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AUSTRALIAN RANGELAND SOCIETY

2nd Biennial Conference

INTRODUCTION

The papers published in this volume have bee contributed and edited for the above conference to be held in the South Australian Department of Lands, Adelaide, on the 15-16th May 1979.

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PRESSURES AND CONSTRAINTS ON ARID LAND MANAGEMENT

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The Situation

As a consequence of previous land administration policies and the current financial problems of the pastoral industry, 68% (1,081) of New South Wales' pastoralists lease a station which is less than one home maintenance area in size. Past policies have created a regional structure which places all stations in a similar position. The structure is one which lacks diversity and finds it difficult to adjust. Today there is tremendous pressure on these pastoralists to either 'get bigger or get out'. In the last five years, 160 Western Division pastoralists (12%) have left the region and between 1970 and 1975, 604 paid employees (44%) lost their jobs. The impact of these changes on the region's economy has been considerable.

The number of jackeroos and station hands working in the most arid unincorporated region of the state between 1965 and 1975 declined by 147 from 208 to 61. Those stations which no longer employ anyone have lost their ability to employ less labour and increase their efficiency. To become more efficient they must now buy more land.

The other adjustment strategies adopted by pastoralists have been to work off their stations, to carry more stock and to diversify into cattle. Until 1970, approximately 10% of the Western Division's livestock in sheep equivalents were cattle, today approximately 34% are cattle (see Table 1).

In comparison with the rest of the Western Division, pastoralists west of the Darling River have spent less time working off their stations. This is probably because these pastoralists are more isolated and hence less able to find work. Table 2 indicates the extent to which graziers east of the Darling River have begun working off their properties.

In Table 3 the average size of Western Division stations was estimated by dividing the number of sheep equivalents (sheep + cattle x 8) carried in the last 16 years by the number of holdings which carried more than 50 sheep in 1977.

These statistics tend to hide the fact that many properties are small, heavily stocked and unlikely to remain viable. There is a need for the smaller properties to be amalgamated which suggests that serious consideration should be given to the introduction of land policies which stimulate this process.

Current trends suggest that in the long run those properties which cannot run at least 5,000 sheep have little prospect of providing a potential purchaser with an adequate standard of living. The Western Australian consultant, Bob Hall, currently advises 48 graziers whose properties average 10,000 dry sheep per man. This technology is likely to spread through much of Australia and it would seem reasonable to expect many pastoralists to be running at least 8,000 sheep per man within the next 10 years.

Figure 1 indicates the distribution of the carrying capacities of the sheep stations of pastoral Australia.

Each state carries a similar number of sheep which are managed by a very different number of pastoralists. The differences are striking and almost entirely due to the constraints imposed by the different land administration policies in each state.

Land Administration, Viability and Structural Change

In South Australia the area of land a person may own is not restricted and hence, the most common station size is that which is just viable - an assessed carrying capacity of 3-5,000 sheep areas. This is very different from the situation in Western Australia where two policies have been introduced in an attempt to create viable stations which find it relatively easy to adjust to changing conditions. In Western Australia new leases may not be issued for areas which carry less than 6,000 sheep and pastoralists selling established leases are encouraged to sell them to adjacent holdings. This policy seeks to establish a viable industry in which the majority of stations have sufficient flexibility to contemplate radical management decisions. The second policy attempts to increase the frequency of land sales by restricting the area of land which a person may lease to 1 million acres (approx. 50,000 sheep areas). These two policies are designed to move towards establishing a pastoral industry which is more flexible and in a better position to adjust to the pressures placed upon it.

It would seem that Western Australia's limit of 1 million acres does not acknowledge that arid land varies in production potential - a limit of 50,000 sheep areas would seem more appropriate. In theory, legislation should be phrased in terms of economic units, home maintenance areas or living areas but in practice it is probably administratively simpler (and cheaper) to define the limit in terms of carrying capacity and review that limit and the state of the entire industry every 10 years. The Western Lands Commission in New South Wales has had several long court cases, with appeals to higher courts, in search of the elusive "home maintenance area". The costs of an exact definition probably do not justify the benefits which accrue from accuracy.

Although the Northern Territory is a cattle state it is also concerned about the tendency of stations to become substandard and does not allow small additional holdings, which are removed from the main station, to be created. In the Northern Territory a station which does not comprise an economic area may only be sold to an adjacent station.

In contrast to the Northern Territory, New South Wales has restricted the area of land which one person may lease to two home maintenance areas and has established policies which encourage the creation of small additional holdings. A home maintenance area is smaller than the minimum area of land allowed in Western Australia and current Western Australian policy recommends a minimum size which is greater than the maximum allowed in New South Wales. A limit of four or five home maintenance areas in New South Wales would seem more appropriate.

From Figure 1 it can be seen that all the sheep country in New South Wales and Western Australia has a similar carrying capacity - between 6.0 and 7.0 million sheep. The consolidation in New South Wales of 1,780 stations to approximately 560 stations is a transition in the next 20 years which would be one obvious scenario.

In Table 4 the stations contained in Figure 1 are classified as substandard (2-4,000 sheep areas), borderline (4-5,000 sheep areas), adequate (5-10,000 sheep areas) and safe holdings (greater than 10,000 sheep areas).

The Future

There is a trend throughout the arid zone for properties to become bigger, more efficient and more flexible. If this trend continues many people will be forced to leave the region and many radical changes in management methods will be made. The challenge facing us is to find ways of assisting the readjustment which must occur and to minimise its economic and social impact.

TABLE 1.

PERCENTAGE OF CATTLE+ IN THE WESTERN DIVISION‡

Shire	1970	1977
Balranald	12	34
Bourke	11	37
Brewarrina	8	24
Central Darling	12	32
Cobar	11	38
Wentworth	13	34
Unincorporated	10	40
Total	11	34

\+ 1 beast = 8 sheep.

‡ The Western Division also includes parts of Carrathool, Bogan, Hay and Walgett Shires.

TABLE 2.

PERCENTAGE OF LANDHOLDERS WITH PART TIME JOBS

Shire	1971	1976
Balranald	18	32
Bourke	11	41
Brewarrina	10	35
Central Darling	16	29
Cobar	17	48
Wentworth+	20	28
Unincorporated	10	26
Total	16	33

+ Many landholders in Wentworth Shire are not graziers. Only 110 people carried more than 50 sheep in 1977.

TABLE 3.

AVERAGE SIZE OF SHEEP HOLDINGS IN 1977

Shire	Size in Sheep Equivalents	Holdings
Balranald	4997	143
Bourke	7029	192
Brewarrina	6193	181
Central Darling	7287	184
Cobar	5265	215
Wentworth	5464	110
Unincorporated	8493	187
Total	6474	1212

TABLE 4. DISTRIBUTION OF PROPERTY SIZE IN SOUTHERN PASTORAL AUSTRALIA

	S.A.	W.A.	N.S.W.
Substandard	16	5	51
Borderline	9	5	26
Adequate	27	27	23
Safe	47	63	None
	99+	100	100

+ Error due to rounding.

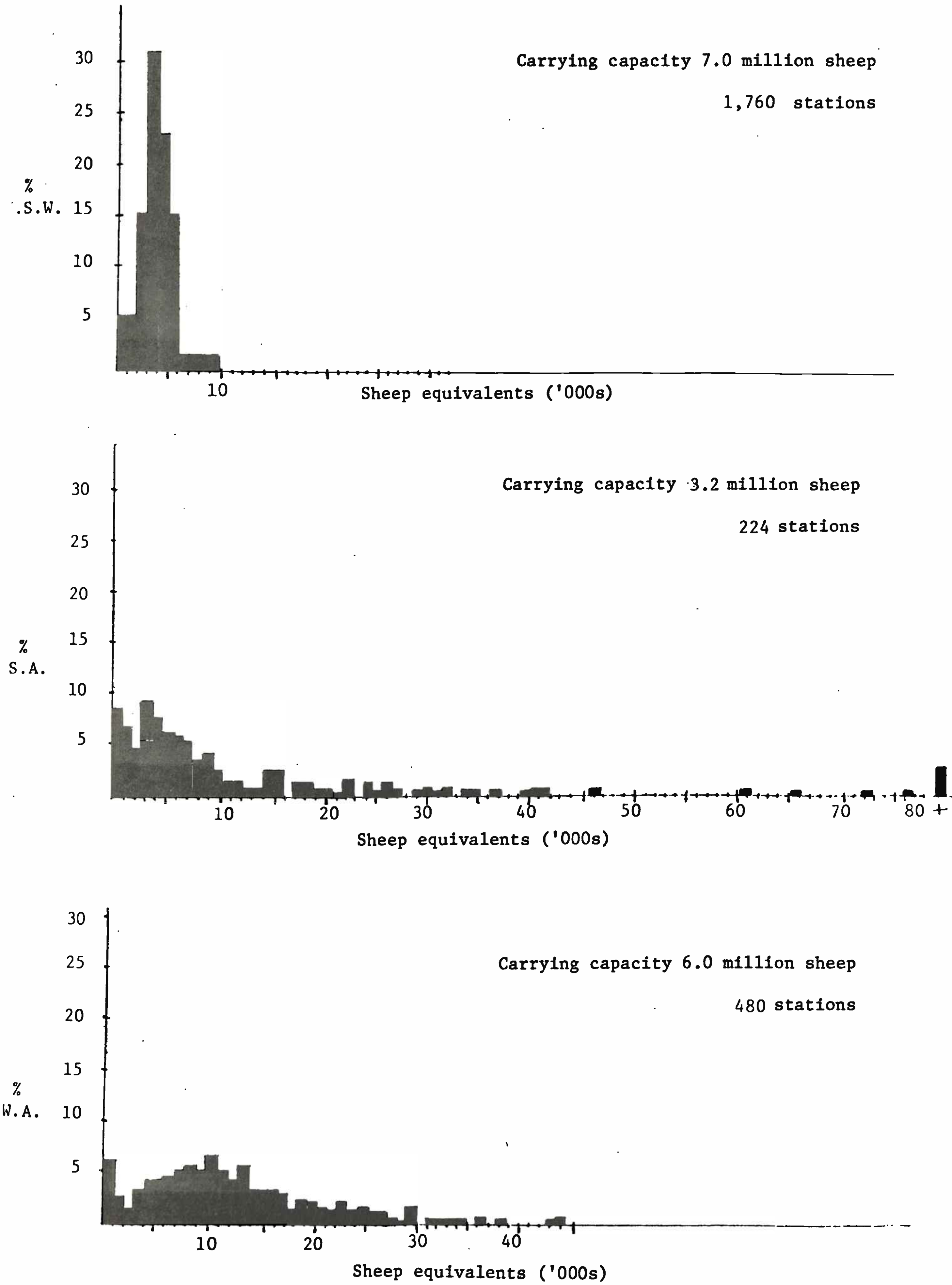

Figure 1. Distribution of sheep station size in pastoral Australia

WILL THE GRAZIER STILL BE ON DECK IN 2000 A.D.?

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Introduction

In a sheep grazing situation where we consider ourselves lucky to break "a bit more than even" in the normal run of events, and basically are satisfied with the LIFE (such as it is), three feeds a day and a good bed at night. We would appear to be presumptuous to bet on what is likely to happen tomorrow, let alone in the year 2000, 21 years hence...

Scenario for the Future

I feel that the world will be even more divided than it is now, if that's possible, and allowing for minor wars and skirmishes to have a diminishing effect on the populations that are unfortunate enough to be involved. Not withstanding, a general heavy increase in the world population must occur and the trend will only be reversed if the big boys in the White House or the Kremlin push the wrong button and precipitate an all out "nuclear war", which almost certainly would mean the end of civilization as we know it.

Let's assume, hopefully, that this doesn't happen and that we are still here trying to exist and make an honest dollar. Land usage, particularly in a Rangelands environment will have to be maximised with more use of land which until now has been regarded as either unproductive or useless. In the higher rainfall country, rough blocks of mallee and porcupine grass will be burnt on a regular basis. To be followed up by sucker control and more burning to make for better grazing country. In the lower rainfall country, under 10" or 250mm, burning and sucker control will be repeated on a 5 or 6 years rotation or when fuel loads permit. Water will have to be piped into these areas if tank catches are not available either because of the lack of rain or suitable sites. More waters will give a better wool clip. The big value of pipelines over dams in this situation is that pipelines can be shut down when not in use and unwanted drinkers (roos, goats, etc.) are cut off from their water source, something you cannot do with a dam.

After all we are paying rates on all this land so why not use it ALL.

Consolidation of existing holdings is as inevitable now as it was 100 years ago. Six hundred sheep in the early 1900's were considered to be enough for a home maintenance area and recent thinking in the Western Division of New South Wales shows that at least 4500 to 6000 sheep would be a realistic present figure. Surely we must be looking at a figure approaching 10,000 sheep 20 years hence, to be handled with a MINIMUM of labor by using contractors for the lamb marking mulesing and shearing operations.

Protein Demand

The need for protein must increase. I envisage not only continued and increasing use being made of our traditional meats, namely beef, mutton and pork but a far greater acceptance of meats that are now regarded as pet foods and in many cases as shot vermin and left to rot in the paddock because of the lack of a market. I refer to our kangaroo, goats, brumby horses and wild donkeys and with reservations to the feral pig. All these animals currently create problems in our Rangelands and all could be worth cold hard cash. If a market doesn't exist it is up to us to help create one and cash in on it. As problems arise, they should be solved.

Who knows what advances will be made with artificial and synthetic foods - such as Soya bean extracts competing with beef. What an outlook it would be for we "scrubbers" if our scientists could do something similar with our porcupine and mallee leaves or alternatively, process them into a cheap type of hardboard to help in the housing or insulation fields, or better still use them as an artificial fuel.

Wool

With our wool, I feel that the demand will continue but the major problem will be whether our increasing costs can possibly be covered by corresponding increases in our returns. I can't help feeling that we won't be able to rely on wool for the bulk of our income as we have done in the past. This will make things hard for people without access to abattoirs or regional sales centres in semi-arid areas. Their recourse for sales of their older surplus sheep (and they will have to be older as transport costs by then will have increased enormously) would appear to be to the export buyer, and great care will have to be taken in this area to make sure that a Buyers Cartel isn't forthcoming, with an eventual price just a little better than break even point. Remember our wool in the early 1960's. Yes, it would have to be better than break even for us to stay in business, as without the producer even a "Cartel Buyer" would soon himself be out of business. Looking into the crystal ball we may even see a floor price scheme for meats with perhaps initial photo descriptions and live weight prices on delivery. A certain winner for any one enterprising enough to have good "agistment paddocks" near the meat delivery point.

Costs

As usual they will be on the UP and UP. Unfortunately, one of our major expense items is fuel, try and envisage this at $5 per gallon ($1 per litre) or better and even those "old timers" who swore it would never happen here, will be out scouring their old rubbish tips and junk heaps to resurrect that old "gas producer". When this happens there naturally would follow a massive increase in fire insurance premiums while the Volunteer Fire brigades would be busier. I would also expect a decrease in the amount of grain delivered. Please take note and make the necessary allowances you folk at the Bureau of Agricultural Economics. It will be difficult for the Government to tax home-produced charcoal - to make up for the loss of excise duty - but undoubtedly they will find a way possibly Inspectors looking for slightly sooty individuals lacking eyebrows and eye lashes.

Far greater use will be made of wind and solar power which is already used extensively by Rangelands users with windmills windlites and solar water heaters. Telecom is currently powering the new radio telephone network with solar powered batteries. Great strides will be made in this field in the next two decades.

A general upwards trend in rents, rates and taxes must also be expected with a tendency for less and less work to be done by those in the taxing authority. Higher taxes will no doubt be justified by them having to put away massive amounts to cover their retiring employees. If a Departmental Head can take out $250,000 in 1979 on retirement heaven help those of us who will have to foot the bill for his counterpart in the Year 2000.

