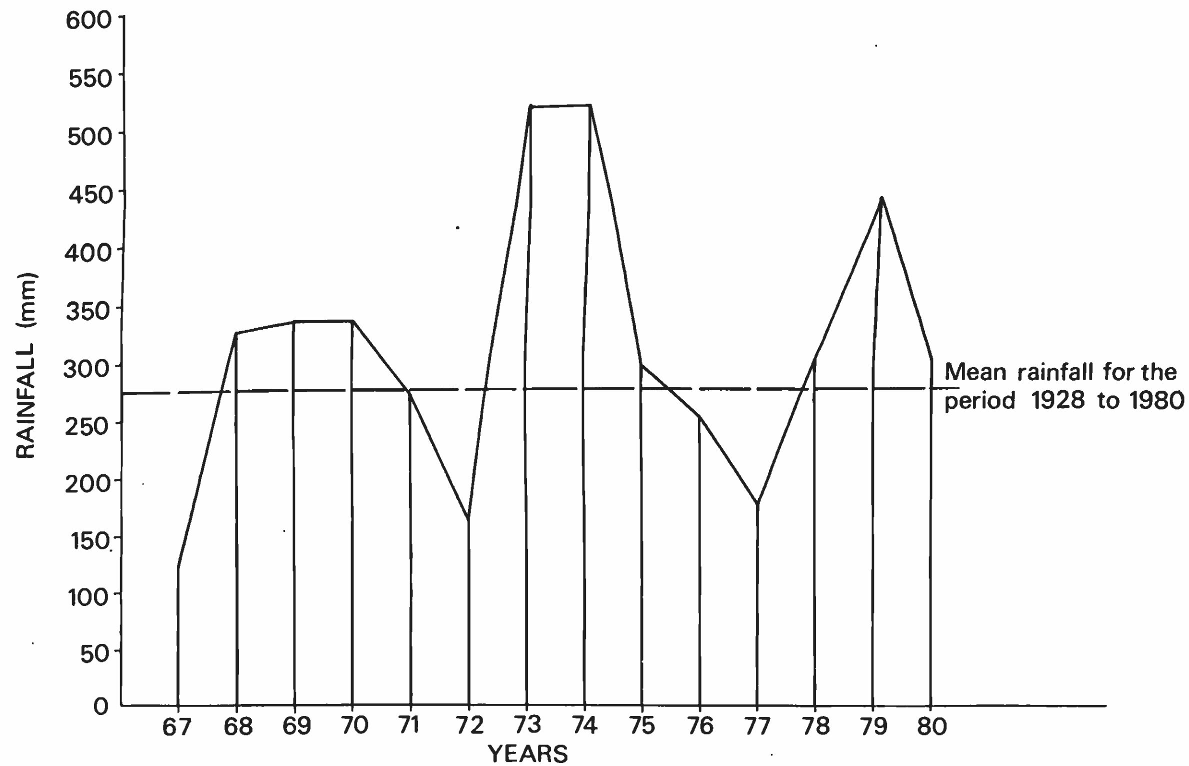


FIG. 1 MORKALLA NORTH AVERAGE YEARLY RAINFALL BETWEEN 1967 AND 1980

Most of the soil parent materials are unconsolidated aeolian strata which range in texture from sand to clay (Butler 1956, 1959, Rowan and Downes, 1963). The mean annual rainfall is 275 mm. The temperature frequently exceeds 33°C and above 38°C temperatures are common during summer. Winter is mild. Potential evaporation is approximately 152 cm per annum. Monthly potential evaporation in summer is 25.4 cm and in winter, 3.8 cm (Central Planning Authority, 1952). Growing season is normally restricted to the three winter months; however, because of the unreliability of the rainfall (percentage variability is about 26 per cent) flash regrowth can occur in late spring or summer as a result of heavy rain.

The purpose of this study was to measure the regeneration of the vegetation between 1968 and 1980 with the excluding of grazing animals so that, in the future, the effect of live-stock and rabbit-grazing on the vegetation and its regeneration could be evaluated.

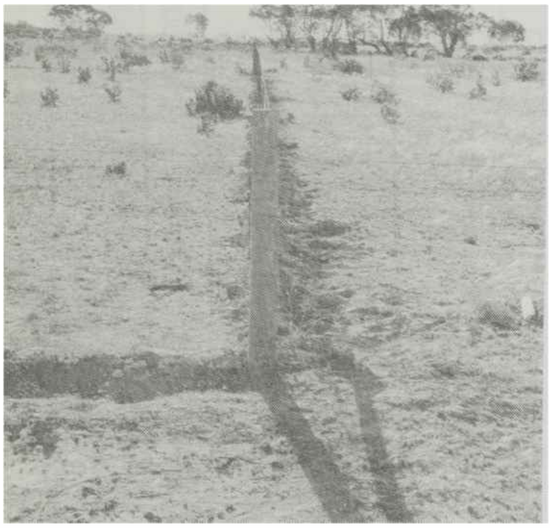
Study Area

In order to study regeneration, three sites were selected on a 7938 ha lease area grazed by 2600 sheep, rabbits and kangaroos (the number of rabbits and native fauna not known).

The original native vegetation of the area was savannah grassland containing pine, belar, buloke, mallees, rosewood, sandalwood, bluebush and saltbush. Stipa and Danthonia spp. were the main indigenous grasses.

The soils are sand and sandy clay with a low fertility level. The pH of sloping and sandy flats is 8.5 with a low chloride content (0.002 per cent in the upper 50 cm and 0.010 per cent in the lower 100 cm of sand). The soil pH of the flat sandy clay area carrying bluebush is 8.2 with a high chloride content (0.50 per cent in the upper 50 cm and 0.59 per cent in the lower 100 cm of sandy clay).

Result of more than
average rainfall



Maireana (bluebush) spp.
in 1968

Maireana (bluebush) spp.
in 1980

Site 1 - Of 2 hectares situated on a gently-sloping area which has a cover of scattered mallee, pine and sandalwood. The groundcover mainly consisted of annual grasses and weeds.

Site 2 - Of 0.5 of a hectare on a flat area which had an original spear grass cover and the surface cover of which consisted of annual grasses and weeds. There was some scalding of the surface.

Site 3 - Of 0.5 of a hectare, had a scatter of heavily-grazed bluebush and a groundcover of predominantly weeds. The original vegetation was probably saltbush/bluebush with a groundcover of native annuals and Stipa. Where the bluebush had been eaten out, severe wind erosion had removed the sandy topsoil to varying depths, to expose a saline subsoil.

Methods

On each of the three sites plots were established, viz. control (grazed); rabbits and sheep excluded (not grazed); and sheep excluded (grazed only by rabbits). Each plot was divided into subplots and random groundcover samples were taken from each subplot yearly, using a quadrat of $\frac{1}{4}$ m^2 subdivided into 16 squares.

TABLE 1. SPECIES LIST FOR REGENERATION PLOTS AND OPEN AREA

SPECIES	ENCLOSURE (Stock and Rabbits Excluded)		GRAZED BY RABBITS (Stock Excluded)		GRAZED OPEN AREA	
	FREQUENT	PRESENT	FREQUENT	PRESENT	FREQUENT	PRESENT
<u>Aizoaceae</u>						
* Gasoul crystallium		X				X
<u>Amaranthaceae</u>						
Ptilotus spathulatus	X			X		
<u>Boraginaceae</u>						
* Echium plantagineum		X	X		X	
Ompalolappula concava	X					X
<u>Campanulaceae</u>						
Wahlenbergia stricta	X					X
<u>Caryophyllaceae</u>						
* Spergularia diandra		X		X	X	X
* Herniaria hirsuta			X		X	
<u>Cruciferae</u>						
* Brassica tournefortii		X	X		X	
* Sisymbrium irio		X		X	X	
* Sisymbrium erysmoides		X	X		X	
Alyssum linifolium	X					
<u>Compositae</u>						
Angianthus strictus	X			X		
Angianthus tomentosus		X				
Brachycome ciliaris	X					
Calotis erinacea	X					
Craspedia chrysantha	X					X
Craspedia pleiocephala		X		X		X
* Centaruea melitensis		X	X		X	

TABLE 1. SPECIES LIST FOR REGENERATION PLOTS AND OPEN AREA (Cont'd.)

SPECIES	ENCLOSURE (Stock and Rabbits Excluded)		GRAZED BY RABBITS (Stock Excluded)		GRAZED OPEN AREA	
	FREQUENT	PRESENT	FREQUENT	PRESENT	FREQUENT	PRESENT
<u>Compositae</u> (cont'd)						
Gnephosis skirrophora	X					X
Helipterum pygmeaum	X					X
* Hypocheoris glabra		X	X		X	
* Onopordum acaulon		X	X		X	
* Sonchus oleraceus		X		X	X	
* Reichardia tingitana		X		X	X	
Vittodinia triloba	X					
<u>Geraniaceae</u>						
Erodium crinitum	X	X	X		X	
<u>Gramineae</u>						
Bromus rubens	X			X	X	
Danthonia caespitosa	X					X
Danthonia setacea	X					X
* Hordeum leporinum		X		X		X
* Koeleria phleoides		X			X	
Stipa variabilis	X			X	X	
Stipa eremophila	X					X
Schismus barbaratus		X				
* Trisetum pumilum		X				X
<u>Goodenianceae</u>						
Goodenia pusilliflora	X					
Goodenia pinnatifida	X					
<u>Labiatae</u>						
Ajuga australis		X			X	

TABLE 1. SPECIES LIST FOR REGENERATION PLOTS AND OPEN AREA (Cont'd.)

SPECIES	ENCLOSURE (Stock and Rabbits Excluded)		GRAZED BY RABBITS (Stock Excluded)		GRAZED OPEN AREA	
	FREQUENT	PRESENT	FREQUENT	PRESENT	FREQUENT	PRESENT
<u>Liliaceae</u>						
Angnillaria dioica		X				
<u>Papaveraceae</u>						
* Papaver sommiferum		X		X		X
* Papaver hybridum		X		X		X
<u>Papilionaceae</u>						
* Medicago minia		X				X
* Medicago polymorpha	X					X
Psoralea eriantha	X					
Psoralea tenax	X					
Swainsona microphylla	X					
<u>Umbelliferae</u>						
Daucus glochidiatus	X			X		X
<u>Uaryophyllaceae</u>						
Spergularia diandra		X				
<u>Zygophllaceae</u>						
Zygophyllum crenatum		X		X	X	
Zygophyllum ammophilum		X		X		X
<u>Chenopodiaceae</u>						
Bassia diacontha	X				X	
Maireana sedifolia	X		X		X	
Maireana pyramidata	X		X		X	
Malacocera tricornis	X			X	X	
<u>Sapindaceae</u>						
Heterodendron oleifolium		X				

* Exotic species

Five of these groundcover samples were selected for species counts and biomass measurements. All the standing biomass within each quadrat was cut off at ground level and collected. The samples were then sorted into grasses, forbs and herbs. The dry weight of each of these categories was determined after drying at 85°C for at least 24 hours. The halophytes yield was estimated.

Results and Discussion

A list of species on the sites and within the quadrats is presented in Table 1. Fifty-five different species excluding trees were found in the regeneration plots and 38 in the outside grazed area. Of the 38 species found on the open-grazed area, the 17 common ones were all exotics. The collected data and observation indicated that plants such as Calotis erinacea, Daucus glochidiatus, Goodenia pussilliflora, G. pinnatifida, Ompalolappula concava, Ptilotus spathulatus and Wahlenbergia stricta were growing vigorously in enclosure free from grazing pressure. Legumes such as Psoralea eriantha, P. tenax and Swainsona microphylla increased their number within the protected area, being free from heavy selective grazing by rabbits.

Members of the daisy family also responded to reduced grazing pressure and were present in higher numbers within the regeneration plots, principally Calotis erinacea, Craspedia chrysantha, Gnephosis skirrophora, Helipterum pygmeaum and Vittodinia triloba. Native grasses were plentiful and growing vigorously following enclosure.

However, in years when the rainfall was more than average (see Figs. 1, 2 and 3) the native grasses formed a dense surface cover (see photo) on the sandy open flats, especially Stipa variabilis.