Food

Food is one of those things that we can't live without. I can see in the country particularly more and more people dealing direct with the food producer and in the cities the present sale system for fruit and vegetable products will be superceded possibly through a central computerised selling system linked to a much better set up of refrigerated and holding facilities which should go a long way in eliminating the massive wastage that we see in this industry today, and should also tend to cut down on that ever present middle man.

Transport

Railways are on the way back. Why present Governments shut down lines and let rolling stock deterioate I'll never know because general fuel costs and the huge increases needed for road maintenance and major highways, will assure the railways of a bright future, they should be upgraded and we hope completely standardised by 2000 and in turn with public transport may at last even be showing a profit. Fuel costs and legislation to keep private transport from inner city areas would automatically eliminate about 80% of the present traffic congestion from those areas and may also "hopefully" eliminate the need for the extremely costly (both monetary and fuel-wise) pollution control devices from our current motor cars.

Conclusion

In summing up I would think that the grazier and the Rangelands will still be around in the year 2000 - he will have to work harder and at a greater variety of things to keep afloat but he'll still be here. He must make more use of the land that he uses and look after it better and not forget that "They aren't making any more land".

I hope I'm here to see it....

EFFECT OF RECENT TAX CHANGES ON INVESTMENT DECISIONS WITHIN THE PASTORAL INDUSTRY

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Introduction

The frequency of changes in income tax laws and rates over the period 1972-73 to 1978-79 has created an uncertain atmosphere for planning and decision making in the pastoral industries.

This paper examines three common investment decisions made by graziers in the light of the changes in taxation rates and concessions. Purchase of a truck (or other item of machinery); clearing of virgin scrub and the employment of an extra man are evaluated in terms of tax saved through making each investment in the years 1972-73, 1975-76 and 1978-79.

The Changes

The personal tax scale has been simplified considerably over the period. The general result has been a lowering in the rate of tax paid on any given level of income, combined with fewer steps in the tax scale.

Changes in the taxation concessions to primary producers have been major. In 1973, the capital expenditure allowance, which allowed expenditure on clearing virgin scrub, soil conservation measures, subdivision fences and water improvements and other developmental expenditure to be claimed as a deduction in the year of expenditure was removed. It was replaced in 1974 by Section 75A that applied to limited items of capital expenditure for example, clearing virgin scrub, and allowed the cost of such clearing to be claimed over 10 years.

The special depreciation allowance of 20 percent on plant, equipment and structural improvements used by primary producers, was withdrawn in 1973. Standard rates of depreciation similar to those used by other taxpayers applied after that. In 1974, an accelerated depreciation allowance on plant and machinery was introduced. This allowed double the standard rate of depreciation to be claimed. This allowance was extended in 1975 to include fences, dams and other structural improvements (except those used for domestic purposes). It was withdrawn in 1976. Standard rates have applied since 1.7.76.

A special deduction, for investment in plant, of 20 percent applied until late 1973. This was replaced in 1976 by an Investment Allowance. Between 1.1.76 and 30.6.78, this allowance was at 40 percent; from 30.6.78 to 30.6.85, it will apply at a rate of 20 percent.

The averaging scheme has been effected not only by changes in provisions relating to its operation, but also by the changes in the personal tax scale. The introduction in 1975, of the concessional rebate scheme, to replace concessional deductions, resulted in primary producers receiving reduced benefits from the averaging scheme. This resulted because of an effective increase in average incomes when the concessional deductions were removed. In 1977, the effectiveness of the averaging scheme was again reduced when the basic personal tax scale was reduced from 8 to 4 steps. Between $3 750 and $16 000, a standard tax rate of 32 percent applied, so averaging was only of benefit to those whose current taxable income and average incomes were around $3 750 or $16 000. As a result of this outcome, which the Government may not have forseen, radical changes to the scheme were made in November 1977. The $16 000 limit was lifted, and the only disadvantage of averaging was removed. This disadvantage occurred when incomes were falling, and primary producers were taxed at a rate determined by their average income, which would be higher than the rate applicable to the income if assessed using the personal tax rates. Now two tax calculations are made, one using average rate of tax, the second using personal tax rates, and the lesser amount is charged.

In 1978, the application of the averaging provisions was limited to the first $5 000 of non-farm income. This change will have the effect of positively discouraging investment by primary producers in income-earning off farm assets.

Effects on Investment

Machinery

Studies by Glau (1971), Beneke (1952) and Edwards (1968), all prior to 1973, concluded that special depreciation and investment allowances result in :-

1. frequent replacement of capital assets being more feasible from an economic view point;
2. a tendency for hired labour and labour saving equipment to increasingly replace the operators labour;
3. an incentive for greater investment in durable capital items.

Glau (1971) estimated that from 1949 to 1966, 4.8 percent of gross investment in the rural sector could be attributed to the investment incentives provided by tax policy.

Table 1 illustrates the effects of the changes in taxation concessions and rates on the decision by two properties to purchase a $15 000 truck. Property A has a taxable income for the income year in question of $20 000 prior to the purchase of the truck and an average income of $15 000. Property B has a taxable income for the income year in question of $50 000 prior to the purchase of the truck and an average income of $34 000.

For the period January 1 1976 to 30 June 1976, as the double depreciation allowance and the 40 percent investment allowance applied, the tax saved by both property A and property B by purchasing a truck in this period, was much greater than in either 1972-73 or in 1978-79.

Tax saved was greater in general when the property was owned by a sole trader or a private company. This is because these two forms of ownership result in a higher rate of tax being paid by the property than if it were owned by a partnership or trust. Exceptions to this occur with the two man partnership on property B in 1972-73 and 1975-76. These exceptions arise because the level of income is such that the averaging provisions do not apply and the resulting rate of tax is high.

The effect of the changing tax concessions and rates is illustrated by the tax saved by the sole trader over the period. Property A, when owned by a sole trader, in 1972-73 saved $3 352 tax by purchasing the $15 000 truck; in 1975-76, the tax saving was $4 608; and in 1978-79, the tax saving would be $1 406. Property B under similar ownership conditions, would have saved \$3 983 tax in 1972-73; \$9 165 in 1975-76; and \$2 440 in 1978-79.

Implications for Decision Making.

The taxation benefits as a result of the same investment decision have varied widely in the period 1972-73 to 1978-79. In recent years, the Government has made some attempt to predict the level of certain taxation measures in the future, for example, they have said the investment allowance will apply at the 20 percent level until 1985. However, the terminal date for the investment allowance has already been changed once and the changes in the tax scale and the averaging scheme in the past two years have reduced the benefit received by primary producers from the Investment Allowance.

Because of the uncertainty surrounding taxation law and regulations over the past few years, primary producers should examine their machinery investment plans in September each year, to see how the Budget announcements have effected them.

Under the new averaging system, tax savings can be made by planning, where feasible, to undertake capital expenditure in years of <u>below</u> average taxable income. In this way the tax savings will be calculated by reference to the taxpayer's marginal rate and not his average rate, and tax savings can accrue.

Capital Investment - Property Development.

Up until late 1973, virtually every expenditure of a capital nature, (except fencing) which could be made to bring land into agricultural production was an allowable deduction in the year of expenditure. Lloyd (1970) when discussing policy issues in 1970, declared that "such tax concessions provide a considerable incentive for the uneconomic development of virgin land, and, perhaps less seriously, of existing farms". No doubt they also encourage some worth while development as well, however, an important incentive for much of the development in this period would have been the tax concessions.

The present situation is that certain capital expenditure is written off over 10 years. This change probably results in development programs being more carefully thought out.

Table 2 illustrated the amount of tax saved by Property A and Property B as a result of making an initial expenditure of $15 000 on clearing virgin scrub in 1972-73, 1975-76 and 1978-79.

The businesses whose rate of tax is highest, for example the sole trader and the private company, benefit more from the taxation concessions. The two man partnership on property B in 1972-73 and 1975-76, benefits considerably as well, because the averaging provisions do not apply to them, and consequently they pay a higher rate of tax.

Because of the total deduction allowed for expenditure in 1972-73, the highest amounts of tax saved occur throughout in this year. In 1975-76 and 1978-79, the amounts of tax saved ranged from $975 for Property B owned by a Sole Trader in 1975-76 to nil for a four man partnership owning Property A in 1978-79.

Taking the properties held as a two man partnership, some estimate of the change in tax savings is arrived at by calculating the total tax saved as a percentage of the initial expenditure. In 1972-73, Property A's tax savings represented 25 percent of the initial expenditure on the clearing, where as Property B's tax savings represented 64 percent. In 1978-79, the tax savings are spread over 10 years, and assuming the tax savings are similar over that period, the total tax saving for Property A would represent 28 percent of the initial expenditure (when discounted back to present day values using 10%) and for Property B would represent 17 percent of the initial expenditure. With fluctuating incomes, the total deduction in the first year (1972-73) was probably more useful than the 10 year write off period.

Implications for Decision Making.

Primary producers may consider the tax savings resulting from the 10 year write off to be insufficient incentive to clear virgin land, and may turn to the purchase of additional cleared land instead. This will be most likely to occur in areas where the technology is insufficiently developed to guarantee complete success from clearing.

Operating Expenses - Employment of a Man.

In the sections on machinery investment and property development, the taxation benefits of investments of $15 000 have been considered, while here the decision to employ an extra man, at a cost of $15 000 per year, is examined. Similar tax benefits would result from any decision to spend $15 000 on operating expenses, for example, repairs and maintenance, annual timber or weed control.

Table 3 examines the effects, over the period 1972-73 to 1978-79, of changes in tax rates and regulations, on the amount of tax saved. It also examines the cases of two levels of taxable income, \$20 000 and \$50 000 prior to the deduction for the wages, and the effects of ownership form on the amount of tax saved.

The effect of the tax rate changes and of the changes in the averaging provisions can be seen in the variation in the amount of tax saved by the Sole Trader. In 1972-73, for Property A, the saving is \$6 647; in 1975-76 it is \$6 142; and in 1978-79 it is \$4 591. Because of the higher rates of tax being paid by the business operated by a Sole Trader and the private company, the tax savings are higher for these two forms of ownership. The decrease in amount of tax saved from the 1972-73 figure is due to a general reduction in tax rates over the period.

Implications

As the rate of tax falls, the importance of tax deductions decrease. Hence, primary producers should be aware of the rate of tax they are likely to be paying, so that they can determine the size of tax deduction that is likely to result from any deductable expenditure.

Conclusions.

The benefits received from various taxation concessions depend on the rate of tax payable. Four man partnerships are liable to the lowest rates of tax of those forms of business organisation considered, and hence benefited least from the tax concessions on the various investments. Trusts, with two adult and two child beneficiaries, were liable to similar rates of tax as the four man partnership in 1972-73 and 1975-76. However, the rate of tax for such trusts increased in 1978-79.

Because of the general reduction in income tax rates, the benefit of the tax deductions has decreased. This effect is seen in the changes in tax saved by employing an additional labour unit over the period.

Tax concessions relating to machinery investment and property development have changed markedly over the period. This has made frequent reviews of investment plans a necessary part of property management.

TABLE 1. EFFECT OF TAX CHANGES AND FORMS OF OWNERSHIP ON TAX SAVED AS A RESULT OF PURCHASING A $15 000 TRUCK

Taxable Income of Property	Total Tax Saved by a Property owned by a				
	Sole Trader	Partnership with 2 partners	Partnership with 4 partners	Private Company with 4 shareholders	Trust 2 adult 2 child beneficiaries
1972-73	$	$	$	$	$
A-$20 000 less $6 000 A.D.[a]	3 352	1 590	1 004	2 952	1 004
B-$50 000 less $6 000 A.D.[a]	3 983	3 842	1 872	2 736	1 872

a Allowable Deductions (A.D.) as a result of purchase of a $15 000 truck.

1972-73 Depreciation 20%	$3 000	
Capital Expenditure Allowance 20%	$3 000	$6 000

TABLE 1 (Contd.) EFFECT OF TAX CHANGES AND FORMS OF OWNERSHIP ON TAX SAVED AS A RESULT OF PURCHASING A $15 000 TRUCK

Taxable Income of Property	Total Tax Saved by a Property owned by a				
	Sole Trader	Partnership with 2 partners	Partnership with 4 partners	Private Company with 4 shareholders	Trust 2 adult 2 child beneficiaries
1975-76	$	$	$	$	$
A-$20 000 less $10 500 A.D.[b]	4 608	3 033	2 480	4 463	2 480
B-$50 000 less $10 500 A.D.[b]	9 165	6 307	3 161	4 848	3 161

b Allowable Deductions 1975-76

Depreciation 2(15%)	) if purchased between	$4 500	
Investment Allowance 40%	) 1.1.76 and 30.6.76	$6 000	$10 500

TABLE 1 (Contd.) EFFECT OF TAX CHANGES AND FORMS OF OWNERSHIP ON TAX SAVED AS A RESULT OF PURCHASING A $15 000 TRUCK

Taxable Income of Property	Total Tax Saved by a Property owned by a: Sole Trader	Partnership with 2 partners	Partnership with 4 partners	Private Company with 4 shareholders	Trust 2 adult 2 child beneficiaries
1978-79	$	$	$	$	$
A-$20 000 less $5 250 A.D.[c]	1 406	1 038	-	2 415	880
B-$50 000 less $5 250 A.D.[c]	2 440	1 415	995	2 415	1 376

c Allowable Deductions 1978-79

Depreciation	15%	$2 250	
Investment Allowance	20%	$3 000	$5 250

TABLE 2. EFFECTS OF TAX CHANGES AND FORMS OF OWNERSHIP ON THE AMOUNT OF TAX SAVED THROUGH CLEARING 1 000 HA. VIRGIN SCRUB - COST $15 000.

Taxable Income of Property	Total Tax Saved by a Property owned by a Sole Trader	Partnership with 2 partners	Partnership with 4 partners	Private Company with 4 shareholders	Trust 2 adult 2 child beneficiaries
1972-73[a]	$	$	$	$	$
A-$20 000 less $15 000 A.D.	6 647	3 750	2 280	7 002	2 280
B-$50 000 less $15 000 A.D.	9 851	9 587	4 464	7 658	4 464

a. 1972-73 - Allowable Deductions (AD) for clearing - $15 000

S.75 total deduction $15 000

TABLE 2. (CONTD.) EFFECTS OF TAX CHANGES AND FORMS OF OWNERSHIP ON THE AMOUNT OF TAX SAVED THROUGH CLEARING 1 000 HA. VIRGIN SCRUB - COST $15 000

Taxable Income of Property	Total Tax Saved by a Property owned by a Sole Trader	Partnership with 2 partners	Partnership with 4 partners	Private Company with 4 shareholders	Trust 2 adult 2 child beneficiaries
1975-76[b]	$	$	$	$	$
A-$20 000	857	158	200	638	200
less $1 500 A.D.					
B-$50 000	975	900	429	731	429
less $1 500 A.D.					

b 1975-76 - Allowable Deductions for clearing - $15 000

S.75A 1/10 of total expenditure per year - $1 500

TABLE 2. (CONTD.) EFFECTS OF TAX CHANGES AND FORMS OF OWNERSHIP ON THE AMOUNT OF TAX SAVED THROUGH CLEARING 1 000 HA. VIRGIN SCRUB - COST $15 000

Taxable Income of Property	Sole Trader	Partnership with 2 partners	Partnership with 4 partners	Private Company with 4 shareholders	Trust 2 adult 2 child beneficiaries
1978-79[c]	$	$	$	$	$
A-$20 000 less $1 500 A.D.	410	727	0	690	251
B-$50 000 less $1 500 A.D.	605	440	320	690	411

c 1978-79 - Allowable Deductions for clearing - $15 000

S.75A 1/10 of total expenditure per year - $1 500.