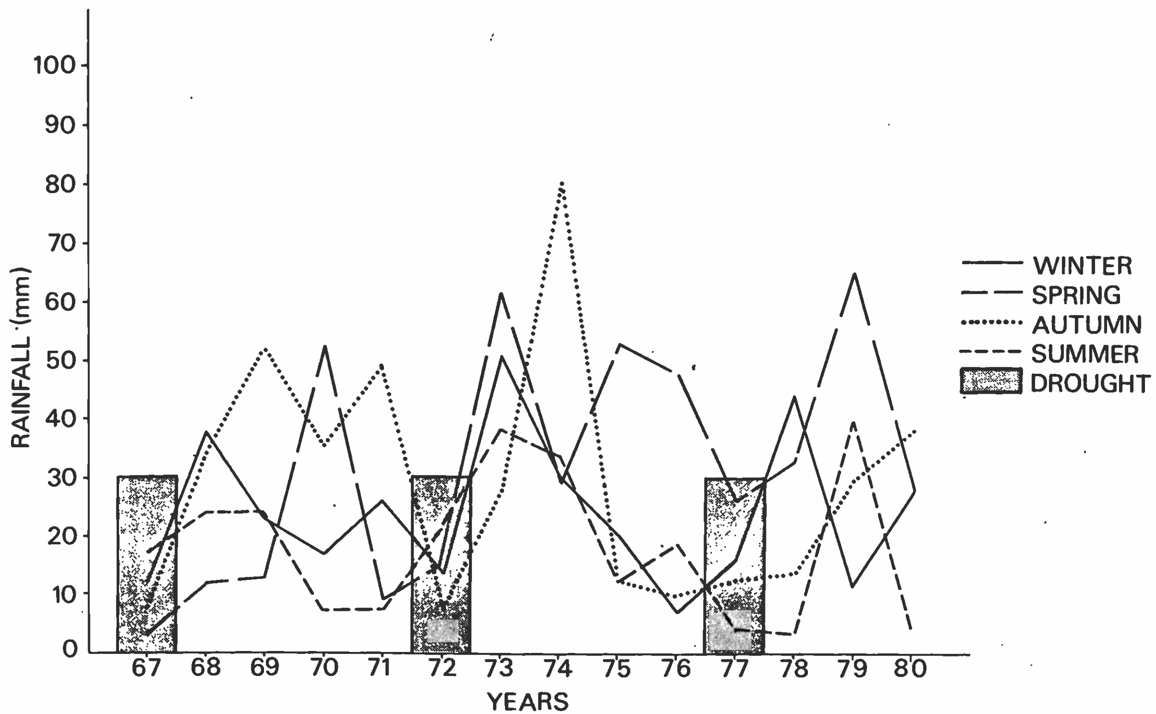


FIG. 2 SEASONAL RAINFALL DISTRIBUTION AND DROUGHT PERIODS BETWEEN 1967 AND 1980

Apart from Bromus grass within the regeneration plots and the open-grazed area a number of exotic weeds was found, the most common being Echium plantagineum, Brassica tournefortii, Sisymbrium spp., Onopordum acaulon, Hypocheoris glabra, Zygrophyllum spp. and Erodium crinitum.

One of the major components of the ground flora, Erodium crinitum, is a native species which was recorded by Zimmer (1946) (under the name E. Cygnorum) as being occasionally present in Tall and Small Mallee areas. Beadle (1948) reported it as becoming very common in Mallee areas in the south-west corner of NSW following clearing and grazing.

The weeds mostly occupy the otherwise bare areas where, after rains, the weed seed germination is rapid and usually short-lived.

The halophytic plant communities also responded to reduced grazing pressure. In the regeneration plots the Maireana spp. became larger and new plants were plentiful (see photos.). Average density of new plants was 1.4 per m^2 on the regeneration plot compared with only 0.2 on the open grazed land. The intervening space between the Maireana bushes was occupied by a sparse layer of herbaceous plants and grasses (Danthonia and Stipa). The density of these other plants is closely related to rainfall. In a year when the rainfall was good the yield was 150-450 kg/ha D.M. They are almost absent in drier years. In contrast the bluebush was quite stable (279-520 kg forage/ha).

TABLE 2. COMPOSITION OF GROUNDCOVER AND BARE GROUND

YEAR AND GROUP	NOT GRAZED (Stock and Rabbits Excluded)	GRAZED BY RABBITS ONLY (Stock Excluded)	GRAZED OPEN AREA
	PER CENT OF GROUNDCOVER		
1968			
GRASSES	11.6	10.9	10.6
FORBS AND HERBS	27.1	26.8	27.2
HALOPHYTIC spp.	1.1	1.2	2.3
BARE GROUND	60.2	61.1	59.9
1980			
GRASSES	33.1	21.5	19.9
FORBS AND HERBS	30.2	25.9	25.5
HALOPHYTIC spp.	7.2	2.0	3.1
BARE GROUND	29.5	50.6	52.5
DECREASE OF BARE GROUND BETWEEN 1968 AND 1980	-30.7	-10.5	- 7.4

Combined data of three Study Areas.

Table 2 summarises the changes which have occurred between 1968 and 1980 in the percentage of bare ground and groundcover and the composition of groundcover.

The analysis of the collected data showed that the highest decrease in bare ground occurred in the regeneration plots where the rabbits and sheep were excluded. The decrease was 30.7%. In plots where only sheep were excluded the bare ground decreased by 10.5%. The smallest decrease occurred in the control area (grazed open area) where the decrease in bare ground was 7.4%. The difference between the plots was significant ($P<0.01$).

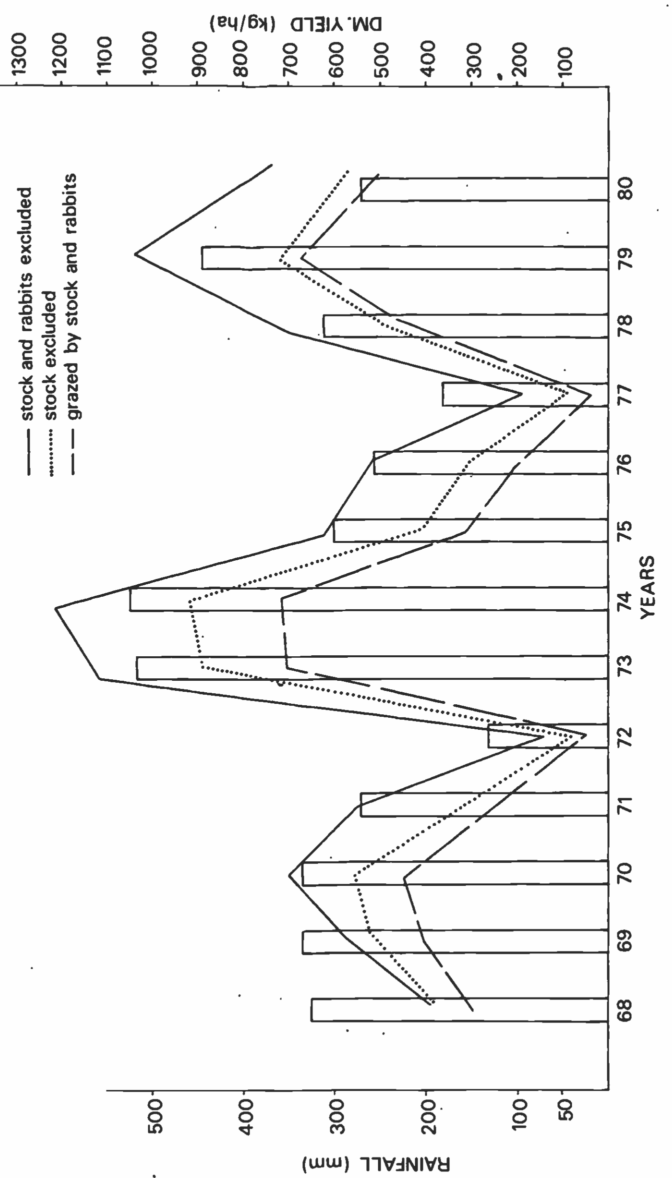


FIG. 3 FORAGE DRY-MATTER YIELD AND RAINFALL

The decrease in bare ground was manifested in the increase of total groundcover in the regeneration plots. Here the improvement in cover has been mainly from grasses, forbs and herbs.

Within these communities a few Callitris preisii seedlings had reappeared in the 12 years following exclusion of rabbits and stock. In the grazed area rabbits killed the young trees by stripping the bark.

The palatable forage yield is presented in Fig. 3. The quantity and quality of forage varied with the rainfall and contained a wide variety of species (Table 1). The dominant grasses (Stipa, Danthonia and Bromus) and Erodium provided approximately half of the forage yield each year. Other contributors were annual and perennial forbs, herbs and halophytic spp. The yield of these groups depended on the amount and season of rainfall (Fig. 3).

After the 1967 drought the groundcover recovered between 1968 and 1970. The D.M. yield was about 700 kg/ha in the enclosures. In 1971 the spring rainfall was very low which resulted in a declining yield for that year and a near nil D.M. forage production for 1972. Above average rainfall in 1973 and 1974 produced a high plant population which resulted in a peak forage D.M. yield of 1250 kg/ha in the enclosures. In 1975 and 1976 the rainfall and forage yield declined and was followed by drought conditions in 1977. A reasonably wet year in 1978 and 1979 produced a good forage D.M. yield of 1050 kg/ha in the enclosures. The analysis of data showed that the significantly higher forage yield occurred in enclosures where rabbits and sheep were excluded during the period of 12 years.

Conclusion

The stocking rate (0.33 sheep per ha) used in the 1960s and 1970s had a disastrous consequence for the area, although some grain feeding was practised at drought times.

At the beginning of the study, the sheet-eroded surface was bare of vegetation and most of the area was overgrazed.

In areas where grazing continued, the regeneration of herbs and forbs was very slow or did not occur at all although some improvement (Table 2) took place in the groundcover of the grazed area as a result of the erection of subdivisional fencing in 1976 and the provision of water by pipeline to the lease area. These factors proved advantageous to grazing management. Where the grazing pressure was reduced, however, a natural revegetation slowly developed with the healing of the bare surface in enclosures.

Rabbits are a problem even now, causing considerable damage to the ground flora. Over areas grazed by sheep, very marked differences are apparent between those parts where rabbits were excluded or where they were present. Their number must be reduced.

The vegetation growth and persistence is governed by rainfall. Consequently the best management for both animal production and vegetation maintenance is a stock rate that never completely defoliates the groundcover. With a 275 mm annual rainfall at Morkalla, this can be achieved by a fixed moderate stocking rate of about 0.13 sheep per ha or by a stocking rate which is adjusted around that figure from time to time to the seasons and rainfall.

Also, the Department of Crown Land and Management should give consideration to the fact that, in this rainfall zone, a stocking rate of 0.33 sheep per ha, apparently needed to provide an acceptable income to the lessee, is beyond the capability of the land to sustain. For this reason, overgrazing will continue unless leases are enlarged sufficiently to allow a lower stocking rate.

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Population dynamics in *Astrebla* grassland - implications for drought management.

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Abstract

The population dynamics of *Astrebla* spp. at two levels of grazing and exclosure are expressed in the form of age structure and used to project the likely changes due to drought. It is concluded that increasing pasture utilization during drought will increasingly delay pasture recovery following drought.

Introduction

Droughts of varying extent and duration occur frequently in *Astrebla* (Mitchell grass) grasslands. These grasslands are particularly susceptible to drought because of the paucity, or in many cases the complete lack, of edible trees and shrubs. The ground layer vegetation therefore becomes susceptible to very heavy utilization during drought where livestock numbers are not reduced. The threatened demise of these important grasslands during severe droughts, for example during the 1930's and late 1960's (see Everist 1935, Williams 1978) atests to the extent of heavy utilization suffered by the vegetation resource.

This discussion paper presents data from a current study into the population dynamics of *Astrebla* spp. under two levels of grazing and exclosure and discusses the implications for the maintenance of the pasture resource during periods of drought.

Population dynamics of *Astrebla* spp.

a. Methods

Population dynamics of *Astrebla* spp. are being studied at one location in each of two commercially grazed paddocks near Blackall, Central Western Queensland. One of these paddocks, designated as heavy grazing, has been grazed at a stocking rate heavier than 'district average' while the other, designated light grazing, has been stocked at about the Queensland Lands Dept. recommended rate of 0.8 sheep ha^{-1}. The study locations in the heavy and light grazing paddocks are 5 km apart and are areas known to be subject to heavy and light grazing respectively (See Orr 1980).

Each location consists of an exclosure containing 30 permanent, one metre square quadrats and surrounded by another 30 permanent one metre square quadrats which are subject to grazing. Charting of Astrebla spp. commenced in 1976 when plants were marked as either existing plants (i.e. present prior to the 1975-6 summer) or seedlings (i.e. new plants resulting from the 1975-6 summer rainfall). Charting has continued annually allowing the age structure of the pasture uder the four treatments to be determined.

The extent of grazing at each of the two grazed locations is assessed in each quadrat in April (end of 'wet' season) and again in October (end of 'dry' season) each year using photographic standards of different levels of A. lappacea utilization.

b. Results and Discussion

Average grazing utilization for the period 1975-1980 was 10% (range 0-15%) and 30% (range 0-50%) for the light and heavy grazing treatments respectively.

An analysis of the contribution of Astrebla spp. plants to each age group as at July 1980 reveals significant differences between the treatments (Table 1).

Significant differences between paddocks in the number of plants older than five years can be explained by a greater rate of death of this age group under heavy grazing (Figure 1).

Significantly more plants in the 3-4 year age group in the heavy grazing paddock is due to greater establishment opportunities than in the light grazing paddock during the 1976-7 summer. The heavy grazing paddock had 3 separate growth periods compared to only 1 in the light grazing paddock. Similarly, the absence of plants in the 2-3 year age group is due to the complete failure of rainfall during the 1977-8 summer.

There are significantly more plants in the 1-2 and <1 year age groups under grazing than under exclosure. The reason for this effect in the 1-2 year age group was not clear, however the substantial contribution in 1980 of plants <1 year old in the grazed treatment, heavy paddock prompted sampling for seed reserves.

An analysis of Astrebla seed reserves in the top 2.5 cm at these sites at December 1980 suggests that the significant grazing effect on age structure in the 1-2 and <1 year age groups resulted from greater seed reserves in the soil (Table 2). From this, it would appear that grazing promotes seed

Table 1. Age structure (years) of _Astrebla_ spp. in 30 m^2 at July 1980 under two levels of grazing and exclosure in _Astrebla_ grassland

Paddock	Ungrazed/Grazed	Age (years) > 5	4-5 (1975-6 seedlings)	3-4 (1976-7 seedlings)	2-3 (1977-8 seedlings)	1-2 (1978-9 seedlings)	< 1 1979-80 seedlings
Light	Ungrazed	93^{apy}	1^{apy}	0^{apy}	0#	1^{apy}	1^{apy}
	Grazed	75^{apy}	23^{apy}	4^{apy}	0	7^{aqy}	5^{aqy}
Heavy	Ungrazed	63^{bpy}	5^{apy}	14^{bpy}	0	2^{apy}	7^{bpy}
	Grazed	62^{bpy}	9^{apy}	22^{bpy}	0	15^{aqy}	183^{bqz}

Means in columns with different superscripts are significantly different ($P \leqslant 0.05$)

a,b for paddock effect

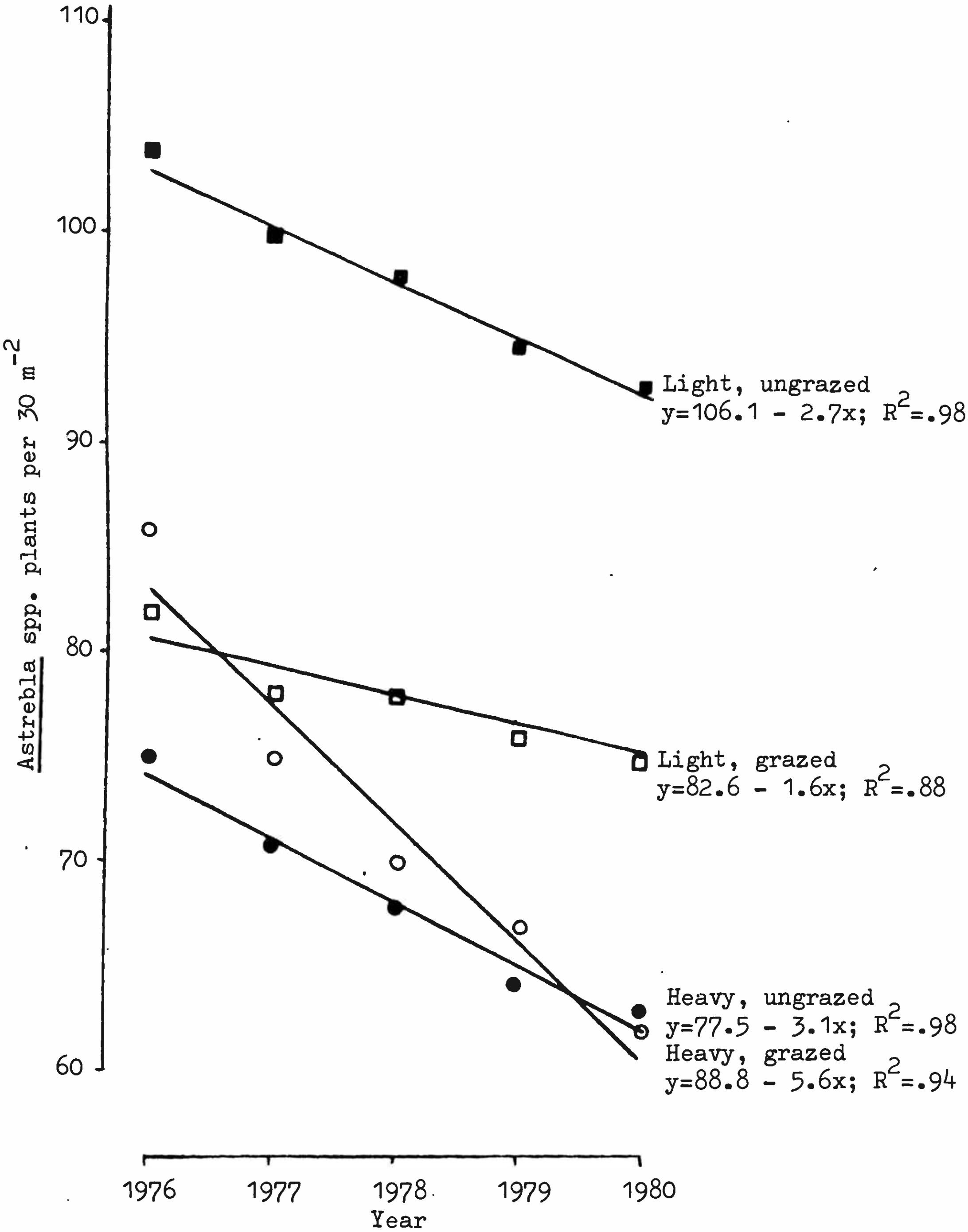
p,q for grazing effect

y,z for paddock x grazing interaction

Analysis performed on square root transformed data.

No analysis performed

Figure 1. Survival of *Astrebla* spp. (plants 30 m^{-2}) between 1976 and 1980 under two grazed and ungrazed treatments in *Astrebla* grassland



production of Astrebla spp., at least in the range of utilization experienced to date in this study.

Tentative results from this study indicate that increased utilization in Astrebla grassland results in an increased rate of Astrebla spp. plant turnover.

Table 2. Seed reserves of Astrebla spp. (seeds m^{-2}) at December 1980 under two levels of grazing and exclosure in Astrebla grassland.

Paddock	Ungrazed/Grazed	Seed Reserves
Light	Ungrazed	57^{apy}
	Grazed	124^{aqy}
Heavy	Ungrazed	102^{bpy}
	Grazed	1124^{bqz}

Means with different superscripts are significantly different ($P \leq 0.05$).

a,b for paddock effect;

p,q for grazing effect;

y,z for paddock x grazing interaction.

Analysis performed or square root transformed data.

This flux operates via a greater death rate in older plants which is compensated, under normal seasonal conditions, by increased seedling establishment. Increased seedling establishment operates via a stimulation in seed production of existing Astrebla spp. plants (at least in the range of utilization experienced in this study).

Implications for drought management

The dynamics of Astrebla spp. populations described above has occurred during a period of favourable rainfall. (Seedling recruitment of Astrebla spp. has occurred in four out of five years of recording). It is probable that drought will interfere with this cycle.

The onset of drought results in increased utilization of Astrebla spp., particularly where livestock numbers are not reduced in line with seasonal rainfall. Increased utilization can be expected to accelerate the death of existing tussocks due to increased defoliation under conditions of soil moisture stress. Thus, the maintenance of Astrebla spp. density relies largely on seedling recruitment which cannot be expected during drought. The result of increased utilization of Astrebla spp. during drought therefore, is a reduction in Astrebla spp. plant density.

A reduction in livestock numbers would appear to be the best drought management based on resource stability. Reduced livestock numbers would minimise the death of established plants through reduced defoliation. These plants can then serve as the seed source for seedling establishment under favourable conditions. Such a drought policy based on resource stability is consistent with results of an economic survey in Astrebla grassland conducted during the drought years 1966-8 to 1969-70 (Childs 1974). This survey showed that higher economic returns were associated with lower stocking rates and a rapid reduction of livestock numbers as pasture conditions deteriorated.

Recovery of Astrebla grassland following drought will be dependent on the establishment of new Astrebla spp. plants from seed reserves in the soil. Plants subject to light grazing during drought can be expected to replenish soil seed reserves rapidly. This is consistent with the results of Everist's (1935) survey which concluded that Astrebla grassland suffered no apparent damage where they had not been overstocked during drought. The build-up of seed reserves in the soil following heavy grazing, however, can be expected to take a longer period because fewer Astrebla spp. plants would survive the drought than under light grazing. Thus, recovery from drought will be influenced by the rate of increase of seed reserves and subsequent plant establishment and this will be governed by the seasonal rainfall following drought. A rapid recovery in Astrebla grassland under the influence of three consecutive years of above average rainfall has been recorded (Orr 1981).

The implication for drought management of Astrebla grassland can be summarised - increasing utilization during drought will require increasing recovery time following drought. Financial incentives should, therefore, be offered to graziers to reduce stocking rates early during drought. Such incentives will be recovered through an earlier return to pasture productivity following drought.

Acknowledgement

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Drought, forage utilization, and their effects on the survival and recruitment of grasses of the mulga (*Acacia aneura*) woodlands.

by

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Abstract

In a mulga (*Acacia aneura*) woodland pasture, the survival of mature grasses and their seedlings was more strongly influenced by seasonal conditions than by grazing, although heavily grazed pastures fared worst. After two years of very dry weather, very few of the plants initially present were still alive. Subsequent pasture regeneration was heavily dependent on seedlings, apparently recruited at the end of the dry period. Undesirable grasses re-established more readily than the principal desirable ones. The implications of this for pasture management are discussed.

Introduction

A major question facing everyone associated with native pastures is whether the species compositions of such pastures have altered as a result of European settlement, and if so, in what ways.

One way of answering the question is to consider the fates of established plants and their seedlings. If the rates of mortality of mature plants and establishment of seedlings are similar, the species would be expected to maintain its position in the ecosystem. If an imbalance exists, the species will either increase or decrease as a fraction of the total pasture, depending on the direction of the imbalance. A long term perspective of such relationships must be adopted as significant changes may occur over decades rather than years. The effects of different seasons and levels of pasture utilization may be major confounding factors, especially in the short term.

Accepted local wisdom in the mulga woodland pastures of S.W. Qld is that wiregrasses (*Aristida* spp.) are increasing at the expense of more valuable grasses. If true, this is cause for great concern as wiregrasses provide inferior forage and the seeds are a costly contaminant of fleeces. However, such observations are based on anecdotal evidence with all the pitfalls that that implies.

This paper presents preliminary findings of a grazing experiment, part of whose purpose was to examine the extent to which pasture utilization alters the species composition of mulga woodland pasture.

Materials and Methods

The experiment site was located in mulga woodlands on 'Arabella' station, approximately 30 km east of Charleville. The paddocks within the site are referred to hereafter as the 80% paddock (22 ha), the 50% paddock (55 ha), the 35% paddock (46 ha), the 20% paddock (110 ha), and the 0% paddock (two ungrazed exclosures, both of 2 ha). The percentages refer to the level of utilization of forage and was estimated as follows. In most years, 10% or less of annual forage production occurs during the 6 winter months (Christie 1978). Hence, the forage at the end of March of each year is that available to support livestock until the following summer, if not later, so stock numbers should be adjusted accordingly. On the first of April every year, each paddock was sampled to estimate the available forage, including mulga leaf within browsing range. Assuming that each sheep has an annual requirement of 400 kg of dry matter, the number of sheep in each paddock is adjusted each April so as to consume 80% of the available forage in the 80% paddock, 50% in the 50% paddock, and so on. Hence, the stocking policy is directed towards the consumption of a known fraction of forage each year, rather than the maintenance of constant numbers of livestock.