TABLE 3. EFFECTS OF TAX CHANGES AND FORMS OF OWNERSHIP ON THE AMOUNT OF TAX SAVED THROUGH EMPLOYING AN EXTRA MAN - COST $15 000.

Taxable Income of Property	Total Tax Saved by a Property owned by a				
	Sole Trader	Partnership with 2 partners	Partnership with 4 partners	Private Company with 4 shareholders	Trust 2 adult 2 child beneficiaries
1972-73	$	$	$	$	$
A-$20 000 less $15 000 A.D.[a]	6 647	3 750	2 280	7 002	2 280
B-$50 000 less $15 000 A.D.	9 851	9 587	4 464	7 658	4 464

a Allowable deduction (A.D.) for $15 000 wages S.51 $15 000.

TABLE 3 (CONTD.) EFFECTS OF TAX CHANGES AND FORMS OF OWNERSHIP ON THE AMOUNT OF TAX SAVED THROUGH EMPLOYING AN EXTRA MAN - COST $15 000.

Taxable Income of Property	Total Tax Saved by a Property owned by a Sole Trader	Partnership with 2 partners	Partnership with 4 partners	Private Company with 4 shareholders	Trust 2 adult 2 child beneficiaries
1975-76	$	$	$	$	$
A-$20 000 less $15 000 A.D.	6 142	4 260	2 480	6 375	2 480
B-$50 000 less $15 000 A.D.	9 750	8 982	4 500	6 760	4 500

S.51 $15 000

TABLE 3 (CONTD.) EFFECTS OF TAX CHANGES AND FORMS OF OWNERSHIP ON THE AMOUNT OF TAX SAVED THROUGH EMPLOYING AN EXTRA MAN - COST $15 000.

Taxable Income of Property	Total Tax Saved by a Property owned by a Sole Trader	Partnership with 2 partners	Partnership with 4 partners	Private Company with 4 shareholders	Trust 2 adult 2 child beneficiaries
1978-79	$	$	$	$	$
A-$20 000 less $15 000 A.D.	4 591	3 221	0	6 900	3 140
B-$50 000 less $15 000 A.D.	5 960	4 300	3 110	6 900	4 073

S.51 $15 000.

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MICROARTHROPODS AS INDICATORS OF RANGE CONDITION

PENELOPE GREENSLADE

South Australian Museum

Microarthropods are surprisingly abundant in rangeland habitats. Densities of the order of up to 10,000 m^2 would be expected in the soil and leaf litter of a non-improved pasture. The most abundant groups on arid and semi-arid sites are Acari (Mites) and Collembola (Springtails). As well as large numbers of individuals there are also large numbers of species present, and these species vary in their microhabitat preferences. Some species are found in soils of different textures such as sands or clays, while others are associated with certain plant species or vegetation associations. Another influence on microarthropod communities is the structure of the soil surface and the protection it affords the soil below. For instance, a well developed leaf litter layer which can be present under trees or shrubs or an unbroken lichen crust would promote development of a large, diverse microarthropod community. Naturally all types of soil surface are sensitive to trampling by stock.

Botanical methods are most commonly used in assessment of range condition either through visual assessment or quantitive sampling. Visual assessment is fast but not necessarily precise or accurate. Plants can take some time to respond to changes in the environment and with the larger ones this could be of the order of several years. For estimates of population, quantitive methods are laborious and involve large numbers of samples and measurements to overcome the effects of naturally occurring variation.

The use of microarthropods as indicators of range condition has some advantages over botanical assessments. For instance they are easily and quickly sampled, their life cycle is short, and there is a rapid population turnover, hence there is an almost immediate reaction to changes in the environment such as those of weather or grazing by changes in species density and/or composition. It has been suggested (Duffey 1975) that the litter fauna responds to trampling by changes in population before any visible or other measurable effect is evident. Collembola, amongst the microarthropods are a particularly suitable group to use in this kind of study. They are abundant and form a high proportion of the microarthropods present. In arid areas Collembola are often the most numerous group in the soil and densities can reach 3,000 individuals/m^2 (Wood 1971, Greenslade 1978). Yet the number of species present in any one rangeland paddock is likely to be of the order of 40, a manageable number and considerably less than that of ants or mites, two other abundant Arthropod groups. Most Collembola species are intimately connected with the decomposer cycle and hence are sensitive to changes in nutrient cycling, soil formation, aeration and drainage. Biomass is high relative to vertebrates such as birds, on these sites and populations of predators higher in the food chain are affected by changes in Collembola populations. Lastly the group contains species which live in many of the microhabitats present, i.e. in soils, on roots, in litter, under stones, in logs and sticks and on the vegetation, particularly under bark and in flowers. Certain species as well are associated with open ground. Consequently changes both in the condition of plants measurable by botanical methods and other changes such as soil surface structure are all reflected in the *Collembola* fauna. For instance an increase in grazing intensity will reduce the protective effect of the litter and lichen crust allowing drying out of the upper layers of the soil. This would reduce *Collembola* populations without immediately affecting plants and the trend could be followed by periodical sampling.

Hence monitoring sites by periodical sampling of *Collembola* can reveal changes which are the result of changes in site condition. Different intensities of grazing can be compared with ungrazed vegetation of the same type and an optimum stocking rate chosen i.e. that one whose fauna is most similar to the ungrazed state. An increase in the abundancy of species associated with open ground could indicate vegetational degradation. Finally an analysis of site faunal diversities can give an indication of the stability of any grazing situation.

Some of these points will be illustrated with examples from three rangeland sites; Kunoth Paddock, Northern Territory and Koonamore and Middleback Stations in South Australia.

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HILL COUNTRY PASTURE DEVELOPMENT

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In this paper I have limited my discussion to the development and management of higher rainfall hill country pasture and its associated problems.

In my opinion the hill country in the eastern part of Australia is still underdeveloped, and its potential seems to be underestimated. This is possibly due to the vast areas of flat land which have been readily available to farmers and graziers.

However if the limiting factor of land use for agriculture in Australia is the availability of water, the great divide has a potential for intensive pasture farming.

Need for Land Classification

It is essential for the individual farmer to have some guidelines for the use of a given type of land in order to prevent misuse of land.

Soil and water conservation must be taken into account when a hill country area is developed. The steepness, gullies, rocks and existing vegetation should be studied.

There is a limit to the use of mechanical cultivation on hill country and a farmer should be advised to what degree he can use mechanical means for the development of his property.

There are so many instances where sloping land has been cultivated or otherwise mismanaged, resulting in serious erosion problems. For example on an overgrazed and neglected farm on the northern side of the Liverpool range I have observed deep gully erosions still progressing on a relatively gentle slope. In one part the gully is at least ten metres deep and further dissection of the smooth land surface is still occurring.

I have observed many cases of surface erosion and gully erosion in the east coast of the North Island of New Zealand. In at least one instance the whole hillside became unstable because of numerous deep gully erosions and the silt washed downstream, causing a serious problem to crop farmers.

It is easy to lose good surface soil and ruin good farm land through simple mismanagement or ignorance but it takes decades and a great deal of effort to rebuild the land.

Because of these factors just mentioned I believe that a land classification map is necessary, in which appropriate land use is described, together with some 'prescription' for the land in order to prevent destruction of the land through erroneous use.

I also consider that there is a need for training programmes in which science graduates have the chance to acquire an integrated understanding of the ecosystem, the relationships of soil-water-vegetation/pasture-grazing animal, and to put this into practice. It seems that the modern system of education has been directed towards super-specialisation, leaving a gap in this area where experts are needed with a broad spectrum of knowledge in the field of agriculture, capable of diagnosing a problem and advising farmers.

Pasture Development

A multi-species pasture, a mixed pasture of at least ten different grass/legume species is needed for a hill country pasture under changeable climatic conditions. Some parts of the Great Divide have a good steady climate ideal for a first-class grass/legume pasture but in general the rainfall pattern seems not predictable in most parts of the eastern hill countries.

The advantages of having a multi-species pasture are:

(1) Some species grow well in wet years, e.g. Ryegrass, White Clover and Red Clover, while others can survive under dry conditions, e.g. Rhodes Grass, Panics, mediterranean type Cocksfoot, Lucerne and Sub Clover.

(2) Some prefer fertile soil, e.g. Paspalum, Ryegrass and Kikuyu, while others tolerate poor soil, e.g. Rhodes Grass, White Clover, Sub Clover and Danthonia species.

(3) Some are winter growing spp. i.e. Wimmera Ryegrass and Sub Clover and others are summer growing i.e. Rhodes Grass, Red Clover, Lucerne and White Clover. Most native grasses are summer growing types.

There are many other factors such as shade or competitive ability under different grazing pressures. However the aim is to have a pasture which has complete coverage on a hill, and which is productive throughout a season, which is able to survive during a period of low rainfall and also is flexible and stands up under varying grazing pressures.

As an example, in our pasture development project at Blackville the following species have been sown.

Grasses: Wimmera Ryegrass, Perennial Ryegrass, Kikuyu grass, Rhodes Grass, Demeter Fescue, Currie Cocksfoot, Green Panic, Phalaris Tuberosa.

Legumes: Haifa White Clover, Seaton Park Sub Clover, Montgomery Red Clover, Lucerne and Woolly Podded Vetch.

Seeds were broadcast by air and by spreader except for the Kikuyu which was sown with Sorghum on one part of the farm only.

The native grasses and legumes are still growing well among the introduced species and in the areas where the sown species failed to establish. I consider that the native grasses and legumes are most useful and important species in hill country pasture as they fill the gaps in pasture improvement and hold the surface soil on slopes. Besides this they are best adapted to the area where they grow and therefore can withstand the conditions which some of the improved species may not be able to withstand.

A selection and breeding programme for better productivity of native grasses and legumes should be carried out. Elongation of the growth period and ability to compete with the introduced species under grazing conditions should be considered in the programme.

Pasture Management

It is often observed that the pasture in N.S.W. is either undergrazed or overgrazed under set stocking conditions. This seems to be due to insufficient subdivision which in turn results in poor stock control on the pasture.

On hill country it is not always possible to subdivide because of the topography, nor is it economical to carry out intensive subdivision programmes. However where possible it should be subdivided along ridges in order to separate the sunny side from the shady side, and also steep country from flat or gently sloping areas. This is to avoid concentrations of stock on one side of the pasture resulting in overgrazing one side and undergrazing on the other.

Spelling paddocks for a certain length of time is one of the most important aspects of pasture management. The actual length of time necessary is dependant on the season, or more precisely, the regrowth rate of the pasture. Many improved pasture species will disappear without regular spelling because they are more palatable to stock than the native grasses, so they are continuously selected for grazing by the animals.

Good hard grazing followed by four to six weeks of spelling is I believe, an essential practice to maintain improved pasture and to increase the animal output of the pasture.

Conclusion

Hill country in Australia is potentially highly productive land and should be developed and managed in a proper manner. Every care should be taken to avoid soil erosion problems because they occur so easily but are so hard to restore. Prevention is the best cure.

Multi-species pasture should be established in order to cope with the changeable climatic conditions and also to achieve a good cover of pasture in a complex hill country situation.

Subdivision is an essential part of hill pasture development. Good grazing management and the survival of a multi-species pasture is only possible with the use of subdivision.

SOME EFFECTS OF GRAZING AND BURNING ON THE FOREST GROUND-COVER IN THE RANGES OF NORTH-EAST VICTORIA

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Abstract

A study was carried out between 1963 and 1975 to investigate the effects of grazing and protective burning on the forest ground-cover in the Ranges of North-East Victoria. The results of the investigation showed some evidence that the forest grassland cannot withstand heavy prolonged grazing. The protective burning resulted in changes in botanical composition although it did not reduce the litter deposition.

Introduction

In the extensive forested ranges of North-East Victoria there is a characteristic altitudinal (climatic) sequence of vegetation from gum-woodlands on the warm lower plains, through box woodlands and peppermint-gum forests, and woollybut forest to sub-alpine woodlands of snow-gum. Two particular zones in this sequence are important because together they are extensive and because of certain landuse practices they may be hazardous to the use of the area for water supply. One zone is dominated by red stringybark (Eucalyptus macrorhyncha) at about 400-700 metres elevation with 500-1 100 millimetres rainfall and its neighbour dominated by narrow-leafed peppermint (Eucalyptus radiata) at about 600 - 1 000 metres elevation with about 900-1 400 millimetres rainfall. The two zones are subject to forest grazing and also are frequently burnt, often intentionally as a means of preventing wild-fire; such practices may be detrimental to the catchment values of these zones.

The Tatonga Timber Reserve straddles the junction of the two zones being on steep slopes representative of the red stringybark zone and on the surmounting plateau representative of the narrow-leafed peppermint zone.

The condition of the Tatonga Timber Reserve in 1963 indicated that intensive grazing and periodic burning had deteriorated the lower strata plant communities under the Eucalyptus macrorhyncha alliance, and on the plateau, within the Eucalyptus radiata alliance.

The result of this was that extensive bare areas occurred and erosion developed. Because the Reserve represents a considerable part of and is itself a small part of a valuable water catchment area upon which a large portion of the flow in the Murray River depends, an investigation was carried out between 1963 and 1975 to assess the effects of grazing and burning on the ground-cover. The purpose of this paper is to provide some information for forest grazing management practices in the catchment.

Location of Study Area.

The dividing ridge between the Mitta and Murray Rivers forms the south side of the Reserve. At its north-eastern corner, a spur runs southwards to divide Georges Creek and Jarvis Creek, both tributaries of the Mitta River. At the junction of the two watersheds the ridge widens to form a plateau at 600 metres elevation. The reserve of about 1 000 hectares is on this plateau and its surrounding slopes.

Environment of Study Area

From the ridge and plateau, the slopes fall away steeply to the surrounding cleared and semi-cleared freehold land.

The dominant rock of the area is grey granite to gneiss. Schists occur to a limited extent.

The climate is influenced by the elevation and rainfall is thought to range from about 914 millimetres per annum and is maximum in winter. Winters are generally cold with severe frosts and snow, which falls occasionally and may last for a day or so. Summers are mild to warm on the plateau but it is warmer on the northern aspects and lower elevations.

Soils of the amphipodsol group are dominant on the plateau and leptopodsols dominate the steep slopes.

On the mountain slopes the ground-cover under *E. macrorhyncha* alliance is composed of the association of the scattered *Hibbertia*/*Danthonia* and *E. goniocalyx*/*Platylobium*/*Dichelachne*/*Stipa* with annual herbs. The ground-cover of the plateau within the *E. radiata* alliance consists of the sparse *Hibbertia*/*Hovea*/*Poa* and *E. maculosa*/*Acrotriche*/*Poa*, with annual herbs.

Previous Land Use

Grazing

The Reserve is held under annual grazing licence, first issued in about 1953, and no restriction was placed on the type of livestock or their numbers until 1962. Local opinion is that up to 600 sheep have been grazed during some years. Stock management appears to be haphazard, and sheep with two years' wool were not uncommon. Wombats, kangaroos and rabbits are present and feed on the Reserve and surrounding freehold land.

Since 1962 the maximum number of sheep allowed to be grazed has been set at 500.

The number of rabbits and native fauna is not known.

Burning

In the past portions of the Reserve have been burnt at intervals of about five years as a means of preventing forest fire.

Methods

Two areas were selected which were representative of the entire area. One site was located on the burnt area on the slope of the western end of the Reserve while the other was located on the plateau in the unburnt northern portion.

On both areas three plots of 0.10 hectares each were established i.e. control (grazed); rabbits and sheep excluded (not grazed); and sheep excluded (limited grazing). Every plot was divided into 15 subplots. Five random ground-cover samples were taken from each sub-plot yearly, using a quadrat of $\frac{1}{4}m^2$ subdivided into 16 squares.

Three of these ground-cover samples were selected for species counts and biomass measurements. All the standing biomass within each quadrat was cut off at ground-level and collected along with the ground litter. The samples were then sorted into herbage and litter. The dry weight of each of these categories was determined after drying at 85°C for at least 24 hours.

Results

Figures 1 and 2 summarise the changes which have occurred between 1963 and 1975 in the percentages of bare ground and ground-cover and the composition of ground-cover.

The analysis of the collected data showed that the highest decrease in bare ground occurred in both burnt and unburnt plots where the rabbits and sheep were excluded. The decrease was 44.4 and 38.7 per cent, respectively.

The difference between the two sites was not significant.

In plots where only sheep were excluded (limited grazing) the bare ground decreased by 29.2% on the burnt site and 15.3% on the unburnt site. The difference between the two sites was significant ($P > 0.01$)

The smallest decrease occurred in the Control (grazed) plots where the decrease in bare ground on the burnt site was 13.3% and on the unburnt site, 7%. Between the two sites the difference was significant ($P > 0.01$).

The decrease in bare ground was manifested in the increase of total ground-cover. The ground-cover consisted of 21 species (Table 1), fifteen being indigenous and the others being introduced species. The improvement in cover between 1963 and 1975 has been mainly from shrubs and grasses.

The shrub vegetation was dominated by *Platylobium formosum* and *Hibbertia obtusifolia*. There was an increase in the population of these woody species (Figure 2), which contributed towards the total ground-cover of the study area. The burning increased the woody shrub population but the grazing had no effect on it at all.

In 1963, herbs represented the smallest percentage of the total ground-cover (Figure 2). However, biomass measurements (dry weight) showed that between 1963 and 1975 there was a small increase in the herb population in every plot. Including the grazed area where the herbs (excluding *Drosera* spp.) were subjected to selective grazing by rabbits and sheep.

The *Danthonia* and *Poa* spp. are the main indigenous grasses to the area. The *Danthonia pilosa* and *Poa australis* population increased more noticeably than any other species within the sites. The grasses were subjected to heavier grazing, which resulted in *D. sciurea* and *D. penicillata* disappearing from the grazed area and eventually being found only inside the area where rabbits and sheep were excluded.

The collected data indicated that burning had little effect on the reduction of litter deposition (Figure 3) although there was some difference between litter deposits of the burnt and unburnt areas but these differences were not significant.

Conclusions

The burning removed the standing dry matter of *Danthonia* and *Poa* and caused more new seasonal growth.

However, the results of the investigation showed that the burning induced changes in botanical composition as in the case of the increased dominance of the woody shrub population in the burned areas (Figure 2). Furthermore the results of the collected data indicated that the litter deposition was not reduced considerably by the protective burning in the forest area (Figure 3).

The results of the investigation showed some evidence that the forest grassland cannot withstand heavy and prolonged grazing by sheep at the rate of about 0.5 sheep/ha and rabbits. This emphasizes the need for low stocking rates and the control of the rabbit population to provide the required conditions for increasing ground cover.

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TABLE 1

GRASS	HERBS	SHRUBS
DANTHONIA racemosa	CENTAURIM minus	ACROTRICHE serrulata
DANTHONIA pilosa	CHEILANTHES tenuifolia	HIBBERTIA obtusifolia
DANTHONIA penicillata	DROSERA auriculata	HOVEA heterophylla
DICHELACHNE sciurea	GERANIUM potentilloides	PLATYLOBIUM formosum
POA australis	GNAPHALIUM japonicum	
STIPA variabilis	HYPERCIUM gramineum	
	HYDROCOTYLE laxiflora	
	PIMELIA linifolia	
	RUMEX brownii	
	RUMEX crispus	
	STYLIDIUM graminifolium	

FIGURE 1 CHANGES IN % OF BARE GROUND AND GROUND COVER 1963-1975

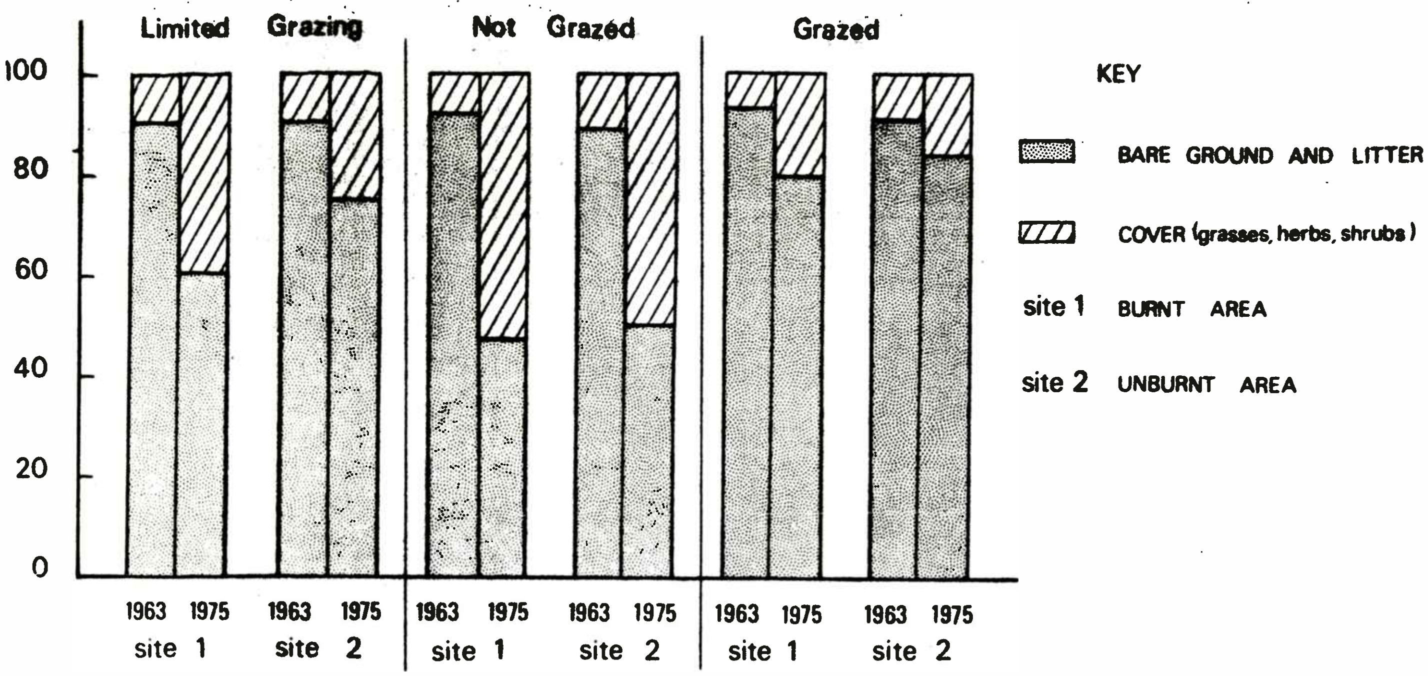


FIGURE 2 COMPOSITION OF GROUND COVER

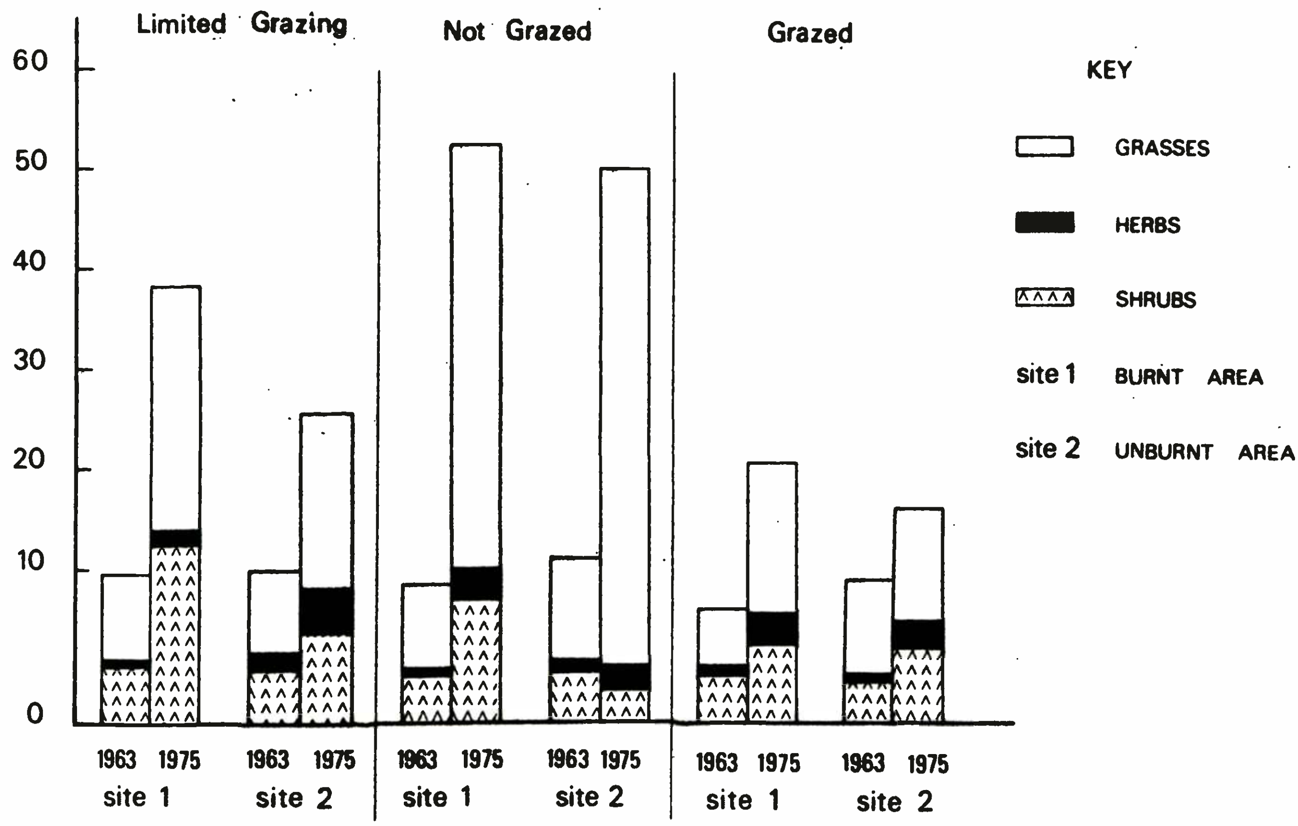
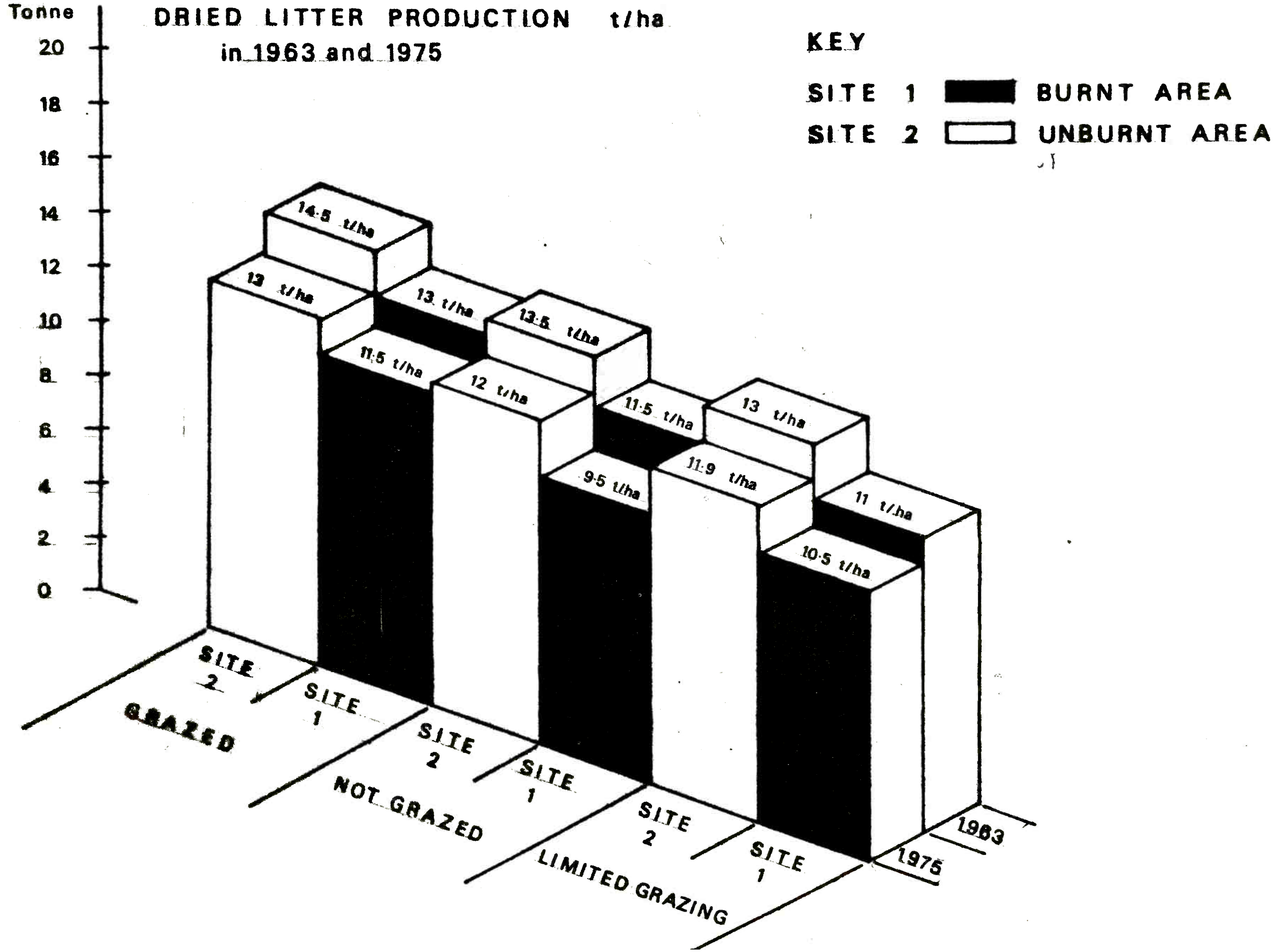


FIGURE 3


Tonne
20
18
16
14
12
10
8
6
4
2
0
DRIED LITTER PRODUCTION t/ha
in 1963 and 1975
KEY
SITE 1 BURNT AREA
SITE 2 UNBURNT AREA
14·5 t/ha
13 t/ha
13 t/ha
11·5 t/ha
13·5 t/ha
12 t/ha
11·5 t/ha
9·5 t/ha
13 t/ha
11·9 t/ha
11 t/ha
10·5 t/ha
SITE 2
SITE 1
GRAZED
SITE 2
SITE 1
NOT GRAZED
SITE 2
SITE 1
LIMITED GRAZING
1963
1975

RABBITS AND RANGE MANAGEMENT

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Despite the introduction of myxomatosis in the early 1950's rabbits remain the major pest of much of inland Australia.

Widespread plagues of rabbits occur every few years. For example, at Quinyambie station in north-eastern South Australia high rabbit numbers were reported in 1931, 1937-38, 1947-48, 1951-52, 1955-56, 1970 and 1973-74.

These plagues are associated with runs of two or more seasons in succession which are favourable for reproduction and survival of rabbits. The increase in rabbits is terminated when the rabbits over-exploit the available food and are left with highly fibrous plant matter which is too indigestible to sustain them. A dramatic population crash usually follows.

At Quinyambie in 1974, a capture-recapture estimate of rabbit numbers suggested that there were about 3 500 rabbits/km^2. After the population had crashed an average of 23 rabbits/ha were found dead on eleven quadrats marked out on the dunes. This is equivalent to 2300/km^2. Assuming that many died in their burrows and knowing that some remained alive, the original estimates were probably not too far wrong.