An initial survey of the site, using a line transect technique indicated that the four perennial grasses, Aristida spp., Thyridolepis mitchelliana, Monachather paradoxa, and Digitaria ammophila, comprised more than 90% of all grasses in all paddocks. Twenty-six permanent quadrats (1 m x 1 m) were established in each paddock and the location of each individual plant of the four preceding species in each quadrat of each paddock was recorded in January 1979. Subsequent recording was limited to occasions preceded by sufficient rain to allow a distinction to be made between live and dead plants and species. Such occasions occurred in May 1979, September 1979, November 1980, and April 1981. Rainfall over this period is shown in Table 1. Comparing current with previous records on the second and subsequent occasions allowed plants to be classified as seedlings, live plants, or dead plants. Seedlings embraced all new plants with three or more leaves. Younger seedlings could not be identified accurately and were excluded. Adjustments were made for apparently dead plants which subsequently resprouted.

Table 1. Summer and winter rainfalls at 'Arabella' between 1/4/1978 and 31/3/1981 both as absolute amounts and as a fraction of the long term average.

Period	Rainfall (mm)	% of long term average
1/4/78 to 31/9/78	323	214%
1/10/78 to 31/3/79	151	42%
1/4/79 to 31/9/79	82	54%
1/10/79 to 31/3/80	78	22%
1/4/80 to 31/9/80	99	66%
1/10/80 to 31/3/81	332	93%

Results and Discussion

The number of individuals of both species groups in each paddock in January 1979 is presented as a base of 100 and changes in their numbers are expressed relative to this base (Figure 1). The initial frequencies of both groups of species are shown on the January base. The four grasses occur with different frequencies in each paddock. It seems likely that a major part of the variation was caused by a wildfire which burnt through parts of the 20% and 35% paddocks between the pilot survey and the first detailed recording in January 1979. However, this does not affect the interpretation of the data. The method used in this investigation examines a known population of individual plants each of which can be re-examined as long as the plant lives.

Between January 1979 and September 1979, a small proportion of both *Aristida* spp and the other grasses died. Less than 10% of the plants alive in January died before May and up to 21% of those alive in May failed to survive until September. Offsetting this was seedling recruitment over the same period resulting in a net increase in the numbers of live plants ranging between 16% and 51% (*Aristida* spp.) and 12% and 39% (other grasses). Differences between treatments were not marked although the net increases were lower in the 80%, 20% and 35% paddocks, possibly as a result of heavy grazing in the first paddock and fire in the other two.

The increase in plant numbers occurred despite the low rainfall received during the summer of 1978/79 and winter of 1979 (Table 1). However, the winter of 1978 was comparatively wet with more than twice the long-term average being received. Some residual benefit may have been derived from

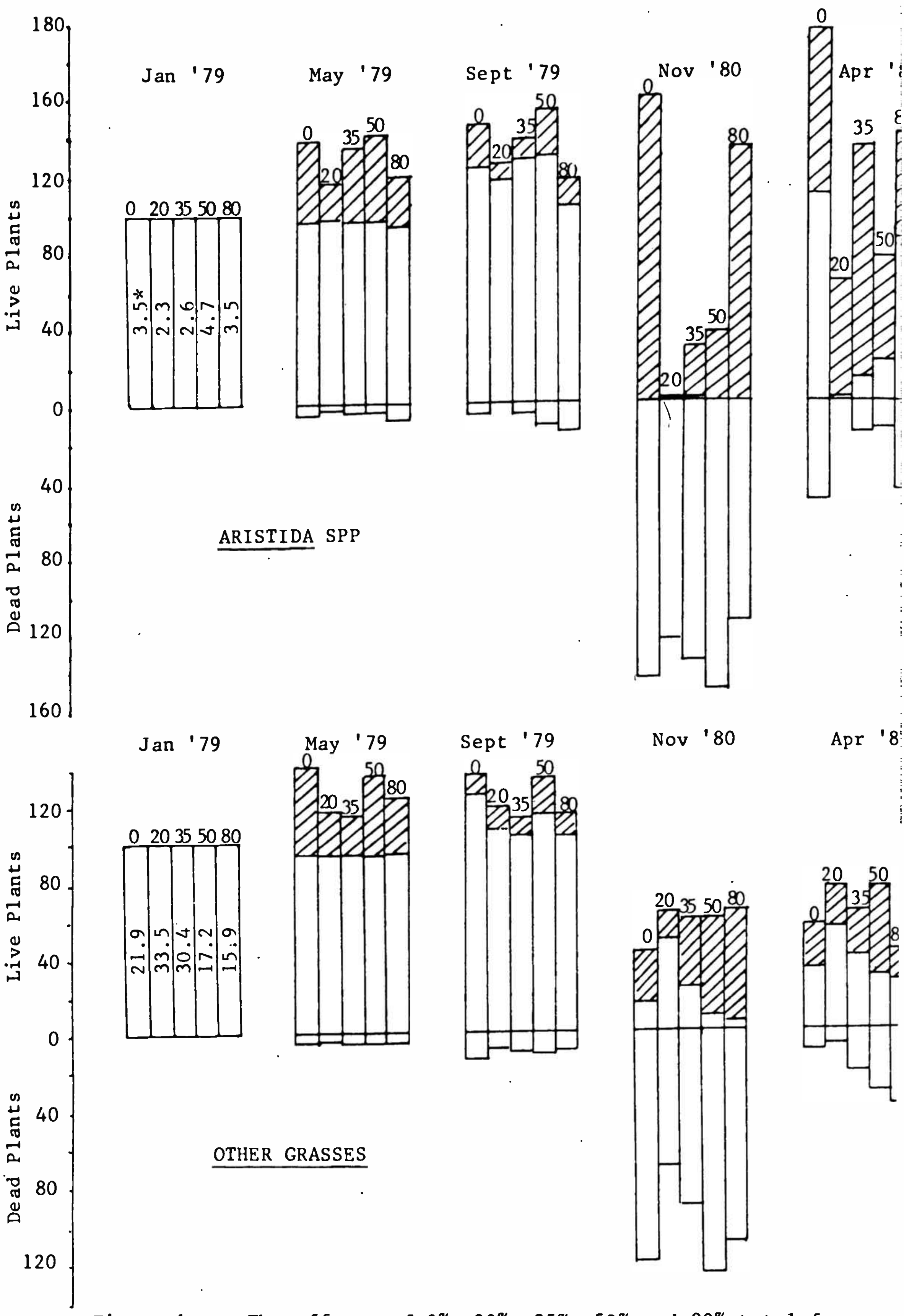

Figure 1. The effects of 0%, 20%, 35%, 50% and 80% total forage utilization on the survival of plants and recruitment of seedlings (crosshatched) of *Aristida spp* and other perennial grasses in mulga (*Acacia aneura*) woodland pasture between January 1979 and April 198 Data is shown relative to January 1979 expressed as a base of 100. (* Initial frequency of individuals per square metre.)

this over the following 12 months. The winter of 1979/80 and summer of 1980 continued the trend of very low rainfall.

In mid-October 1980, a total of 102 mm of rain fell over a 13 day period, promoting sufficient growth to allow recording in November 1980. No Aristidas survived the protracted dry period in any of the 0%, 50%, or 80% paddocks, and less than 2% survived in the 20% and 35% paddocks. Of the other grasses, less than 20% of the plants alive the previous year survived except in the 20% paddock in which 40% survived. The great majority of plants present in November 1980 were recently recruited seedlings probably germinating after the October rain.

Seedling recruitment of other grasses by November 1980 was sufficient to lift the total numbers of individuals to between 42% and 63% of the levels of January 1979. Greater numbers of seedlings were recorded in the more heavily grazed paddocks. About half of the seedlings died before April 1981 but germination over the same period more than replaced losses except in the 80% paddock which declined to 43% of its population of January 1979.

In the 0% and 80% paddocks of November 1980, there were more Aristida plants than at any previous time and all were seedlings. Fewer seedlings were recorded in the 35% and 50% paddocks and none in the 20% paddock, although they were present but too small to be identified.

Between November 1980 and April 1981, Aristida seedlings were recruited at a higher relative rate than seedlings of the other grasses. While about half the seedlings recorded in November 1980 died before April 1981 all paddocks showed a net gain over that period. Aristida numbers in both 0% and 80% paddocks were greater than on any earlier occasion.

The data from the 20% paddock, and to a lesser extent the 35% paddock, must be interpreted with care. The effects of the fire mentioned earlier are confounded with those of grazing pressure and may be responsible for some of the apparently anomalous results. For instance, the greater survival of the three desirable grasses may be because the fire destroyed older, larger plants but not smaller ones with lesser amounts of fuel. The loss of large plants might decrease interplant competition and allow a greater survival rate during the ensuing dry period.

Drought conditons during the 1979/80 summer resulted in minor stock losses in the 20%, 35%, and 50% paddocks. Between November 1979 and February 1980, two thirds of the sheep in the 80% paddock were lost and the paddock was destocked for 12 months commencing in April 1980 as there was insufficient forage to support any livestock. The subsequent recovery of the 80% paddock needs to be viewed in the light of a pasture overgrazed to the point of collapse and allowed to recover subject to grazing only by native herbivores. A comparison with the ungrazed exclosures (0% paddock) (figure 1) shows that, except for a flush of germination by the three desirable grasses in November 1980, seedling recruitment and plant survival was poorer in the 80% paddock. This is probably due to heavy grazing diminishing both the seed pool and the surface litter necessary for successful establishment.

In assessing the implications of these data for management of rangeland pastures, it must be stressed that during the two year drought nearly all the original plants perished and were replaced by seedlings. This change was not apparent from the periodic visual appraisals of the pasture undertaken 6 or more times a year. Such discrepancies between data and subjective impressions underline the pitfalls of placing undue reliance on visual and anecdotal evidence in assessing pasture condition.

Management practices need to be adjusted to take into account the large contribution made to pasture recovery by seedlings and the relatively trivial contribution by established grasses. Seedlings need time to grow and establish. There is little reason to believe that grazing small seedlings enhances their survival.

Prior to european settlement, droughts were accompanied by attrition of the indigenous herbivores whose numbers increased through natural reproduction when good seasons returned. Thus, seedlings were subjected to only light grazing and probably had reasonable opportunity to establish. This contrasts strongly with modern pasture management. Once useful rain has fallen, a grazier is likely to do either or both of two things. Firstly, he will cease pushing mulga, and secondly, he may bring in stock from outside. The grazing pressure on seedlings must be much greater than before european settlement. It is difficult to be optimistic that under such a system pasture productivity can be maintained in the longer term with existing management.

The maintenance of plant numbers is important in these pastures but so too is the pasture composition. *Aristida* spp. recovered more rapidly than the three desirable grasses, *Thyridolepis mitchelliana*, *Monachather paradoxa*, and *Digitaria ammophila*. Given the undesirable nature of *Aristida* spp., the speed and extent of its recovery must cause apprehension.

It remains to be seen whether *Aristida* spp. has gained a permanent advantage and whether the other species will return to their former levels. The rapid increase of *Aristida* spp. in ungrazed paddocks suggests that the advantage may be more transient than real. Nevertheless, the reliance on seedlings for regeneration of all paddocks and the greater attrition rates in the more heavily grazed pastures underline the potential to destabilize the pasture. Excessive grazing at inopportune times may cause serious and, perhaps, permanent damage. Until a great more is known about the recovery potential of mulga pastures, prudent management indicates lenient grazing is desirable, especially immediately after a protracted dry period, to allow adequate seedling establishment.

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SHEEP FAECES AS AN INDEX OF ANIMAL ACTIVITY OR INTRAPADDOCK USAGE PATTERNS

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ABSTRACT

Animal activity and the distribution of faeces were studied on a small paddock grazed intensively by Merino sheep. Irrespective of whether sites were used for camping or grazing, the pattern of faeces weight differences across the paddock was focussed on the camp and reflected total sheep time per unit area. However, defaecation was observed to be associated with activity on the camp and the amount of faeces on the paddock at large found to be a function of the time at which a site was traversed following a period of rest.

Introduction

The number of faecal units (Riney 1957, Donald and Leslie 1969, Lange 1969), the volume (White 1960, Rawes and Welch 1966, 1969) and weight (Warren 1971, Cadwalladr and Morley 1973, Andrew 1978) of faeces per unit area have been widely used as indices of sheep density, intrapaddock usage patterns and relative stocking pressure. In situations where observation of flock activity was difficult, such indices have been employed to explain the role of the animal in the creation of intrapaddock vegetation patterns (Gillingham and During 1973, Andrew 1978, Graetz and Ludwig 1978). However, these indices are based on rather tenuous assumptions about sheep behaviour and its relationship to the spatial and temporal distribution of faeces. For example, the assumptions that faeces are dropped where an animal grazes and/or that the amount voided is proportional to the time spent grazing there, are common (Rawes and Welch 1966, Warren 1971). These in turn are based on the assumptions that defaecation activity is either more or less regular (Riney 1957), or occurs at random (England 1954). Data to support any of these assumptions are scant.