Prior to the population crash, the daily water turnover (ml/day) of rabbits was measured using radioactive (tritiated) water. Since the water content of the foods the rabbits were eating was known, and the rabbits lived too far from tanks and troughs to go to drink it was possible to calculate the food intake of each rabbit.

The rabbits were eating on average about 100g dry food each night. Taking the minimum estimate of rabbit numbers (2300/km^2) this amounts to 230 kg dry plant matter/km^2. This is equivalent to one tonne of fresh bindyi (Bassia) or annual saltbush (Atriplex).

The productivity of the land is hard to assess, but my own observations suggest that the standing crop at the end of a good growing season might at most be in the order of 100 000 kg/km^2. Only about a third of this is likely to be useful to the rabbits (Cooke, 1974), so this means that it would take the rabbits only 3-4 months to eat out all the useful components in the pasture once the growing season finished. When the ephemeral pastures have been eaten out, the rabbits turn to woody perennial vegetation for their food, and can often be seen scrambling high up into shrubs to reach young twigs and leaves.

On Quinyambie station, cattle are run at a rate of one to every 2-3 km^2. In terms of grazing pressure on the vegetation rabbits were eating about seventy times as much vegetation as the cattle during the final months of 1974. Of course this severe grazing is not continuous and in seasons between rabbit plagues cattle might be the major herbivore. While these figures indicate the degree of competition which may occur between rabbits and domestic stock, rabbits probably have a far more insidious effect on the long term productivity of arid zone vegetation. In particular it is worth considering their effects on perennial vegetation which is essential for maintaining a stable pastoral industry during droughts.

It is an unfortunate fact that the climatic events which promote rabbit plagues are similar to those necessary for the regeneration of many arid zone shrubs, e.g., the mulga Acacia aneura (Preece 1971 a,b)

In many areas, as rabbit numbers crash near the end of a plague, rabbits severely ringbark and defoliate perennial shrubs and kill seedlings.

Data collected by Crisp (1978) on Acacia aneura and A. burkittii at Koonamore Vegetation Reserve suggest strongly that rabbits have severe effects on regeneration. Despite exclusion of sheep in 1926 there was little regeneration of A. burkittii until myxomatosis broke out in the 1950's. Regeneration of young mulgas was confined to a few plants within enclosures with rabbit proof fences until the mid 1960's. In 1965 or 1966, some young mulgas apparently germinated and survived. In those years the pattern of rainfall was unusual in that it enabled seeding and germination of mulga but did not promote high rabbit numbers.

These seedlings and some that germinated in 1968 and 1969 were saved from severe damage when rabbits on the reserve were poisoned in late 1969.

Subsequently rabbits have been poisoned and fumigated nearly every year and there was further successful recruitment of mulga in the very wet seasons of 1973 and 1974.

The story which is emerging from this study is clear. Despite the absence of stock from the reserve for a period of thirty years, there was no widespread regeneration of mulga until rabbits were kept low.

Crisp (1978) argued that in areas like Koonamore, regeneration of mulga had been so poor in the presence of rabbits that it was not likely to offset the natural mortality of older trees. Lay (1972) in a survey of mulga in the north-west of South Australia is not so pessimistic but details of the age structure of mulga populations are not available for wide areas of the State. Both authors might be correct in their conclusions because rabbits are generally less common on the harder soils of the north-west than they are in the sand dunes of the east.

Any attempt to promote regeneration of Acacias and other palatable shrubs such as cassias must take into account all grazing animals. Spelling of paddocks from livestock may only be part of the solution, or may not be necessary at all if the major grazing animals happen to be rabbits as is the case at Quinyambie.

The normal techniques for controlling rabbits, e.g. poisoning, ripping and fumigation would be expensive if applied generally in the pastoral regions and could not be justified in terms of net returns from livestock production. However, poisoning might be done strategically, say, following a successful germination of seedlings to ensure that they could reach a stage of growth where they can survive attacks by rabbits in later plagues.

To summarise, there is no doubt that rabbits are a major competitor with livestock and are a threat to the long term viability of the pastoral industry in some parts of South Australia because of their effects on perennial vegetation. Management of pastoral lands should include an assessment of the importance of rabbits in any given area to ensure that efforts aimed at range improvement are not wasted through lack of knowledge of this major pest.

As yet, there are no economical broad-scale techniques for control of rabbits in the pastoral areas - although strategic control as part of a broad management program is a useful point for further investigation and economic assessment.

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PASTURE DAMAGE AND REHABILITATION ON MANUNDA STATION, S.A.

G. SKIPPER

Manunda Station, via Yunta, S.A. 5440

Introduction

Manunda Station is situated in the north east of South Australia, some 180 km north-east of Burra and 50 km south-east of Yunta, with an average rainfall of 200 mm. At the moment the Pastoral Board allow it to run 10 sheep/km^2 (25/mi^2) and it is interesting to note that in the government gazette of 1857, that some of this area was rated at 100 sheep to the square mile. The country is steep and undulating over most of its 60 000 ha running out to flat country in two of its southern paddocks. The pastures are salt and blue bush, with the main ground feed of bindii, spear and other grasses.

Stocking history

Prior to the railway going through to Broken Hill, the stock of this area in the western district of N.S.W. were driven down a stock route from Broken Hill to the big markets at Burra, through the station country, via the Peg Line, along which the then government had sunk big earthen tanks, approximately five miles apart. Two of these dams are on Manunda's flat country. At the turn of the century an old lessee, Joe Gould, saw two mobs of 10 000 sheep go through Manunda in one week and one manager, the late Charlie Hemmings, talked of netting 10 000 rabbits from one of the government tanks in one night. Because of this overstocking both by sheep and vermin, the country in that end of Manunda drifted to such an extent that one had to climb out of a window of the old homestead, and shovel sand away from the doors to be able to enter. Later the homestead was moved away to a higher site. When I took over as the present manager, in 1943, there were nearly 2 000 ha of completely bare country, from which on most days of the year dust rose in willy-willies, or in great clouds. The company was paying rent on this and getting nothing from it.

Rehabilitation

In 1946 I decided to do something about it, together with the late D. Miles of Yalpara. We started with a double mould-board plough pulled by a Cleirach Crawler, with the mould-board lined up to give a broader furrow and a higher bank. The furrows were half a chain apart. In 1953, having gained some regeneration, a single mould-board plough on a three point linkage on a Fordson Major tractor. This work was much quicker and therefore less costly. Two furrows were made between the existing furrows. The total cost of the full operation was approximately 67 cents an acre ($1.70/ha) and the result over a period of years was at least 80% coverage by the natural pastures and bushes.

Later the company purchased a disc pitter, which is a four disc plough with a third of each disc cut away to give broken furrows 18 inches long, the depth ranging from 3" to 5" depending on the texture of the soil.

Since 1953 many more acres have been treated, on the basis of when anyone on the place has time to put in.

In 1977, assisted by a small government grant, a number of acres were retreated where earlier efforts had failed, and the regeneration after the June rains of 1978 is the quickest ever seen here.

Although the treatment in the area of Manunda may have taken some years to turn bare areas to full grazing areas, where no sheep could be run, and where dust would foul the wool, now thirty sheep to the square mile are being grazed and there is no sign of any dust.

What ever the cost of rehabilitation, it pays in the long run.

TILLER DEVELOPMENT IN ARISTIDA JERICHOENSIS AND THYRIDOLEPIS MITCHELLIANA

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Abstract

Tillers of Aristida jerichoensis and Thyridolepis mitchelliana were dissected at various stages of development between their first appearance and exsertion of the seed head. The differences observed suggest that Aristida jerichoensis is potentially more resistant to grazing than Thyridolepis mitchelliana.

Introduction

Very little is known of the physiological basis of, firstly, the distributions of native species in pastures and, secondly, of changes in these distributions with time (Christie, 1973). This paucity of information about the physiology of native pasture species exists despite the observations of a number of authors (Scott, 1956; Hedrick, 1958; Booysen, 1966; Barnes, 1972; Taylor and Whalley, 1976) that such knowledge of the growth and development of pasture species is central to the development of intelligent pasture management.

One aspect of plant growth and development which may influence the persistence of grasses subjected to grazing is the initiation and elongation of the growing points of tillers. As tillers develop the growing point is elevated above ground level. The rate of elevation differs between species (Booysen, 1966).

The higher a growing point, the more likely it is to be removed by grazing. The developing seed head will also be lost if it is present, as well as the expanding leaves on that tiller. Thus, the plant will lose not only future leaf material which is necessary for the immediate growth of the plant but also future seeds which are necessary for the success of the species. Conversely, a plant which has a lower growing point and/or which delays the elevation of the growing point necessary to exsert the seed head will be more resistant to grazing (Arnold, 1977) all other things being equal.

Species of the genus Aristida are often considered undesirable in rangeland areas (Whalley et al, 1978; Crutchett, 1978) both because of their poor palatability and the problems created by the presence of their seeds in both fleece and carcass. In south-west Queensland, Aristida jerichoensis is considered an undesirable species while Thyridolepis mitchelliana is considered highly desirable. The experiment reported here examined the development of the tillers and growing points of both species.

Materials and Methods

Seedlings of Aristida jerichoensis and Thyridolepis mitchelliana were grown in pots under well-watered and fertilised conditions.

Individual tillers were tagged on the day they first appeared. Daily tagging commenced at 5 weeks of age and continued for a period of 2 weeks. In excess of 80 tillers of both species were dissected down to the growing point. At the time of dissection, tillers ranged in age from 2 days to 27 days from the date of tagging.

For each dissected tiller, data were recorded on the number of leaves initiated, the stage of development of the growing point, the length of the growing point from the last leaf initial and the distance of its base from the base of the tiller.

Results

Aristida tillers initiated only 4 to 6 leaves each, whereas *Thyridolepis* tillers initiated from 6 to 9 leaves per tiller.

In *Thyridolepis* tillers, few growing points closer than 20 mm to the base of the tiller had initiated a seed head while those further than 25 mm had all done so. In *Aristida* tillers, growing points 2 mm or more from the base of the tiller had all initiated a seed head.

The growing points of *Thyridolepis* tillers were found to be progressively further from the base of the tiller in successively older tillers (Fig.1). Similarly, the developing seed heads in older tillers were both larger and more advanced in their development than those in the younger tillers. The seed head commenced development in most tillers between 6 and 8 days from the date of tiller appearance.

A different pattern of development was found in the *Aristida* tillers. The age of the tiller was found to give little indication of the likely stage of development of the growing point. Some tillers were found to have commenced development of the seed head as early as two days after the date of tagging whereas others had yet to do so as late as 22 days after tagging. Because of the destructive nature of the sampling and the uncertainty as to when a tiller may have initiated its seed head, it was not possible to ascertain the rate of seed head development although an impression was gained that, once commenced, the development of the *Aristida* seed head proceeded more rapidly than that of *Thyridolepis*.

Discussion

Caution should be exercised in extrapolating these results to a grazing situation as at least three complicating factors exist. Firstly, even if the growing point is not removed, a grazed tiller may not continue growth (Davies, 1976). Secondly, grazing decreases apical dominance (Knight, 1970), an effect which may have important consequences for *Aristida*. Thirdly, and most importantly, grazing may slow the rate at which the growing point is elevated above ground level (Booysen, 1966). Despite these difficulties, the data provide a useful starting point in considering the relative resistance to grazing of the two species.

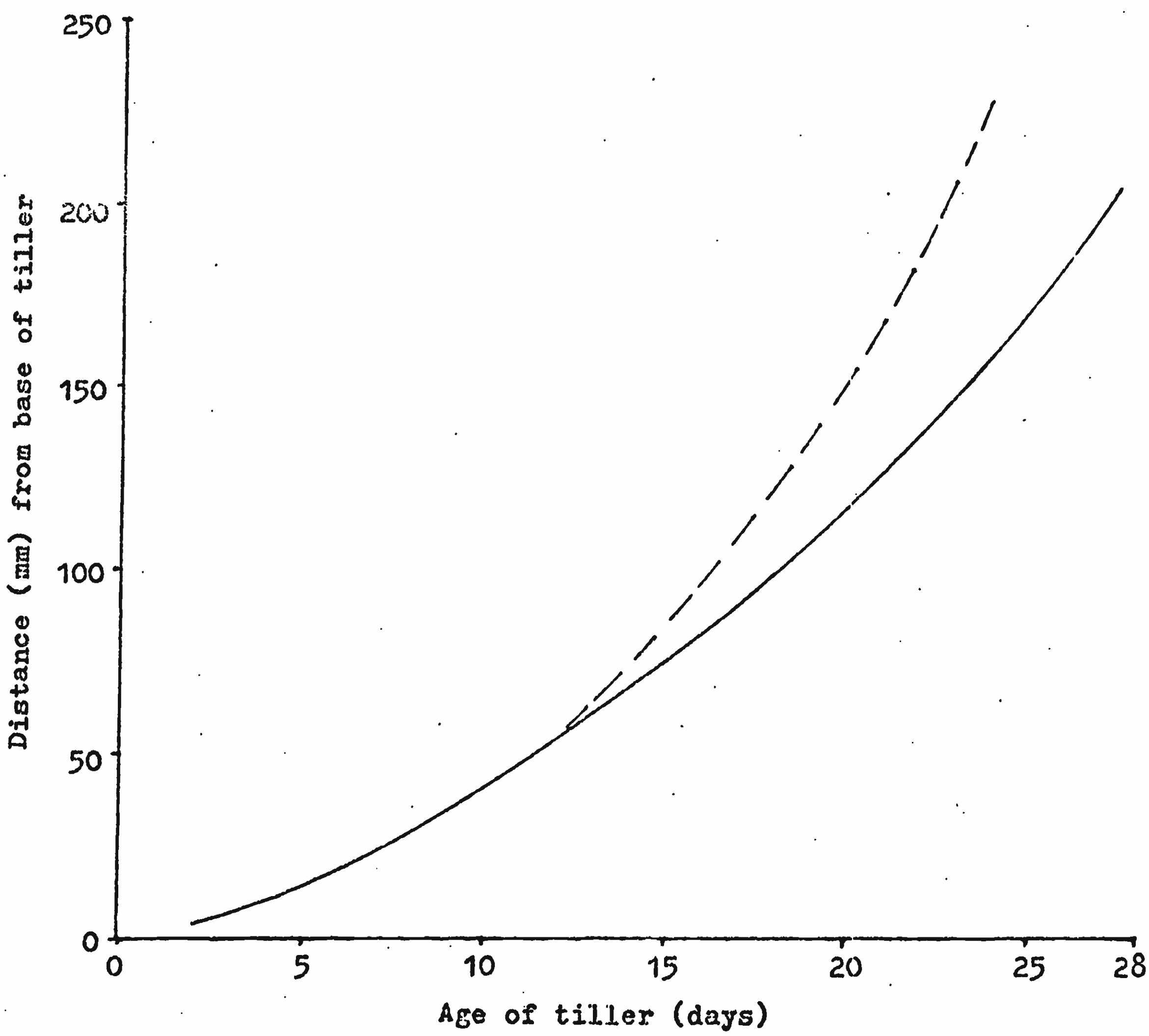
Thyridolepis mitchelliana had much higher growing points than *Aristida jerichoensis* especially when tillers were in the vegetative phase of development. When arising from nodes near ground level, it is doubtful if the growing points of these latter tillers would ever be removed by a grazing animal except under extreme conditions. When considering a *Thyridolepis* - *Aristida* pasture, more growing points of the

Thyridolepis would be likely to be grazed off than those of the Aristida, especially in view of the latter's unpalatability. Such a situation would confer a resistance to grazing and competitive advantage upon Aristida jerichoensis and may explain, at least in part, the observation that Aristida ramosa has spread through overgrazing following burning (Whalley et al, 1978) even though it is not as aggressive a species as has been supposed (Harradine, 1978).

Little, if any, apical dominance seemed to exist between the Thyridolepis tillers. This phenomenon usually is not well developed in young plants (Milthorpe and Davidson, 1966). Aristida jerichoensis may be an exception as apical dominance is the most likely explanation for the delayed development of many of its tillers.

Scott (1956) has proposed that with a knowledge of when the growing points of various species are raised and when they are not, it may be possible to graze strategically so as to favour desirable species over undesirable ones. In the arid zone, with growing seasons which are often of very limited duration, the scope for such manipulation seems limited. Perhaps the best that may be achieved is to avoid favouring Aristida jerichoensis at the expense of Thyridolepis mitchelliana, even if the reverse is not possible.

FIGURE 1. THE DISTANCES OF THE BASE OF THE GROWING POINT (———) AND TIP OF THE SEED HEAD (— — —) FROM THE BASE OF TILLERS OF DIFFERENT AGES IN THYRIDOLEPIS MITCHELLIANA



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THE FUTURE WATER RESOURCES INFORMATION REQUIREMENTS OF THE PASTORAL INDUSTRY IN SOUTH AUSTRALIA

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Abstract

A brief description of the area is given followed by a description of the present water resources data collection network. The need for a comprehensive water data collection programme is established and an integrated programme proposed.

Introduction

Collection of water resources data in the arid areas of South Australia is seen to be increasingly needed for operational and developmental aspects of many activities within the area. Included are legal, mining, community water supply, transportation, tourism and environmental requirements, as well as those of the pastoral industry. In this paper, however, only the pastoral requirements are considered, within an integrated data collection programme serving all these needs.

Description of the Area

The area concerning this paper is that part of South Australia contained in the pastoral lands.

The rainfall of the area is low and erratic. Important sources of additional water to the area are :

(1) inflows from the north east in the form of surface flows of major rivers rising in the higher rainfall areas of Queensland and the Northern Territory and which traverse the southern extension of the Simpson Desert in South Australia.

(2) the occurrence of groundwater within the Great Artesian Basin. This also has its major intakes in Queensland.

Most of the rivers of the area drain to large salinas, Lakes Eyre, Blanche, Frome, Torrens and Gairdner. The quality of surface water flow is usually good until it reaches these salinas where solution of accumulated salt and subsequent evaporation makes the water unusable for consumption. The quality of underground water is variable but generally deteriorates to the south and west.

Existing Data Collection

There is reasonable amount of daily rainfall readings in the area - but an extremely poor coverage of pluviographs, which provide information on rainfall intensities.

Streamflow quantity and quality information is also very scant and most data is centred upon the Flinders Ranges area.

Although considerable information regarding underground water is available, collation, analysis and review of the data is required.

The Pastoral Industry Data Requirements

Legal

South Australia receives significant inflows from rivers having their headwaters in Queensland and the Northern Territory. The water is generally of very good quality and forms a vital resource for the pastoral industry.

It is suggested that a legal agreement between the States must eventually be sought if the availability of water in this area is to be assured and better use of the water is to be made both in Queensland and South Australia. It is strongly recommended that an equitable agreement can only be reached if accurate data is available on the long term characteristics of the flow across the borders.

Should any developments occur in Queensland which would reduce the frequency and/or magnitude of such flows, then it is highly desirable that this State should be in a position to objectively assess the effect of these reductions. In such cases data is necessary for sound hydrologic analyses to be carried out to evaluate the effects.

In the case of groundwater, there is less urgency for an interstate agreement, since groundwater changes are very slow. However the Bureau of Mineral Resources has taken the initiative by setting up an investigation programme, with interstate co-operation, into the characteristics of the Great Artesian Basin. The aim of this investigation is to produce a mathematical model of the basin which can be used to simulate the effects of various operational alternatives. Such a model could be a valuable aid for reaching agreement on management policies for the basin, which could eventually become the basis for a legal agreement.

Land Management

Many suggestions have been made for changes in the land management system of the area which could lead to significant long and short term advantages for the pastoral industry.

For example, one recent suggestion has been to change to a mainly free range neo-nomadic system. This conceptual method of operation might allow better advantage to be taken of the good feed situations when and where they occur, and grazing pressures could be withdrawn appropriately from lands under drought stress. Advantages of this method of operation are seen in terms of better management and maintenance of the land resource, and the increase in cattle output from the area.

It is considered that water resource information will be an important input into any decision regarding such changes in land management. In arid areas where high variability exists, long and continuous water records are required if meaningful analyses are to be performed in making such decisions, and hence data collection networks must precede the final decisions by many years.

It is likely that analysis will be required to correlate data on feed availability with data on the frequency of floods, local rain and droughts in both the eastern and western catchment areas.

A knowledge of the probability of floods and droughts on all river systems is required in addition to a knowledge of their conjunctive probabilities, since it is on a knowledge of the difference in conditions within different parts of the area that the neo-nomadic management alternative is based.

It will be necessary to establish a catchment model which can predict the extent of flooding in the Diamantina, Georgina and Cooper flood plains. This would require a knowledge of catchment conditions and behaviour in Queensland as well as in South Australia.

A similar model will be required for the western rivers also. Since, with exception of the Finke, these catchments lie almost entirely within South Australia the responsibility for data collection lies only with South Australia.

Data is required in order to both develop the required models and then to subsequently use them as a tool in management of the area. It is at present technically possible to collect the required data and develop the necessary models.

Possible Enhancement of Local Groundwater

The western fringe of the pastoral area coincides generally with the western fringe of the Great Artesian Basin. In these areas the quality of water extracted from the Great Artesian Basin is often poor and imposes a restriction on the development of both commercial and pastoral enterprises.

Within this country are areas of relatively high relief. In particular there are the Stuart Ranges, especially the eastern scarp of this range, the break-away country, the Everard Ranges and the eastern portion of the Musgrave Ranges.

These areas are relatively steep, rocky and appear to produce proportionally high quantities of runoff from the infrequent rainfall. Typically, large incised creeks emerge from the escarpments onto the plains to become wide, braided meandering creeks which often disappear within short distances of their source. The area appears to be highly weathered and fractured and not conducive to surface storage due to potential leakage. The high evaporation rate in the area, of the order of 4m per annum, also further reduces the feasibility of long term surface storage.

In these areas dams could be built to temporarily store runoff, deposit suspended sediment and then supplement or sweeten nearby aquifers using artificial recharge.

This technique appears a distinct possibility for stock and small town supplies.

Such an artificial recharge system would however require detailed local geological mapping and this could only be economically undertaken after :-

(1) the need for such a water supply was established.

(2) the required runoff quantities and qualities can be shown to exist.

Data is therefore required to established runoff characteristics in the area to enable the feasibility of such schemes to be established and to aid in their design. Obviously all potential sites cannot be gauged, but representative catchments could.

Possible Future Engineering Developments

Further to the possibility of improving the efficiency of use of existing resources as mentioned above, there is some scope, due to the very low topography and land gradients, for artificially regulating and diverting river flows in the area to increase the feed resource available. Examples of such possible regulation are :

(1) Diversion of a greater proportion of water down the Strzelecki Creek from Cooper Creek. This would increase feed in the Strzelecki Track areas.

(2) Temporary damming of water passing through gaps in the dune field areas to increase water levels and lateral extension of areas flooded. Such schemes could include regulation of flow from Cooper Creek into Lake Hope and similar lakes. Reduction in cease to flow storage in certain existing lakes would increase availability of water for downstream irrigation and this would enhance production in these areas.

(3) Diversion of more water from the Warburton into the Kallacoopah. Again this would increase flow and feed in the Kallacoopah region.

(4) Diversion of more water from the Diamantina down Gumborie Channel. This would increase feed in this area and reduce water flowing into Lake Eyre.

(5) Temporarily damming inflows to Lake Eyre to create artificial flood plains thus increasing the feed and production in the area.

All of these schemes, and there are undoubtedly many more, are aimed at maximizing the use of flood waters during their passage through the pastoral areas and minimising the flow of water into Lake Eyre and the other salinas.

Before any such schemes were embarked upon, careful analysis would be required to ensure that a net economic, social or environmental disbenefit would not be incurred.

The Proposed Data Collection Network

A proposed data collection network, which has been proposed, incorporates the existing networks, with additional data acquisition in the areas of :-

(1) surface streamflow

(2) surface water quality

(3) meteorology

(4) groundwater characteristics

It is intended that these four data networks would complement each other and would be implemented together in a co-ordinated manner. It is emphasised that all of these networks form an integrated data acquisition network and one should not proceed out of balance with the others.

Surface Streamflow

A good gauging station site should combine the following features:

(1) confined section

(2) stability

(3) good access

Sites having all of these features are few and seldom occur in the locations at which data is required and particularly in the case of larger rivers, are difficult to find at all. Invariably compromises must be accepted and a site chosen which does not fully meet with the desirable standards and yet by careful operation can still provide adequate information to fulfil the objectives of the study.

Fig. 1 shows the proposed network.

Surface Water Quality Network

Since water quality measurements mean little unless they can be associated with a flow rate, water quality

Conclusions

The value of data is only realised at the time decisions using the data are made. Thus the expenditure of money on data collection for future planning is a risk undertaking. However in so far as the authors believe that sufficient developments in the area, which require data for their correct development are likely to take place, then it is considered that the present water resources data collection programme in the arid areas of South Australia does not satisfy the identified requirements.

In general, and in the arid areas particularly, it is desirable that a long period of hydrologic record be available when analysing data. Developments in the area are foreseen which may need this kind of information within the near future, and therefore if these developments are to make proper use of the water resources in the area, data collection must commence soon.

It is technically feasible to collect the data necessary to meet the identified data requirements. Economic calculations have been performed which show samples should be taken only at gauging stations, unless a specific need is established at some other location.

It is therefore considered that the water quality programme in the area be extended to include all gauging stations in the area.

Meteorological Network

As has been previously mentioned the existing rainfall network, particularly the pluviograph network is poor. It is envisaged that each gauging station will incorporate a pluviograph within its instrumentation or shall have at least one pluviograph installed in its catchment.

All homesteads and communities which are not included in the daily read rainfall network operated by the Bureau of Meteorology should be investigated with a view to provision of a rain gauge and inclusion in this network.

Groundwater

Existing information should be collated and analysed and supplementary information collected where deficiencies exist. Some detailed investigations will be required for artificial recharge proposals as the need arises.

that data collection would become highly cost effective even if only a minor improvement in pastoral industry unit efficiency resulted.

Acknowledgement

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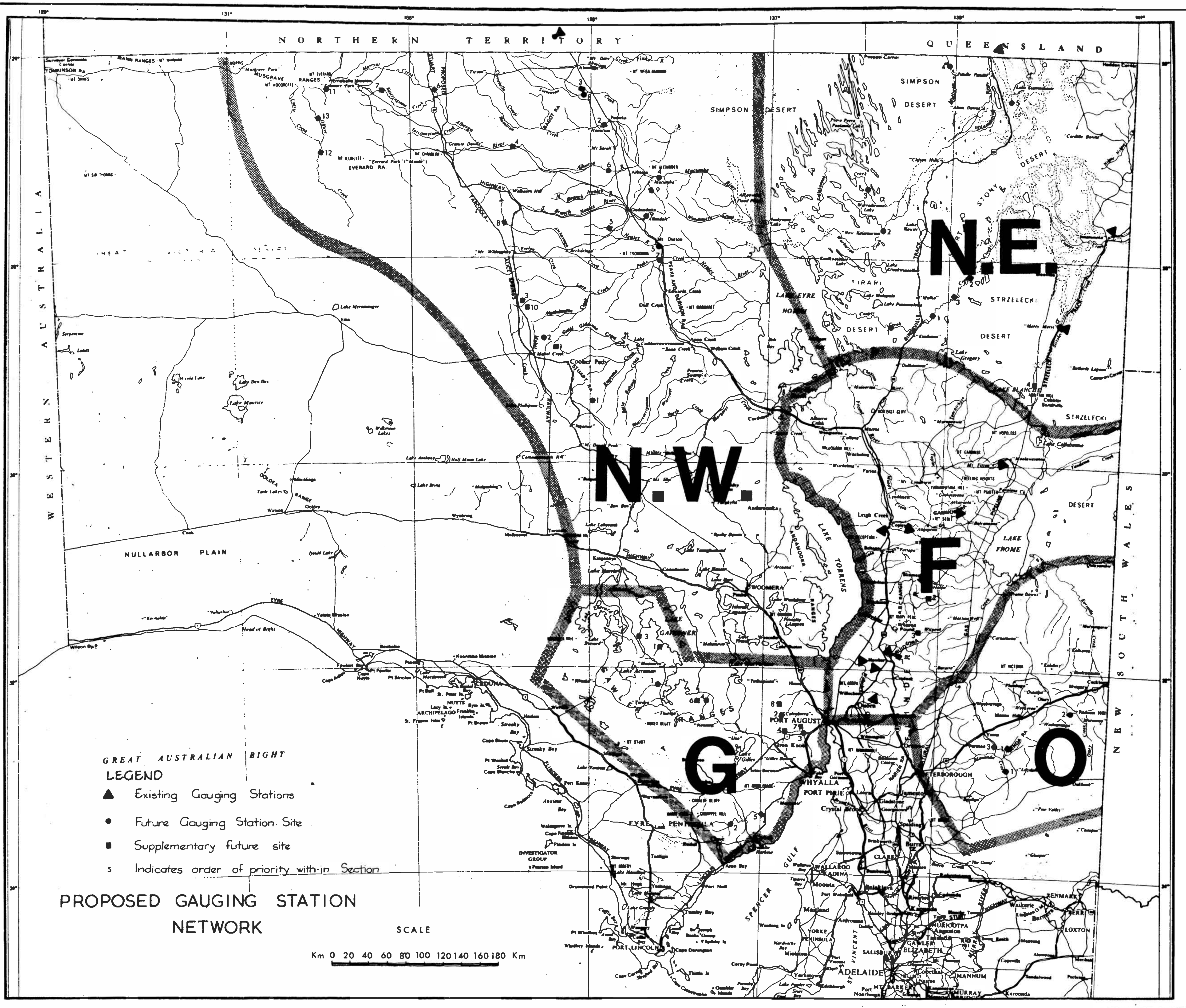

NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
NEW SOUTH WALES
N.E.
N.W.
F
G
O
SIMPSON DESERT
STRZELECKI DESERT
TIRARI DESERT
NULLARBOR PLAIN
LAKE EYRE NORTH
LAKE TORRENS
LAKE FROME
GREAT AUSTRALIAN BIGHT
SPENCER GULF
EYRE PENINSULA
YORKE PENINSULA
GAWLER RANGES
EVERARD RA.
MUSGRAVE RANGES
Coober Pedy
WOOMERA
PORT AUGUSTA
WHYALLA
PORT PIRIE
CEDUNA
PORT LINCOLN
ADELAIDE
RENMARK
LEGEND
Existing Gauging Stations
Future Gauging Station Site
Supplementary future site
5 Indicates order of priority with-in Section
PROPOSED GAUGING STATION NETWORK
SCALE
Km 0 20 40 60 80 100 120 140 160 180 Km

THE EFFECTS OF RAINFALL AND GRAZING ON STABILITY AND FORAGE PRODUCTION IN ASTREBLA GRASSLAND

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Astrebla grasslands are of considerable importance to the pastoral industry in Queensland and the Northern Territory because of their greater livestock carrying capacity when compared to other arid pastures under comparable rainfall.