Lange and Willcocks (1978) have studied the distribution of sheep faeces over a 1.25 hectare arid-zone paddock and shown that faeces weight was positively and linearly related to total sheep time spent per unit area. The activities of grazing, ruminating, resting and idling occur at different sites in a paddock and encompass different intensities and proportions of the ecologically important effects of the animal (viz. defoliation, treading and excreta deposition); both in a spatial and a temporal sense. Therefore depending upon whether the sheep were grazing or resting at a site for a given time, their effect on the pasture is likely to be different. Thus for meaningful interpretations using faeces distribution, one really needs to know how the faecal index reflects both the animals' activity and its ecological impact on the vegetation. Reports of such relationships are scant.

This paper reports on a study of the occurrence of defaecation events, sheep activity and faeces distribution, and the relationships among these in an intensively grazed pasture on the Northern Tablelands of New South Wales.

Methods

Site

A 0.1 hectare portion of an 0.4 hectare Shannon Vale Nutrition Station paddock was fenced off from the remainder of the paddock. This portion was chosen because of its uniformity in terms of botanical composition and herbage mass. In addition, two weeks before the study commenced, the pasture was mown to a height of 2.5cm. A water point was located at the centre of the paddock. Otherwise the paddock was free of obstructions and an unimpeded view of the whole area was possible.

Sheep

Ten, four-rising-six tooth Merino wethers were used in the experiment. They had been grazing together as a flock for a week prior to the experiment and were accustomed to small paddocks and handling.

Location and activity of sheep

The axes and co-ordinates of a 7 x 9 grid were marked with pegs and numerals along the paddock fence. Cells of the grid were approximately 16 square metres in area. The location of sheep was recorded with respect to the grid, through the marked perspex window of an observation tower, in a modification of the method of Kilgour *et al.* (1975).

At ten minute intervals, animal location, defaecation and drinking activity, along with an instantaneous characterization of each animal's activity as walking, standing or lying, were recorded. An animal's location was taken as the cell in which the greater number of the animal's feet were observed. Notes were made as to whether those animals standing were grazing or resting. Animal location and activity was recorded from 32 to 40 hours of a 72 hour period. Such data were collected over four consecutive 72 hour periods and resulted in 8040 animal activity/location records being available for analyses.

Supplementary observations were made of diurnal activity to describe the flock's general activity and record the occurrence, location and time of any observed defaecation event. A spotlight was required for observation between 1950 and 0540 hours and these times were taken to delineate the diurnal and nocturnal periods of a day.

Faeces sampling

Within each grid cell four quadrat positions were systematically and permanently located. The area was cleared of faeces before grazing commenced and on four occasions at 72 hour intervals, all whole pellets of faeces were collected from within an 'X' shaped quadrat (0.2 sq. m.), dried at 70^{o}C for 48 hours and weighed. Data for the four quadrats in each grid cell were accumulated for analyses.

Data analysis

Relationships among the various categories of animal activity and weight of faeces were examined by regression analysis. Simple linear, logarithmic and quadratic forms were fitted and by inspection of the fit and variance accounted for by the different forms, relationships were chosen for discussion. As a simple indication of the strength and nature of any relationship, the correlation coefficient only is given. Where a test of parallelism indicated a non-significant difference between the slopes of the regression for each time period, only the overall correlation coefficient has been presented. Otherwise, the correlation coefficients for each of the four time periods are given.

The small amount of additional variation accounted for by multiple regressions did not warrant their inclusion in the discussion.

Results and Discussion

Sheep activity

A sheep camp is a place where sheep regularly and habitually rest; in this paddock there was only the one. Soon after daylight and before sunrise the sheep moved off the camp and commenced the first of several periods of grazing, interspersed with periods of standing and lying, ruminating and idling on the camp (Figure 1). The times spent grazing (Figure 1) agree well with those of Southcott *et al.* (1962) and Lynch and Hedges (1979) for a nearby centre, Armidale.

Over the seven full days of observations a mean of 36 percent (range 28-45%) of the flock's time was spent grazing in the paddock at large (Table 1). Sheep were walking and occasionally standing whilst grazing. The remainder of the day (64 percent, range 55-72%) was spent camping on those animal observation cells that account for 14.3 percent of the paddock area (Table 1). This area was used 3.7 times on average (range 2-5) in the diurnal period (Figure 1), and virtually continuously in the nocturnal period (Table 1). In moving to the camp the flock would either continue grazing to the edge of the

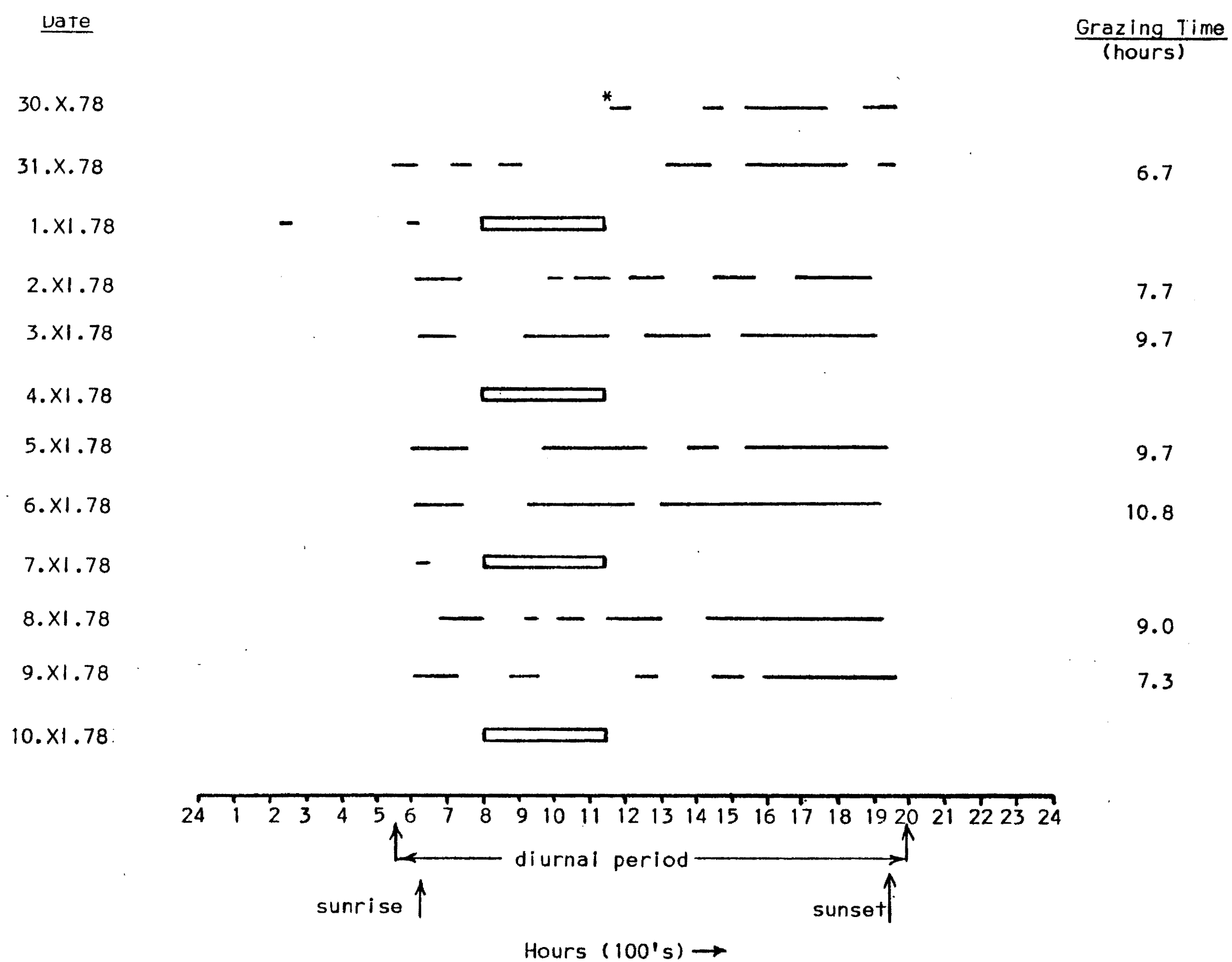

Figure 1 Periods when the greater proportion of the flock was traversing the paddock at large, grazing (——), resting on the camp ( ) and when pasture/faeces sampling was conducted (▭) from the time sheep were introduced to the paddock (*).

TABLE 1

Mean percentage of time spent in different paddock cells during both the diurnal (0540-1940 hours) and nocturnal (1950-0530 hours) periods of two of the seven days of observations. The nine cells used for either diurnal or nocturnal camping are delineated.

DAY: 31.X.78-01.XI.78

a) Diurnal Period

Grid Columns

	1	2	3	4	5	6	7	8	9
Grid Rows 1	0.94	0.94	0.82	0.00	0.71	1.18	1.65	3.18	16.59
2	0.94	0.94	1.29	0.71	1.18	1.18	2.82	2.47	29.65
3	0.00	0.00	0.71	0.82	0.82	0.47	2.24	0.59	5.18
4	0.82	0.12	0.00	0.35	1.18	0.94	0.35	0.71	2.12
5	0.47	0.35	0.59	0.12	1.41	0.71	1.53	0.71	1.53
6	0.00	0.47	0.24	0.24	1.29	1.29	0.24	0.47	1.41
7	0.00	0.00	0.00	0.47	0.48	0.12	0.00	0.12	1.06

b) Nocturnal Period

	1	2	3	4	5	6	7	8	9
Grid Rows 1	0.51	0.85	0.00	0.00	3.39	4.92	5.08	14.75	60.68
2	1.02	0.34	0.00	0.00	0.00	0.00	0.00	0.34	7.80
3	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DAY: 06.XI.78-07.XI.78

a) Diurnal Period

	1	2	3	4	5	6	7	8	9
Grid Rows 1	6.82	1.88	2.24	0.94	1.65	6.71	6.35	7.06	5.18
2	2.82	0.47	1.88	3.18	0.59	1.41	1.65	2.35	1.41
3	2.71	0.82	1.88	1.41	1.06	0.47	0.94	0.71	0.82
4	1.29	1.65	0.47	0.24	0.71	0.82	1.41	1.18	1.29
5	0.47	0.12	0.59	1.88	1.76	1.29	0.71	0.47	0.94
6	3.18	0.24	0.59	1.06	1.29	0.94	0.47	0.94	2.35
7	0.71	1.29	1.18	1.29	0.24	0.71	0.12	0.00	0.71

b) Nocturnal Period

	1	2	3	4	5	6	7	8	9
Grid Rows 1	0.00	0.00	0.00	0.00	0.00	16.44	24.58	18.31	34.24
2	0.00	0.00	0.00	0.00	0.00	0.51	0.68	0.00	5.42
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

camp or stop grazing and walk head-up toward the camp. Sheep were recorded grazing in the nine cells designated as camp in only 15 of the 8020 animal observations.

Faeces distribution

From 49 to 62 percent of the weight of faeces collected on the paddock was estimated to be on the camp area. The total weight of faeces collected on the camp was 31 to 39 times that of the paddock average (36.2 gm^{-2}). The mean weight of defaecations (defined as a heap of faecal pellets) on an off the camp were 50.3 g (range 29.5-72.9 g) and 17.0 g (range 13.0-23.2 g) respectively.

Biologically relevant as well as statistically significant relationships were recorded for the regression of time spent in various activity states on the weight of faeces (Table 2). No additional variation was explained by using log faeces in the regression, however in this case the slopes of the regression lines were parallel (Table 2). In the case of the simple linear regressions, the slopes of the regressions for the four time periods were significantly different indicating a change over time in the strength of the relationships (Table 2). Inspection of the raw data suggested that the variability in the small scale distribution of faeces largely accounted for these inconsistent differences. Changes in temperature and wind speed and their concommitant effects on the pattern of animal activity also appeared to be important. Time spent in the diurnal activity states tended to account for less variation in the distribution of faeces than time spent in activities in either the nocturnal period or during the whole day (Table 2).

Clearly the intrapaddock concentrations of sheep faeces are not related to grazing activity but a function of time spent on the camp. Yet animal observations indicate that while on the camp sheep spent virtually all of their time either standing or lying. Time spent in these activity states accounted for a high proportion of the variation in the distribution of faeces (Table 2).

The relationships between faeces weight and total sheep time per unit area were similar in nature but not as strong as those reported in Lange and Willcocks (1978). This may reflect differences in intensities of animal observation and the scales of the two studies.

TABLE 2

Correlation coefficients (r) for the regression of faeces weight on sheep time spent in various activity states per unit area.