Forage production in *Astrebla* grassland is highly variable because of large rainfall variability. During severe drought forage production is so low that almost any stocking is overstocking (Blake 1936) while in very wet years grazing or burning to reduce plant cover has been advocated (Everist and Moule 1952) to allow the pasture to remain green for a longer period. Rainfall variability also influences the ability of *Astrebla* spp. to respond to current season rainfall. The failure of mature *Astrebla* spp. to respond to heavy summer rainfall following a severe drought (Roe 1941) was attributed to plant mortality as a result of the drought (Williams and Roe, 1975).

Grazing also influences the proportion of *Astrebla* spp. in *Astrebla* grassland and Orr (1975) has summarized those grazing factors which reduce *Astrebla* spp. These factors include the removal of seedlings, excessive grazing during active growth, grazing dormant plants close to ground level and burrowing for roots.

Separating the effect of rainfall from the effect of grazing in determining the decline in the proportion of Astrebla spp. during drought is difficult (Roe and Allen, 1945; Davidson, 1954). A number of authors (Everist and Webb, 1975; Williams and Roe, 1975) concluded that rainfall is more important than grazing. However, Everist (cited in Orr 1975) maintained that grazing management may have an immediate effect on the grassland and the long term effect of such management is less easy to predict.

The results reported in this paper are the results to date from a study aimed at monitoring the reaction of Astrebla grassland to seasonal rainfall under heavy grazing in order to assess the differential effects of grazing and non grazing on the proportion of Astrebla spp. in the pasture.

Method

An area 20 x 20 m was exclosed in November 1975 in a commercially grazed Astrebla grassland site in Central Western Queensland which was known to have been subject to heavy grazing over a ten year period. Thirty permanent quadrats, each 1 m^2, were positioned inside this exclosure while outside another thirty permanent quadrats, each 1 m^2, and subject to grazing were positioned.

These quadrats were sampled in November 1975 and since then, annually in April. In each quadrat, the projected foliage cover of Astrebla spp. was estimated visually, the number and diameter (1 cm above ground level) of Astrebla spp. tussocks recorded and the yield of Astrebla spp. in both grazed and ungrazed areas and of the annual grasses and forbs in the ungrazed area estimated by a visual technique.

(With increasing age, Astrebla spp. plant tussocks tend to break down into separate segments whose origin is often difficult to determine. Where this occurred, each segment was recorded as being a discrete entity. A subjective decision on what constituted a discrete tussock was necessary.)

To overcome this difficulty with plant density *per se*, plant demography was followed in each of the sixty quadrats using a hand charting technique. Each quadrat was divided into sixteen grid units, each 25 x 25 cm, and the position of each *Astrebla* spp. plant, both mature and seedling, marked within each grid unit.

A series of grazed class photo guides (Schmutz, 1971) were prepared for *A. lappacea*. These were used to assess forage use in grazed and ungrazed (*i.e.* at the time of exclosure) quadrats in November 1975 and thereafter in April and October each year in the grazed quadrats.

Rainfall figures for each summer period (October - March inclusive) were supplied from the property homestead approximately 8 km away. The number of growth periods in each summer was determined by the number of falls of rain which exceeded 40 mm since a minimum of 40 mm is necessary for *Astrebla* spp. to produce new shoots (Everist, 1964).

Results and Discussion

Rainfall recorded over the period of this study has varied from well below to well above the summer rainfall mean of 300 mm approx. (Table 1).

The rainfall for 1975-6 was unusual in that almost all the rain fell over a period of 3 months and resulted in prolonged growth of Astrebla spp. The 1976-7 rainfall occurred as 3 distinct growth periods while no effective rainfall occurred during the 1977-8 summer.

The extent of forage use in October of both 1975 and 1976 was greater than in April of the following year (Table 2) and reflected the influence of favourable rainfall on plant growth. The failure of the 1977-8 summer rainfall is reflected in increasing forage use from April 1977 to October 1978. The highest levels of forage use measured have been within the 50% level adopted by Ebersohn (1970) and Burrows (1978) as representing proper use in Astrebla grassland.

Substantial changes in the plant density basal area and projected foliage cover of Astrebla spp. occurred during the period of this study (Table 3). Increases in basal area over the 1975-6 and 1976-7 resulted from the growth of new main tillers on existing plants and this increased the diameter of existing tussocks while the decline recorded in 1978 appeared to result from the death of tillers located in the plant centres, possibly older tillers. This breaking down of tussocks, in turn, resulted in the increase in the tussock density recorded in 1978. The increases in projected foliage cover over the 1975-6 and 1976-7 summers further emphasises the ability of Astrebla spp. to respond to favourable rainfall. Differences between ungrazed and grazed areas were minimal particularly with basal area. Differences in projected foliage cover between grazed and ungrazed areas were caused mainly by grazing (Table 2) although projected foliage cover fell between 1977 and 1978 under exclosure.

Differences in tussock density between grazed and ungrazed may be the result of technique rather than of ecological consequence, i.e. differences may be the result of measuring tussock density in the manner outlined in the methods.

Astrebla spp. seedlings established following both 1975-6 and 1976-7 summers but not during 1977-8 (Table 4) and there appeared to be little difference between the grazed and ungrazed areas. The data for the 1976 cohort in both grazed and ungrazed areas suggest, in this cohort at least, that there is a loss of some seedlings over the first summer followed by a period during which the seedling population becomes steady.

The 3 separate growth periods that occurred during the 1976-7 summer and the resultant *Astrebla* spp. seedling establishment is in accord with the suggested (Williams and Roe, 1975) rainfall pattern which gives use to *Astrebla* spp. seedling. The establishment of *Astrebla* spp. seedlings in 1975-6 suggest that the rainfall pattern is not as crucial as suggested by these workers.

Substantial changes in the yields of *Astrebla* spp. in both grazed and ungrazed areas and of annual grasses and forbs in the ungrazed area occurred over the period (Table 5).

Differences between *Astrebla* spp. yields between grazed and ungrazed occurred only at one sampling date and was caused by the removal of *Astrebla* spp. by grazing (see Table 2). The lack of difference between Astreblaspp. yield between grazed and ungrazed at April 1978 is interesting since the grazed area had been subject to 45% forage use (see Table 2). Observation suggests that much of the Astrebla spp. yield in the exclosure had fallen to the ground as litter. The difference in the yields of annual grasses and forbs between 1976 and 1977 appeared due to the pattern of rainfall. Following the first growth period in the 1976-7 summer there was growth of both the ephemeral and the Astrebla spp. component. With the further rainfall the growth of the ephemerals was progressively excluded through the extensive growth of Astrebla spp.

Conclusions

Results from this study confirm earlier conclusions (Everist and Webb 1975; Williams and Roe 1975) that rainfall has a greater effect than grazing in Astrebla grasslands. The large increases in basal area projected foliage cover and yield of Astrebla spp. following the 1975-6 and 1976-7 summers indicate the ability of Astrebla spp. to respond to favourable summer rainfall even under moderate (i.e. 50% forage use) defoliation. As the proportion of Astrebla spp. in the pasture builds up through favourable seasonal conditions there is a decline in the yield of annual grasses and forbs. This decline is probably the result of increased competition for moisture from the perennial Astrebla spp. plants. In contrast, the failure of effective summer rainfall results in increased defoliation such that the proportion of Astrebla spp. is reduced and, under these conditions, rainfall promotes the growth of ephemeral species. Thus, the proportion of Astrebla spp. during drought will be closely related to stocking management.

A high proportion of Astrebla spp. in the forage should confer maximum pasture stability in an ecological context. However the subsequent suppression of ephemeral species may reduce animal production from such pastures because of the effect of ephemeral species, particularly broadleaf species, on animal liveweight (Lorrimer, 1978) and presumably also wool growth. Such considerations strongly suggest that the pasture composition resulting in optimum sheep production differs from that which confers maximum pasture stability. Furthermore, graziers in central western Queensland Astrebla grasslands find that the best sheep production occurs in "semi drought" years i.e. an abundance of ephemeral species with just sufficient Astrebla spp. for animal maintenance during dry periods.

TABLE 1. SUMMER RAINFALL TOTALS (MM) AND NUMBER OF GROWTH PERIODS FOR A THREE YEAR PERIOD

	YEAR		
	1975-6	1976-7	1977-8
Rainfall	278	572	170 (approx.)
No. growth periods	1	3	0

TABLE 2. EXTENT OF FORAGE USE (%) IN GRAZED QUADRATS AT SEVEN SAMPLING OCCASIONS

1975	1976		1977		1978	
November	April	October	April	October	April	October
50	30	45	5	20	25	45

TABLE 3. **PLANT DENSITY (TUSSOCK m^{-2}), BASAL AREA (%) AND PROJECTED FOLIAGE COVER (%) OF ASTREBLA SPP. AT A GRAZED AND UNGRAZED SITE ON FOUR SAMPLING DATES**

	November		April 1976		April 1977		April 1978		LSD
	Ung.	Gra.	Ung.	Gra.	Ung.	Gra.	Ung.	Gra.	5%
Plant density *	3.0 (1.537)	3.0 (1.661)	2.7 (1.399)	3.6 (1.799)	3.2 (1.684)	4.80 (2.124)	5.1 (2.160)	6.1 (2.371)	.381
Basal area *	1.4 (1.014)	1.6 (1.193)	2.3 (1.297)	2.4 (1.463)	3.9 (1.787)	3.7 (1.844)	2.3 (1.422)	2.0 (1.314)	.265
Projected foliage cover	5 (.039)	8 (.066)	27 (.281)	13 (.134)	55 (.624)	54 (.600)	40 (.425)	31 (.325	.100

* Analysis performed on square root transformed data.

Analysis performed on angular transformed data.

Row means in parenthesis are transformed data to which LSD values are applicable.

TABLE 4. **SURVIVAL OF ASTREBLA SPP. SEEDLINGS (SEEDLINGS 30 m^{-2}) AND SITES OF GRAZING AND NON GRAZING**

(a) GRAZED

		SAMPLING DATE		
		September 1976	September 1977	August 1978
	1976	25	9	9
Population	1977		44	27
	1978			0

(b) UNGRAZED

		SAMPLING DATE		
		September 1976	September 1977	August 1978
	1976	24	14	14
Population	1977		60	39
	1978			0

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SOIL SEED RESERVES OF SOME LEGUME SHRUB POPULATIONS IN THE SEMI-ARID

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Abstract

(1) Stands of the legume shrubs *Acacia victoriae*, *Cassia nemophila*, and *Cassia phyllodinea* in a semi-arid area had soil seed reserves in the range 100-3500 m^{-2}.

(2) Of these reserves over 70% were viable but only about 2% would germinate without treatment to break dormancy imposed by the hard seed coat. Varying temperature regimes from 32/25°C to 18/10°C had little effect on germinability.

(3) After moderate winter rains seedlings emerged at densities equivalent to less than 1% of the soil seed reserves.

(4) Sites with stands where a large proportion of adult plants had reached reproductive sizes had larger seed reserves.

(5) There was much variation in soil seed density within stands. Some of this was explained by distance from seed-producing plants.

Introduction

Seeds in or on the soil are an important part of many plant populations. Different and usually more laborious methods are needed to study them than to study actively growing plants. For this reason relatively little quantitive information on them is available. What information exists is of two main kinds.

First, there are some studies of populations of particular species where an effort has been made to describe soil seed reserves (e.g. Sarukhan 1974, Marshall & Jain 1966, Watkinson 1978). These studies have been of herbaceous species, often annuals. This bias reflects both an emphasis on these species in formal studies of plant population dynamics so far, and the obvious importance of seed reserves in maintaining populations of such species.

Second, there are studies of the seed flora in soils of various communities. Data are collected usually by counting seedling emergence from soils kept moist, or less commonly by sorting through soils, with or without a preliminary flotation. The results of many such studies are summarized by Harper (1977). These data also emphasize seeds of species which are short-lived in vegetative phase, because seeds of such species are commonly produced more abundantly, and live longer in the soil.

The data reported in this paper, on the other hand, deal with the seed reserves of populations of comparatively long-lived woody plants. They also give some detail on the proportion of those seeds present which are readily germinable, dormant, or inviable.

The species studies were Acacia victoriae Benth., Cassia nemophila (var. zygophylla) (Benth.) Benth. and C. phyllodinea R. Br. These are legume shrubs which are extensively distributed throughout arid and semi-arid Australia

(Symon, 1966; Hopper and Maslin, 1978). A. victoriae is a small spreading shrub, often with several stems and growing to a height of 3-5 m. It occurs on river flood-out country and also along temporary water courses. C. nemophila and C. phyllodinea grow to a height of 3 m and are usually found on sandy soil. Stands occur of a single species or of combinations with each other or with other shrub species. Their seeds are large (weights ± S.E.: A. victoriae, 26.5 ± 0.52 mg; C. nemophila 17.9 ± 0.4; n = 294 and 196 respectively). This fact, with the low litter content of the soils make it feasible to sieve the seeds from substantial soil volumes.

There is only one item of information in the literature on the soil seed reserves of these species. This is the comment of Hall, Specht and Eardley (1964) that no seedlings emerged on the sites of C. nemophila stands in response to appropriate rain when more than ten years had elapsed since the adult shrubs had been removed.

The site of the present work was Fowler's Gap in far western N.S.W., an area receiving an average of 195 mm of rain p.a. though the rainfall is highly unpredictable.

Methods

Some data have been collected from ten stands of shrubs. Table 1 summarizes which variables were measured, and the sample size, at each site. Grids of sizes up to 4 x 60 m were laid out, and soil samples were taken usually at 2 m intervals on these grids. All plants in the immediate vicinity of the grids were mapped. This enabled the spatial distribution of the soil seed reserve to be related to the distribution of adult shrubs. In addition, the population size structure of each patch was examined by taking measurements of the height and diameter of all plants in a larger area surrounding each grid. At some sites plants were recorded as being in heavy, light or no fruit. The value of height plus diameter (H + D) of each shrub was used as a measure of its size. This index was found by Crisp and Lange (1976) in their study of Acacia burkittii to be linearly related to age.

Each soil sample was of 20 x 20 cm to a depth of 5 cm. Preliminary work on the distribution of the seeds of Cassia spp. throughout the soil profile (unpublished) show that between 85 and 95% of the soil seed reserve is in the upper 5 cm. layer of the soil. In this respect, these species are comparable to those studied by other workers (e.g. Robinson and Kurt, 1962; Major and Pyott, 1966).

Seeds were extracted from the soil by sieving. The sieves used were of aperture sizes 3.35 mm and 1.40 mm. Any seeds which were obviously non-viable, for example, those which consisted only of an empty seed coat, were discarded and not considered in the overall estimate of soil seed populations. (Only a few seeds fell into such categories). It was not possible to distinguish seeds of C. nemophila from those of C. phyllodinea.

Seeds of A. victoriae and C. nemophila were tested for germinability in petri dishes on moist filter-paper. (The C. nemophila seeds used in this experiment were known to be of that species because they were taken from beneath stands of shrubs which did not contain C. phyllodinea). It was found necessary to pre-treat the seeds of both A. victoriae and C. nemophila before large-scale germination could be obtained as for many seeds with hard tests (Larsen, 1966; Preece, 1971; Clemens, Jones and Gilbert, 1977). The seeds of A. victoriae were pre-treated by placing them in water at 80°C for 8 minutes. This treatment proved ineffective for seeds of C. nemophila, which responded to manual chipping of the seed coat. Germination trials on both treated and untreated seeds were carried out in the dark at three different temperature regimes as follows:

(i) 14 hours at 32°C alternating with 10 hours at 25°C.

(ii) 12 hours at 25°C alternating with 12 hours at 18°C.

(iii) 10 hours at 18°C alternating with 14 hours at 10°C.

These temperature regimes were selected to represent various seasonal conditions experienced by the plants in the field. The full range of field soil temperatures (Bell 1973) was by no means covered, however.