Relationship	ANIMAL ACTIVITY STATES											
	Walking			Standing			Lying			Total		
	Diurnal	Nocturnal	Total Day	Diurnal	Nocturnal	Total Day	Diurnal	Nocturnal	Total Day	Diurnal	Nocturnal	Total Day
Log faeces overall t	0.07		0.08	0.43	0.43	0.48	0.52	0.56	0.54	0.43	0.49	0.54
Linear overall t	-0.01											
Linear individual												
t1			-0.09	0.71	0.80	0.82	0.46	0.83	0.77	0.60	0.82	0.81
t2			0.37	0.80	0.85	0.85	0.89	0.90	0.91	0.88	0.90	0.90
t3			0.06	0.38	0.84	0.82	0.89	0.73	0.81	0.83	0.86	0.88
t4			-0.10	0.28	0.56	0.62	0.49	0.69	0.77	0.42	0.65	0.75

where r with (n-1) = 62 and t = time period(s)

$P < 0.05 = 0.25$
$P < 0.01 = 0.32$
$P < 0.001 = 0.40$

Occurrence of defaecation events

At the first faeces sampling the number of distinct heaps of faeces across the paddock were counted. Assuming that each heap represents a defaecation event, then an average of 7.97 events occurred animal^{-1} day^{-1}. This value agrees well with those given by England (1954) and Hafez and Scott (1962).

In the course of observations 75 defaecation events were recorded. We thus estimate that 11.7% of the defaecation events that occurred over the course of the experiment were actually seen. The occurrence of these events in relation to animal activity both on and off the camp are given in Table 3. Thirty-four percent of defaecations occurred within one minute of each other. This is taken as evidence of some alleomimetric behaviour in defaecation activity. Clearly the majority of defaecation events occur on or near the camp and the amount of faeces on the paddock at large is primarily a function of the time at which a cell was traversed in relation to the cessation of a period of rest.

Conclusions

The large amount of faeces found on sheep camps (Hilder 1964, Gillingham and During 1973) is a function of three factors; total time spent the larger quantities of faeces being voided and animal activity on the camp. Whilst the weight of faeces reflects total sheep time per unit area, it is more a function of camping activity and the time at which a site was traversed since camping, at least on the Northern Tablelands. It follows that the amount of faeces is unlikely to be proportional to the defoliation pressure at a site, but may reflect the impact of trampling or nutrient enrichment.

We thus suggest that the major intrapaddock floristic differences that characterize sheep camps (Whalley *et al.* 1978) are perhaps created more by trampling and nutrient enrichment and less so by grazing. In terms of creating such intrapaddock differences it appears that resting behaviour may be more important than grazing behaviour.

Acknowledgements

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TABLE 3

Occurrence of defaecation events in relation to animal activity both on and off the camp.

On camp defaecations:	%
on standing after lying	33
whilst standing	20
after disturbance	11
Off camp defaecations:	
within 10 minutes after an on-camp rest period	10
within 20 minutes after an on-camp rest period	5
within 30 minutes after an on-camp rest period	3
within 40 minutes after an on-camp rest period	1
More than 40 minutes after an on-camp rest period†	17
	100%

† 90 minutes was the longest time interval between cessation of a period of rest and when a defaecation event was recorded.

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THE MEASUREMENT OF SHEEP DIET USING SMALL GRAZING ENCLOSURES

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ABSTRACT

A method for obtaining quantitative diet information for sheep is described. It requires no elaborate equipment or procedures. Dietary intake is measured as the daily difference in available forage in a heavily-grazed enclosure; the forage is measured using the Adelaide technique. This procedure gives data with smooth curves suitable for use in preference models and indices, and a new "Area" index was developed to summarize the data from these experiments. The advantages of the method are that it does not require elaborate equipment or techniques, dietary intake is averaged over all of the sheep and the whole of each grazing period, and the sheep appear to graze normally. Its principal disadvantage is the error associated with each intake value, which is twice that of the associated forage values, but ways of ameliorating this are discussed.

Introduction

It is important to know what the grazing animal eats, both from an animal nutrition and from a pasture management point of view. This supposedly basic information is often imperfectly known. For example Leigh and Mulham (1967) when studying the diet of sheep in semi-arid pastures of the Riverine Plain, found that *Calocephalus sonderi* averaged 15% of the diet even though it was "generally regarded as a worthless weed", and that pig face (*Disphyma australe*), held by some to be quite palatable, was only lightly grazed.

There are basically three ways of studying diet. The animal is watched as it grazes, or the pasture is watched as it is grazed, or one inspects the material that has actually been swallowed. The bulk of information in the literature comes from the first two methods and ranges from anecdotal to quite rigorous observations. To date however, decisive information has come from the last procedure, of which there are three variants, namely the study of taxonomically - identifiable residues in dung, inspection of gut contents of grazing animals, and the use of oesophageal fistulation.

We wished to quantify sheep diet in relation to available forage in the arid chenopod shrublands of South Australia without being dependent on veterinary facilities. We developed a new method to do this which is free of such dependence. The information we gained on the diet of sheep in arid chenopod shrubland using this method will be reported elsewhere. In this paper the method is described and illustrated with a set of data collected at Middleback Station, Whyalla, S.A. in November 1972. A new preference index for summarizing this data is proposed. The strengths and weaknesses of the method are discussed, particularly in comparison with the use of oesophageal fistulated sheep.

Philosophy of the method

Forage weight of individual shrubs can be measured with an accuracy of 10% or better using the Adelaide technique (Andrew *et al.* 1979). This is sufficiently precise to enable dietary intake to be measured as the difference in available forage before and after a grazing period, providing this difference is sufficiently large. Our method involves stocking an enclosure with enough sheep to eat most of the forage in a week, and simultaneously measuring the forage on a daily basis. The relative error of the total forage will be much less than that for individual shrubs, as it is the sum of many values, each with a random error. Vegetative growth is assumed to be negligible over this time. Thus intake is calculated daily as the forage difference. Since the decline in available forage will be more rapid for a preferred species a preference index can be calculated based on the area beneath the forage *vs* time curve. When scaled to lie in the range 0-1 (0 for an uneaten species, 1 for a species eaten completely in the first day), this is called the 'Area' index.

The method thus requires three important criteria. First, the enclosure must be not so large as to prevent the total forage from being estimated with sufficient accuracy. Second, the stocking rate must be sufficiently high so that the daily decrease in available forage (*i.e.* intake) can be discerned from the errors of measurement. Third, the enclosure must be sufficiently large to allow the expression of normal grazing behaviour (with the obvious exception that ranging behaviour is necessarily restricted).

Field procedure

An enclosure of 0.1 ha with an adjacent holding pen was erected in chenopod shrubland. Drinking water was provided and six 3-year-old ewes were put in the pen. While they were acclimatizing, permanent quadrats were laid out in the enclosure. Forage was measured in them using the 'Adelaide' technique for shrubs and modifications of this for the grasses and forbs.

The sheep were then introduced into the enclosure. At 24 hour intervals, coinciding with their natural resting period, they were herded into the holding pen, and the weight of forage in the enclosure was measured. This took up to three hours, after which the sheep were returned to the enclosure. This routine was continued for one week. Litter fall was measured in small quadrats so that it could be included as a correction factor. The amounts recorded were generally trivial.

Results

The time-course of total forage and total intake, and the relation between them (Figure 1), show smooth curves with errors not atypical for such ecological measurements. The first two criteria were clearly met *viz*, forage was measured sufficiently accurately and intake was discernible as forage difference. The third criterion also applied. The grazing and resting behaviour appeared to be normal, and sheep tracks were cut radiating from the water trough throughout the enclosure akin to the pattern in station paddocks (Lange 1969).

Intake per head, before it declined, was 1.5 kg day^{-1} which is in the range of values expected. The individual species data are plotted in Figure 2 with the exception of *Maireana pyramidata* and *Enchylaena tomentosa* (present in small quantities and not eaten till the last day) and *Rhagodia spinescens* (not eaten at all). The individual species show a slightly erratic but still regular behaviour. For example the bluebush (*Maireana sedifolia*) forage as measured on day three was slightly more than that of the preceeding day. Such discrepancies are inevitable given that forage values have some error and this is doubled when intake is calculated by difference. This is exacerbated in cases such as bluebush with a low intake relative to the weight of forage on offer. Nevertheless, it is clear that the sheep acted as generalist feeders taking some of all the available species with the exception of *Rhagodia spinescens*. *Bassia* and *Atriplex vesicaria* comprised the bulk of the diet.

Discussion

The main problem with the method is the doubling of the error when the intake values are calculated. There are two ways of alleviating this problem apart from reducing the error of the forage estimates as much as possible. The first is to develop formulae for preference indices or models which use the forage values directly and not the calculated intake values. The second is to smooth the curves of forage decline over time in those cases where the decline is not regular and interpolate adjusted forage and intake values from them. Such a smoothed curve is shown in Figure 2 for bluebush. An example of the first approach is a dietary preference index

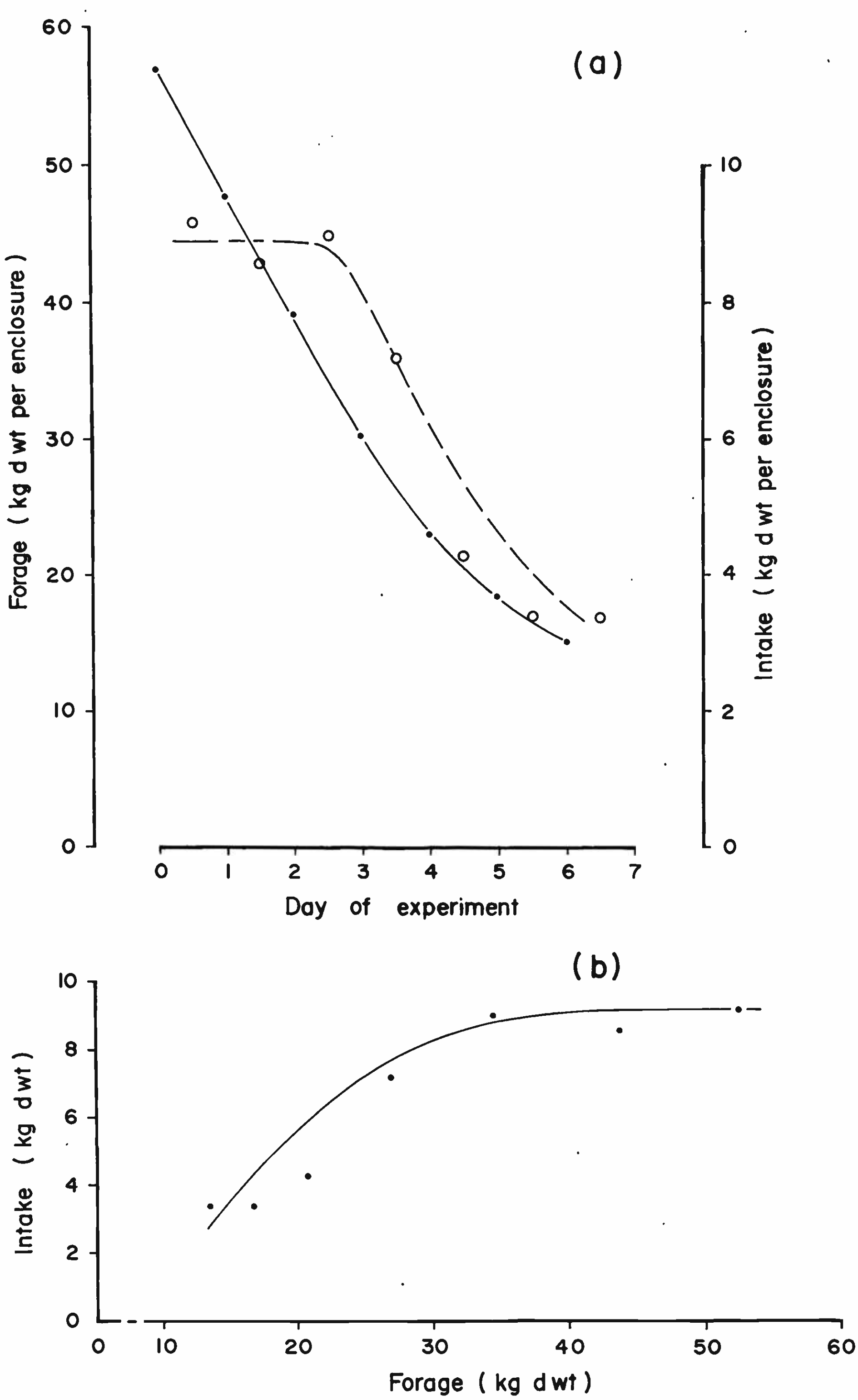

Figure 1. (a) The change in total forage on offer in the enclosure (.) and total intake (o) over the duration of the experiment; and (b) the relation between total intake and total forage on offer.

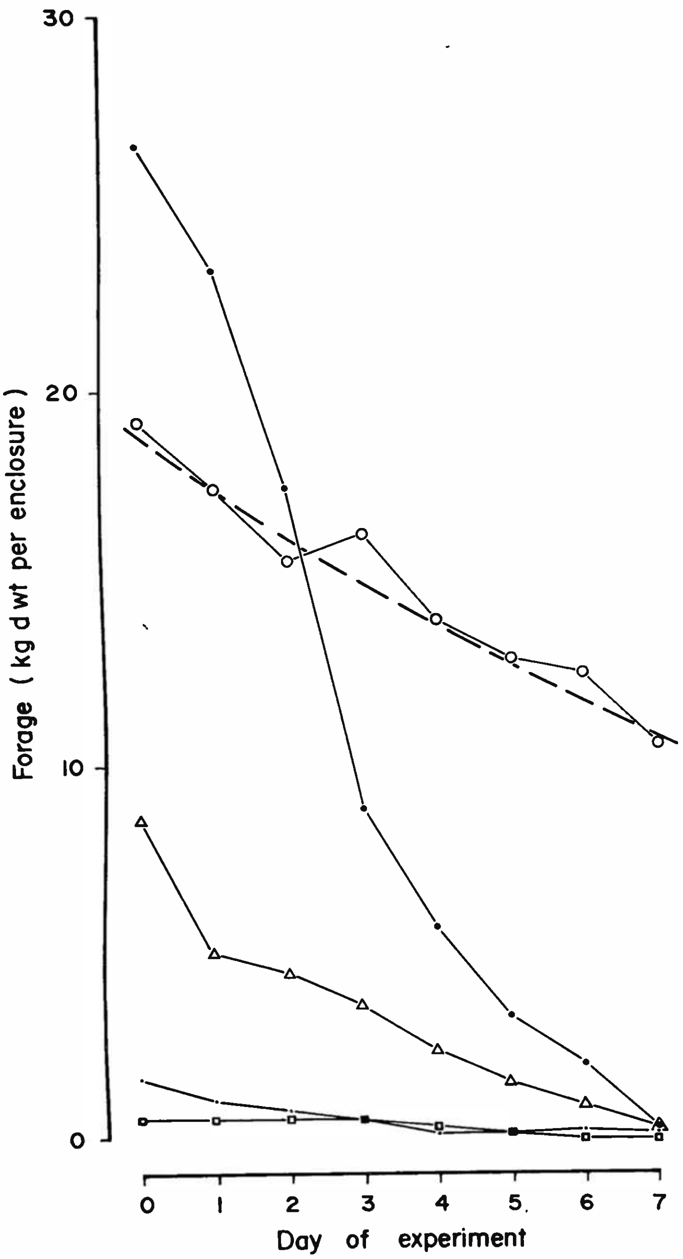

Figure 2. The decline in forage of individual taxa over the course of the experiment. *Bassia* spp (●); *Atriplex vesicaria* (△); *Maireana sedifolia* (o); *M. turbinata* (□); grasses (.). The smoothed curve for bluebush (*M. sedifolia*) is shown by the dotted line.

(the 'Area' index) developed by us to analyse these grazing experiment data. The usual indices of dietary preference *e.g.* Van Dyne and Heady (1965) and Ivlev (1961) relate the proportion of a food in the diet to its relative availability. These are calculated for each grazing period using the (smoothed) forage and intake information. The values of the Area index and of the Ivlev index (Table 1) show that the grasses were the most preferred although they did not contribute the bulk of the diet, and some species like *Maireana turbinata* became preferred only when other more palatable species had disappeared. These results accord with experience elsewhere (*e.g.* Leigh and Mulham 1966a).

Total intake, too, can be studied and the totality of our data together with those from the Riverine Plain (Leigh and Mulham 1966a,b; Robards, Leigh and Mulham 1967) suggests that the shape of the intake *vs* forage curve is quite characteristic. Intake per head is approximately constant at high levels of forage availability and it declines well before the sheep appear to have difficulty in finding forage. The causes of the decline were subsequently examined and the results will be discussed elsewhere.

It is of interest to compare diet data obtained using both forage decline and oesophageal fistulated sheep simultaneously. The Riverine plain data permit this comparison and the results are given in Table 2. Clearly there are considerable discrepancies between the two methods especially for the first day's grazing where the rank orders of intake differ - the grasses ranking higher in the fistula samples and the chenopods and clover ranking higher in forage decline. These differences are undoubtably due to a number of factors - loss by trampling in the denser Riverine vegetation and errors associated with forage measurement for forage decline, and for oesophageal fistualtion, the short sampling time of 30 to 50 minutes, the use of fasted sheep, the use of only three of the six sheep in the light of high individual diet variability, and the possibility that the sheep may select a 'softer' diet on account of the fistula. These factors highlight the caution that is necessary when interpreting any such dietary data.

Our procedure for studying diet has several advantages but only a few drawbacks. No special equipment or facilities are required; a single person trained at forage measurement can handle the work load, but obviously more people will get the forage measured more quickly or more accurately by enabling more intensive quadratting. We found this procedure an excellent teaching tool for acquainting final-year botany undergraduates with the

Table 1. Preference index values for all species.

	Area Index[1]	Ivlev Index[2]	For Day Number:					
		0-1	1-2	2-3	3-4	4-5	5-6	6-7
Grasses	0.82	0.45	0.32	0.27	0.68	-1.00	-1.00	-1.00
Atriplex vesicaria	0.74	0.50	-0.18	-0.23	0.28	0.36	0.35	0.69
Bassia spp	0.72	-0.14	0.22	0.35	0.32	0.42	0.63	0.70
Maireana turbinata	0.47	-1.00	-1.00	-1.00	0.38	0.65	0.79	-
M. sedifolia	0.27	-0.31	-0.41	-0.61	-0.53	-0.49	-0.50	-0.37
M. pyramidata	0.08	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	0.83
Enchylaena tomentosa	0.08	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	0.83
Rhagodia spinescens	0.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
Total	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[1] Area Index

$$= 1 - \left[\frac{\left(\sum_{i=0}^{n-1} \left(\frac{F_{i+1}}{F_0} + \frac{1}{2}\left(\frac{F_i - F_{i+1}}{F_0} \right)^{2} \right) - \frac{1}{2} \right)}{(n-1) - \frac{1}{2}} \right]$$

; max preferred = 1
min preferred = 0

where F_i = forage measured on day i

[2] Ivlev Index = (D - F)/(D + F) where D = % of species in diet
F = % of species available as forage;
max preferred = +1
min preferred = -1

Table 2. Comparison of diet determined by two methods from the same experiment - forage difference and oesophageal fistulation (OF). Data is from Table 3 of Leigh and Mulham (1966a).

% DIET:

	Day 1		Day 2	
	Forage Difference Day 1-2	OF Day 1	Forage Difference Day 2-3	OF Day 2
Danthonia caespitosa	1.8	13.2	0.2	-
Hordeum leporinum	1.1	35.0	0.8	6.0
Hedypnois cretica) *Hypochaeris* spp)	0.6	0.5	0.1	1.5
Medicago polymorpha	70.9	27.0	23.4	31.0
Medicago burrs	-	2.5	-	3.0
Atriplex vesicaria	13.6	1.0	57.1	36.0
* *Kochia aphylla*	3.0	-	3.3	3.0
K. pentagona	5.3	-	1.1	-
K. excavata	3.0	-	1.1	-
Nitraria schoberi	0.8	-	0.5	-
Other species	0.0	20.5	12.5	19.5
TOTAL	100.1	99.7	100.1	100.0

* Now *Maireana* spp.

practicalities of field experimentation. The intake values are obtained over a full 24-hour period, unlike that obtained using oesophageal fistulated sheep. Furthermore, the diet is the average of all the sheep thus avoiding the problem of individual variability encountered when measuring the intake of only a few of them. In fact, given the man-power, it would be feasible to increase the number of sheep used by increasing the enclosure size proportionately so as to obtain a better average diet. Another advantage is that sheep grazing behaviour appears to be normal. The main disadvantages are that the diet is derived from a restricted area; that the forage available at any time is that which has not been eaten previously (thus the amount available, and probably its palatability and digestibility, steadily declines during the experiment); and that the intake values have attendant error problems, although these can be partly overcome. Rain could be a problem by making the forage measurement more difficult, but no rain fell during any of our experiments.

Conclusions

We have developed a method for obtaining useful quantitative information on sheep diet which has no dependence on elaborate techniques or facilities, and which does not require fistulated animals. Our method has a number of other advantages, and there are ways of ameliorating its main drawback which is the error associated with the intake values.

Acknowledgements

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WHAT HOPES FOR THE PASTORAL INDUSTRY

IN THE ARID ZONE OF AUSTRALIA?

After 50 years of experience in the ARid Zone, I am not optimistic that it is possible for economic continuous grazing of the pastoral lands without very drastic management changes.

In an article of mine, written and published in 1935, I said :

> "The man from the outback ... pastoral areas will be driven from the land sooner or later. A few good seasons may postpone the inevitable, but at the present rate of degeneration (SA) it will be in the near futtre ... "

To explain that statement :

At that time I was living in the Arid Zone, on a pastoral area of about 300,000 acres, where I ran up to 5000 sheep and 100 cattle. This was virgin country - Saltbush, Mulga, Bluebush, Myall, with well vegetated sand ridges; my carrying capacity was about one sheep to forty acres. My experience here, and in the northern part of the Flinders Ranges where I managed a property for twelve years, indicated to me that hard hoofed introduced animals (domestic animals) largely were responsible for the destruction of the soft soils of the Arid Zone. It is not generally appreciated that none of our native animals is hard hoofed. Their feet are padded and resilient, and thus adapted to cause little damage to an old and vulnerable land.

When small water supplies (200 gallons per day) were asociated with large paddocks (25-30 square miles) and stocking rates were low, there was very little damage to vegetation. The large, lightly stocked paddocks meant that there was always good feed on the remote areas where stock moved in moist cool weather. Was it economic? Yes -- but only because it was managed and worked by myself and one station hand, with irregular assistance from Aborigines.

The Arid Zone comprises over 75% of Australia, that is, according to Prescott --

	000 Sq.Miles	Percentage of Aust.
Extensive sheep and cattle country	1344	45.1
Sandy and stony desert areas	580	19.5
Stony table,ands and ranges of the deserts and tropics	379	12.7
	2303	77.3

There are three major users of the land resources of the Arid Zone - Pastoral, Recreational and Mining. The latter two are acting responsibly.

The percentage of the Arid Zone affected by mining or projected for mining is very small, and there is no doubt the mining industry's restoration work, now being done by professionals, is satisfactory in most mined areas.

Recreation is a relatively new industry and the authorities also are coping with the problem of an industry expanding faster than any other, and competitive with the pastoral industry nationally and economically.

The Standing Committee on Soil Conservation has estimated that about 30% of the Arid Zone is "too dry even for pastoral production." Prescott has estimated that this area comprises 'Sandy and Stony Desert' or 'Stony Tablelands and ranges of the deserts and tropics' (see table above). The major threat to this vast area is that of feral animals. Their impact on the Arid Zone has not been assessed or faced by Governments. We have seen how the European Rabbit and the Cat have adapted to existence in drought years; and how they can proliferate in good seasons. Other animals we know will also adapt to the Arid environment. It is significant that 70,000 camels were shot in the Northern Territory in 1979.

The pastoral industry in the Arid Zone is an important industry, providing grazing for about one-quarter of livestock in Australia. Statistics indicate that its relative value is declining, being based on a diminishing resource -- perennial vegetation. The Standing Committee on Soil Conservation (SCSC) states :

> "The problems of the Arid Zone are still not fully assessed; the size, ecological fragility and low productivity of the Zone impose great difficulties."

It seems to be impossible to develop systems of land use and land management which maintain and, where possible, improve the productivity and stability of the land, and minimise land degradation.

Australia is the last great arid continent to be exploited by the white man, and I emphasise white, for the Aborigines have lived on the land for 40,000 years or more; and though they most certainly modified it over this period, they did not destroy it as we are destroying it today We do not understand the functions of the inter-related resources of the Arid Zone -- we have not demonstrated that our land use practices are any better than those of pre-history exploitive land uses which resulted in the deserts of the Old World.

The fact the Rangeland Society has been formed and comprises pastoralists, scientists and others, indicates a real appreciation of the Arid Zone's problems.

There are very few pastoral properties which have been continuously stocked that do not show loss of perennial vegetation and tree cover, erosion and desertification. Huge areas of arid pastoral lands are now deserts. Anyone who has travelled from Marree in the South to Birdsville will have seen the utter devastation created in not much over 50 years. It does not appear that removal of stock has increased vegetative cover in this area east of

Lake Eyre. This scene is repeated throughout the pastoral lands, although not to the same extent.

The size of the deserts surrounding permanent water is in almost direct relationship to the volume of water for stock, and of course the soil type. Too much water is the cause of desertification because of the concentration of stock it engenders, particularly in times of drought. My little wells of 200 gallons per day carrying a few hundred sheep showed little vegetation deterioration and no desertification.

On one property not far from Katherine the land owner had not bulldozed the trees - he had removed some low scrub and under-storey vegetation, and spread super by air. His parklike woodland had a wide range of native grasses and clovers and his cattle were all fat. His neighbours, who had cleared every tree, were suffering from drought. Even the Research Station had no feed and miserable cattle. The answer surely was - Leave the trees and keep the canopy.

The benefit of the infrequent rains of the Arid Zone can be increased by maintaining tree and shrub cover, thereby reducing wind velocity and providing shade.

The stock-carrying capacity of the Arid Zone is not high, and it must tend to decrease as the perennial vegetation lessens and erosion increases. Some people think that irrigation is the hope of the Arid Zone, but there are very few areas in the world where broad-acre irrigation has not led to rising water tables and salting. Before spending money on costly irrigation schemes, a great deal more investigation and research is needed.

In conclusion --

I cannot do more than quote from the Preface to the published Proceedings of a Symposium held in the Academy of Science in Canberra, May 1969, edited by R.O. Slatyer and R.A. Perry. The Preface by Slatyer states --

- History has shown that man's utilisation of the world's arid lands has, in general, caused progressive deterioration of the natural vegetation, of the animal resources, and finally of the landscape itself.

- In Australia, although little arid land settlement extends for much longer than 100 years, limited areas have already been seriously damaged, and signs of increasing degradation are apparent in most regions currently being grazed. There seems little doubt that progressive deterioration will occur if present practices are continued.
- In order to arrest this tendency and preserve the arid lands for the future in a manner which is consistent with non-destructive utilisation, it is clearly desirable that the national character of the problems should be recognised and steps taken to solve them.

- The problems are complex. They call for an assessment of the resources of the arid lands, the changes that have resulted from utilisation and the significance of those changes, and planning to assure long term conservation of the arid lands.

- Differences of opinion as to the best means of arid land utilisation are inevitable. In particular, there is a conflict of interest between those whose primary concern is to conserve the arid land resource and those who wish to obtain an economic return from it.

At least there are indications of what we should not do. Those who are not prepared to accept these land use practices will destroy the Arid Zone and, in so doing, themselves.

DEWAR. GOODE

TOWARDS A MEASURE OF FOOD SELF SUFFICIENCY FOR ABORIGINAL MICRO-COMMUNITIES

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Introduction

A comparatively new demographic phenomenon occurring in the central Australian arid rangelands is the establishment of micro-communities, of homelands or outstation Aboriginal people, scattered throughout what is now Aboriginal land (1). These people are seeking to achieve a measure of cultural integrity.

The communities are usually based on an extended family, dominated by one or more men who are either the traditional owners of that land or the traditional managers (2) of that land.

I have used the word micro-community to describe these groups because I believe they are the smallest socio-administrative unit in the Northern Territory. In the N.T., towns are administered by the Local Government Act; communities that are not gazetted as towns but have sufficient people can be gazetted as communities and be administered by the Community Government Act. Outstations or home-lands come under neither and have been left to develop as best they can. The establishment of such groups raises many questions both for the Aboriginal people living in them and for scientists and technicians involved in working in the area of rangeland management.

The single most important issue in the 70s for central Australian Aboriginals was the question of land rights. The question that faces them in the 1980s is that of land management.

Since people generally adopt models of management that they have previously been exposed to, this paper will briefly examine the socio-economic history of central Australia. Some of the options available for the establishment of these homelands or micro-communities will be examined.

Socio-Economic History

Prior to European contact, Aboriginal people were nomadic hunters and gatherers, existing in an environment that bound man to the land in a relationship which is often incomprehensible to non-Aboriginals. This relationship achieved a balance between all components of the environment.

The opening up of the inland began with John MacDougall Stuart, and the subsequent explorations of Burke and Wills, Leichhardt, Giles and others until the 1870s, commenced a period of dynamic social change that continues today.

The construction of the overland telegraph, which connected Adelaide and Darwin, was closely associated with the establishment of a pastoral industry in the 1870s. Pastoral settlement was marked until World War II by an attitude of conquer and control towards Aboriginal people by both settler and Government officer alike. Acts of retribution lead to bloodshed on numerous occasions (Hill 1970).

The granting of award wages on pastoral properties during the 1950s and 60s terminated the feudal relationship which often existed between white owner and Aboriginal worker and as a consequence many Aboriginal people drifted into Government settlements. These settlements rapidly became institutionalised bureaucracies. They were overpopulated with people from different tribes and clans and were administered by a Public Service system more suited to urban Australia than the rangelands. It is little wonder that such communities became a source of social and physical conflict.

With the advent of self determination and the rush of funds that accompanied that policy in the 1970s, many Aboriginal people took advantage of such changes and moved back to their traditional areas in an attempt to develop a neo-traditional lifestyle protected by distance from the influence of white society.

As a consequence, Aboriginal people have been exposed to two models of management in their contact with Europeans, i.e. rangeland exploitation and bureaucratic administration. The former has been responsible for quite considerable destruction of the environment. The latter has consumed enormous amounts of energy, money and labour for very little return, in terms of production, or management of the environment.

Altogether, Aboriginal people have been exposed to three types of management models which I have called:

(i) Traditional
(ii) Exploitative
(iii) Bureaucratic

Aboriginal people must be provided with a fourth model, one that is compatible with the neo-traditional lifestyle that they wish to establish and equally compatible with the environment. If such a model is not developed and the historical models of exploitation and/or government bureaucracy are continued, the consequences for rangeland management may be disastrous.

This alternative model must have food self sufficiency as an integral part of its design. By producing his own food for his own consumption, man enters into a different relationship with his land than that of the hunter and gatherer, and different again from the man seeking to make a profit from his land.

To be compatible with the ultimate goal of effective rangeland management, several questions must be answered. These are:

(i) How technically efficient can food production become?
(ii) How economically efficient can it become?
(iii) What is the impact on the environment?

This paper is too short to answer all of these questions, but I would like to review some of the potential problems of food production in neo-traditional situations.

Food Self Sufficiency

Traditionally, rangelands have permitted both agricultural and pastoral activities. Cattle, camels, goats and horticultural production represent possible options as sources of food and cash for micro-communities.

Aboriginal people have already had considerable contact with cattle and camels. The rural extension programme at the Institute for Aboriginal Development (I.A.D.) is currently working with 16 cattle enterprises. The I.A.D. has received requests from five micro-communities in the Pitjantjatjara area to investigate the potential of a camel industry and a further one from a micro-community north-east of Alice Springs for assistance with a goat industry. In regard to horticultural activities, gardens in the micro-communities are common. Thirty-six of fifty micro-communities visited by the I.A.D. extension programme in the last year had a garden.

Given the above interest in food producing activities, it is clear that Aboriginal people have a distinct desire to achieve greater levels of food self sufficiency. Pastoral enterprises have been of prime importance in most instances but horticultural activities are becoming increasingly important.

A. Pastoral Enterprises

Historically the pastoral activity which has been dominant on Aboriginal land is that of beef cattle production.

For the reasons discussed below, micro-communities are looking towards alternative livestock enterprises as potential sources of food and income. Camels and goats could complement and in some cases replace existing beef cattle herds.

i) Beef Production.

Minimum management practices have been a common feature of the cattle industry in central Australia, although economic developments since World War II have demanded more efficient management. The advent of the brucellosis and tuberculosis programme in the late 1970s has further emphasised the need for sophisticated management practices with regard to labour, land and capital to achieve disease-free status and still remain economically viable.

How many Aboriginal enterprises will survive the impact of the brucellosis and tuberculosis programme is not clear. Some have already achieved disease-free status or are about to, others will cease to operate as cattle enterprises.

It is apparent that the possibility of micro-communities operating cattle enterprises on a low technological base and growing in management ability as their expectations increase is no longer an option. Disease eradication requirements must be met and high levels of management are required to make a large scale enterprise viable. Consequently, there is no time for management skills to develop and for micro-communities to become major pastoral operations gradually.

Cattle enterprises can continue to provide a valuable and comparatively cheap source of protein to a population consistently under the threat of malnutrition. What may conceivably occur is that micro-communities will run small "killer" herds to maintain a protein supply for their people. These herds would not require the high levels of management and labour input necessary in commercial herds.

ii) Camels.

Feral camels have existed in significant numbers in central Australia since the 1920s and 30s, when Afghan drivers let their stock go rather than kill them following their replacement by motorised transport. Up until the 1960s, many Aboriginal people continued to use them as a means of conveyance.

Mathewson (1981) indicated that there are markets in the Middle East for camel meat. The development of a camel industry would provide an alternative, culturally acceptable enterprise which could generate a substantial income. Such an industry could also provide a source of meat to micro-communities.

The main advantages of camels for the micro-communities are:

(i) They require a less complex infra-structure than cattle, e.g. fewer bores, fences etc.

(ii) They may have a less detrimental effect on the environment than cattle.

(iii) They are physiologically adapted to arid rangeland conditions.

(iv) They require only low levels of management at present.

iii) Goats.

Goats have been the "enfant terrible" of arid rangelands. Mismanagement of goat enterprises has increased desertification throughout the world. Management of goats in terms of efficient use of the environment requires a thorough knowledge of land/animal interactions. This knowledge may not exist among Aboriginal people (Mackenzie 1980).

This is of necessity only a brief review of the potential for pastoral activities. Where does it lead us? What is indicates is that there is potential for livestock activities which can provide food and cash to the micro-communities of rangeland Australia.

How to ensure that such activities are technically, environmentally, and economically efficient, is a question that must be answered. It is a question that all who are involved in rangeland management must be prepared to assist in answering.

Livestock activities are only one half of the food story. Agricultural or more specifically horticultural activities are the other.

B. Horticulture

Last and Wikilyiri (1977) ascertained that tomatoes, grapes, melons and citrus fruits were popular among Aboriginal people, and the number of gardens in the micro-communities of central Australia have validated their conclusions.

Last and Wikilyiri (1977) and Miles (1976) suggested that trickle irrigation was an appropriate technique for use in arid rangeland communities. Phillpot (1977) showed that it is more economically efficient than other techniques, given low management input. Further, such a method can achieve quite high levels of production for relatively low levels of capital investment.

In terms of food production, horticulture represents a real option to Aboriginal people. However the conditions which Last and Wikilyiri (1977) defined as being necessary for the successful development of a horticulture enterprise in an Aboriginal community still apply.

These are:

(i) Clearly defined purposes,i.e.is the garden for food, employment, profit, or a combination of these?
(ii) A good water supply.
(iii) An easy method of irrigation for the operator.
(iv) Knowledge about growing food: the correct fertilizers and the control of pests is needed.
(v) Sufficient fencing and sufficient tools.

It is the responsibility of scientists, extension workers and rangeland managers to provide information and assistance, so that the impact of such projects is not environmentally destructive. Advice on potential environmental impact is more likely to be accepted if advisers are seen to be useful in assisting people achieve greater measures of food self sufficiency.

Conclusions

It is obvious that human habitation of arid rangelands has an impact on the management of such lands. It is likely that numerous scattered micro-communities will have a greater effect than a few large communities if current management practices continue. Micro-communities could easily become operative units in implementing non-destructive management practices but if they become impoverished then land management will be minimal.

A co-ordinated extension programme can provide the information, training and technological advice to field workers, community advisers and community leaders that will enable the micro-communities to achieve greater levels of efficiency in food production and utilization of land.

I would suggest that by achieving greater levels of food self sufficiency the micro-communities may be more receptive to concepts of effective rangeland management.

The expertise already exists in Alice Springs, but it is scattered throughout a variety of Departments, agencies and groups. There is an urgent need to co-ordinate such expertise not just for the micro-communities but for all inhabitants of central Australian rangelands who wish to live in empathy with their environment.

Footnotes

1. The Aboriginal Land Rights Act 1977 (N.T.) granted traditional land owners title to reserve land and provided a means of claiming vacant crown land. This act was complemented in South Australia by the Pitjantjatjara Land Rights Act (1980) which did the same for the traditional owners of the North West Reserve.

2. In traditional Aboriginal society, there are people who own land and people who are responsible for managing it.

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