For each combination of pre-treatment with temperature there were 2 replicates of 25 seeds each. Germination was observed until it stopped, about 12 days. Any seeds which imbibed but failed to germinate were tested for viability with a tetrazolium stain (1% solution of 2,3, 5-triphenyl tetrazolium chloride) which stains red in respiring tissue. Those which neither germinated nor imbibed were re-treated and tested again. For Cassia seeds the first pre-treatment was with hot water and the second by manual chipping.

Soil samples were collected in November, 1977, after nearly two years of drought. Fig. 1 shows that the last substantial rains had been between December 1975 and February

1976. The drought continued until May 1978. In May and June 1978 about 130 mm of rain at Fowler's Gap resulted in germination of both A. victoriae and Cassia spp. (As with seeds, the early seedling stages of C. nemophila and C. phyllodinea were indistinguishable). At each site, seedling density and distribution were investigated. A number of 0.25 m^2 quadrats were placed within each mapped area and all seedlings within these quadrats were counted. Seedlings which resulted from rain in May and June 1978 were readily distinguishable from older plants.

Results

The densities of seeds of A. victoriae and Cassia spp. as calculated from the number of seeds extracted from the soil samples are shown in Table 2. Large soil seed reserves are present. The estimates presented only represent seed populations in the top 5 cm of the soil so total populations may be larger.

Figure 2 shows that plants of all three species began to set fruit substantially at height plus diameter values of about 2 m, equivalent to about 1 m high. Accordingly seed densities in particular quadrats were regressed on the distance to the centre of the nearest plant of the same species over 1 m high (Fig. 3). These regressions showed significant logarithmic declines in soil seed density with distance from the nearest adult plant. In other words, soil seed tended to be concentrated under the canopy of adult plants, as would be expected for large seeds with no special adaptations for dispersal. The slope of the decline with distance did not differ between species.

Table 3 shows the results of germination trials. The marked effect of pre-treatment upon percent germination is comparable to that obtained for other hard-seeded legumes (e.g. work on seeds of Acacia spp. by Clemens, Jones and Gilbert, 1977). Three-way G-tests (Sokal & Rohlf 1969) showed that there were highly significant effects of pre-treatment, but no significant effect of temperature regime, on percent germination.

Tetrazolium tests showed that all seeds which imbibed but failed to germinate were inviable, showing no staining apart from that produced by obvious fungal and bacterial activity. The germination trials indicate the high percentage viability of the soil seed reserves of both A. victoriae and Cassia spp. However, only a small proportion of these reserves will germinate even after heavy rains, the rest remaining dormant. Only when the seed coat is broken will germination take place. It seems likely, therefore, that under field conditions there would be a gradual release of seeds from the dormant soil seed reserves as scarification takes places by natural processes.

As with Acacia aneura, a few seeds of A. victoriae are retained on the parent plant after they are ripened (Davies, 1976). This would have been a source of recruitment of seeds into the soil seed population of this species, between November 1977 when the soil was sampled and May 1978 when germination began. The amount of seed added would, however, have been relatively small. There would have been no loss of seeds from the soil reserves as a result of germination during this period. It is therefore considered that seed and seedling numbers can be compared (Table 2). Table 2 shows the densities of seedlings about 4 weeks after the start of the rains both absolutely and also as a proportion of soil seed density of each species. At no sites does this proportion exceed 1%. Thus the low percent germination under laboratory condition of seeds which had not been pre-treated is parallelled by a low percent germination of the soil seed reserve in the field. In general seedling densities were higher at sites with larger soil seed reserves.

It was also found that seedlings were not evenly distributed across the surface of the soil, seedling densities being highly variable even within a particular site. As with seeds, concentrations of seedlings often occurred beneath the canopy of adult plants. Variation in seed and seedling densities between sites is largely explicable in terms of the composition of the adult plant populations. For example, site 1, which was found to have a large soil seed population of _A. victoriae_ and a relatively dense population of seedlings had many large, seed-producing adult plants; while site 2, which had a relatively low seed population and relatively few seedlings after rain, had an adult plant population dominated numerically by many small individuals. Fig. 4 gives size-class distribution of the adult plants at the sites 1-3, taking height plus mean diameter as a measure of size. Even though only a small proportion of the total soil seed reserve germinated after rain, seedling densities were usually 10^3-10^4 times adult plant densities.

Discussion

Barbour (1969) concluded, from his study of age distributions in the arid-zone shrub *Larrea divaricata*, that for this species, germination and establishment are relatively rare events. A similar conclusion was reached by Preece (1971) who, on the basis of work on the germination behaviour of *Acacia aneura*, was able to predict the frequency with which germination might be expected under field conditions. The risks of living in an environment in which conditions suitable for germination are both infrequent and unpredictable may be minimized by large reserves of viable seed, shown here to be present beneath stands of *A. victoriae* and *Cassia* spp. We cannot tell from these data how frequently a cohort germinates in these species. It is obvious, however, that the persistence of seed reserves throughout the drought until May 1978 enabled these species to respond immediately conditions were suitable. It is also clear that even if another drought follows immediately, killing those seedlings which germinated in 1978, a large reserve of viable seed remains in the soil.

Acknowledgements

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TABLE 1. SUMMARY OF SAMPLE SIZES (m^2) FOR DIFFERENT LIFE STAGES AT 10 SITES. INDIVIDUAL QUADRATS FOR SEEDS WERE 0.04 m^2 AND FOR SEEDLINGS 0.25 m^2.

Site	Area Mapped For Adults	Area Sampled For Seeds	Area Sampled For Seedlings
1	120	1.20	15
2	576	1.52	21
3	240	1.20	15
4	240	1.04	30
5	480	0.60	15
6	240	0.56	0
7	120	0	15
8	120	0	15
9	0	0	5.25
10	0	0	20

TABLE 2. SEED, SEEDLING AND ADULT PLANT DENSITIES (m^{-2}) OF THREE SPECIES OF SHRUBS AT 10 SITES. "ADULT" REFERS TO ANY PLANT ESTABLISHED BEFORE 1977. SEED DENSITIES GIVEN TO 2 SIGNIFICANT FIGURES. DASHES (-) INDICATE VALUES NOT MEASURED. VALUES ARE MEANS ± S.E.

Site	Species	Adult	Seed	Seedlings	Seedlings as a percentage of seed reserves
1	A. victoriae	0.24	1500±300	4.0±1.3	0.26
	Cassia spp.	0.02	300± 90		
2	A. victoriae	0.19	200± 80	1.5±0.3	0.31
	C. nemophila	0.08	200± 55		
3	C. nemophila	0.06	-	-	-
	C. phyllodinea	0.04	-	-	-
	Cassia spp. (total)	0.10	120± 40	1.0±0.3	0.86
4	A. victoriae	0.06	1100±200	1.8±0.4	0.16
5	C. nemophila	0.03	-		
	C. phyllodinea	0.02	-		
	Cassia spp. (total)	0.05	340± 70	7.5±1.6	2.06
6	A. victoriae	0.30	3500±540	-	-
7	A. victoriae	0.55	-	0.7±0.2	-
8	A. victoriae	0.47	-	10.7±2.7	-
9	Cassia spp.	-	21± 1	-	-
10	Cassia spp.	-	2± 1	-	-

TABLE 3. PERCENTAGE GERMINATION OF SEEDS OF TWO SPECIES UNDER THREE TEMPERATURE REGIMES AND WITH OR WITHOUT PRETREATMENT TO BREAK DORMANCY. SEE TEXT FOR FURTHER DETAILS.
** SIGNIFICANT AT 0.005 LEVEL. *** SIGNIFICANT AT 0.001 LEVEL.

Germination Conditions		Species	
		A. victoriae	C. nemophila
32/25°C	Treated	72	86
	Untreated	0	4
25/18°C	Treated	94	88
	Untreated	6	4
18/10°C	Treated	96	68
	Untreated	2	2

Results of G-test		
Temperature x germination	4.99	3.074
Pre-treatment x germination	251.24**	215.714***
Interaction	12.446**	4.928

Fig. 1. Seasonal rainfall totals recorded at Fowler's Gap Station between Autumn 1970 and Autumn 1978.

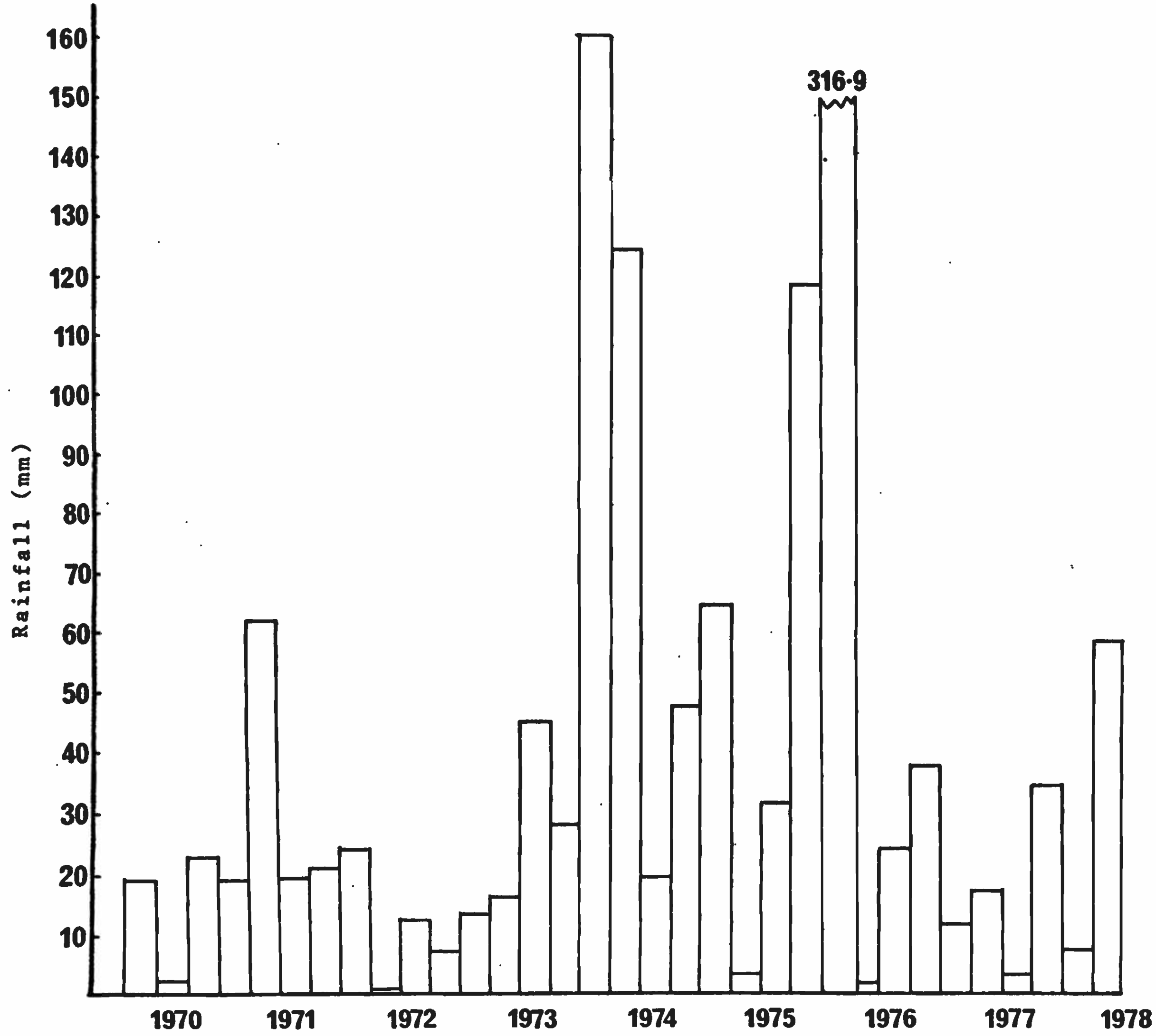


Fig. 2. Percentage of plants in various size classes which produced fruit.

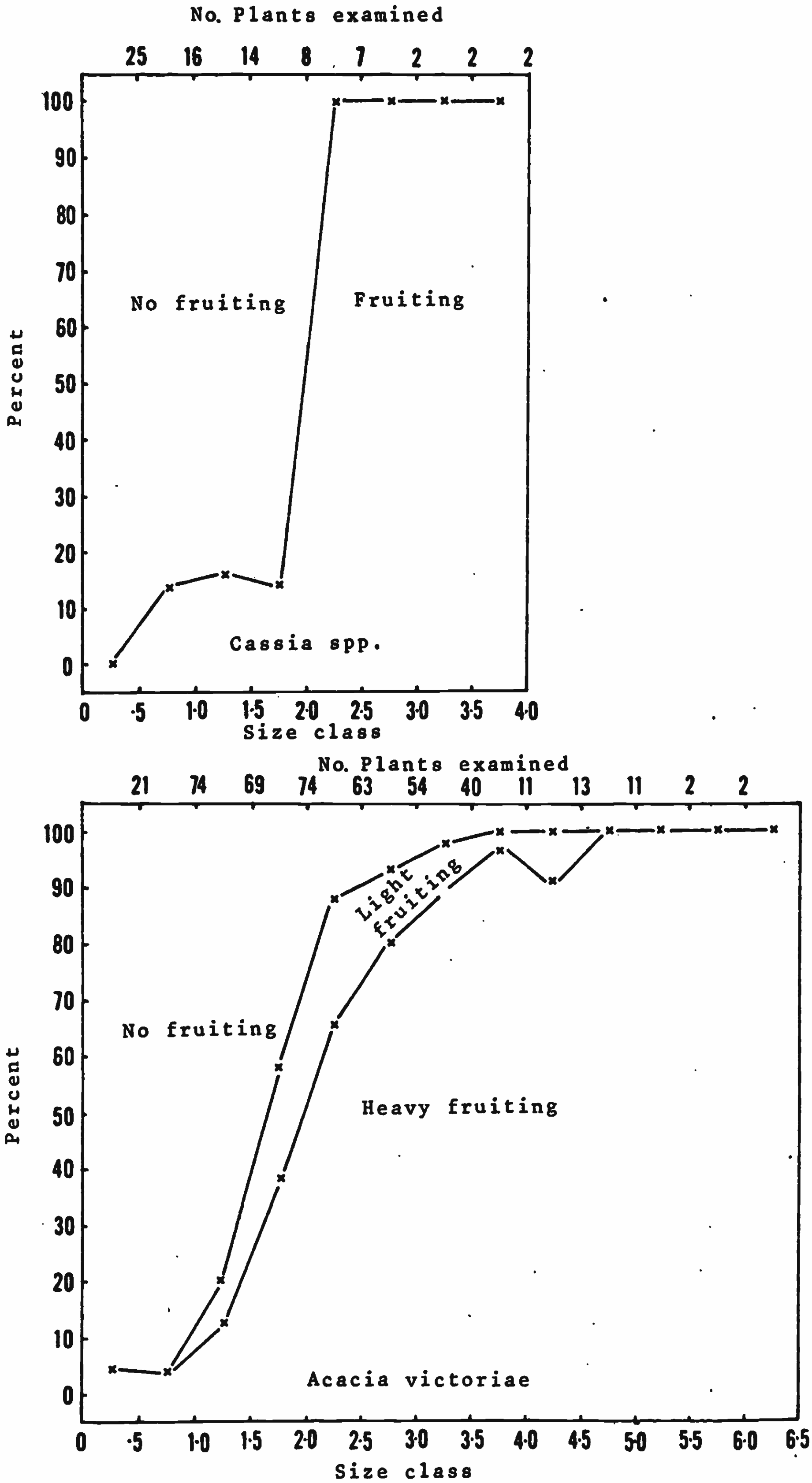


Fig. 3. Relationship between the number of seeds extracted from a soil sample and the distance between the sampling site and the centre of the nearest plant over 1 m high.

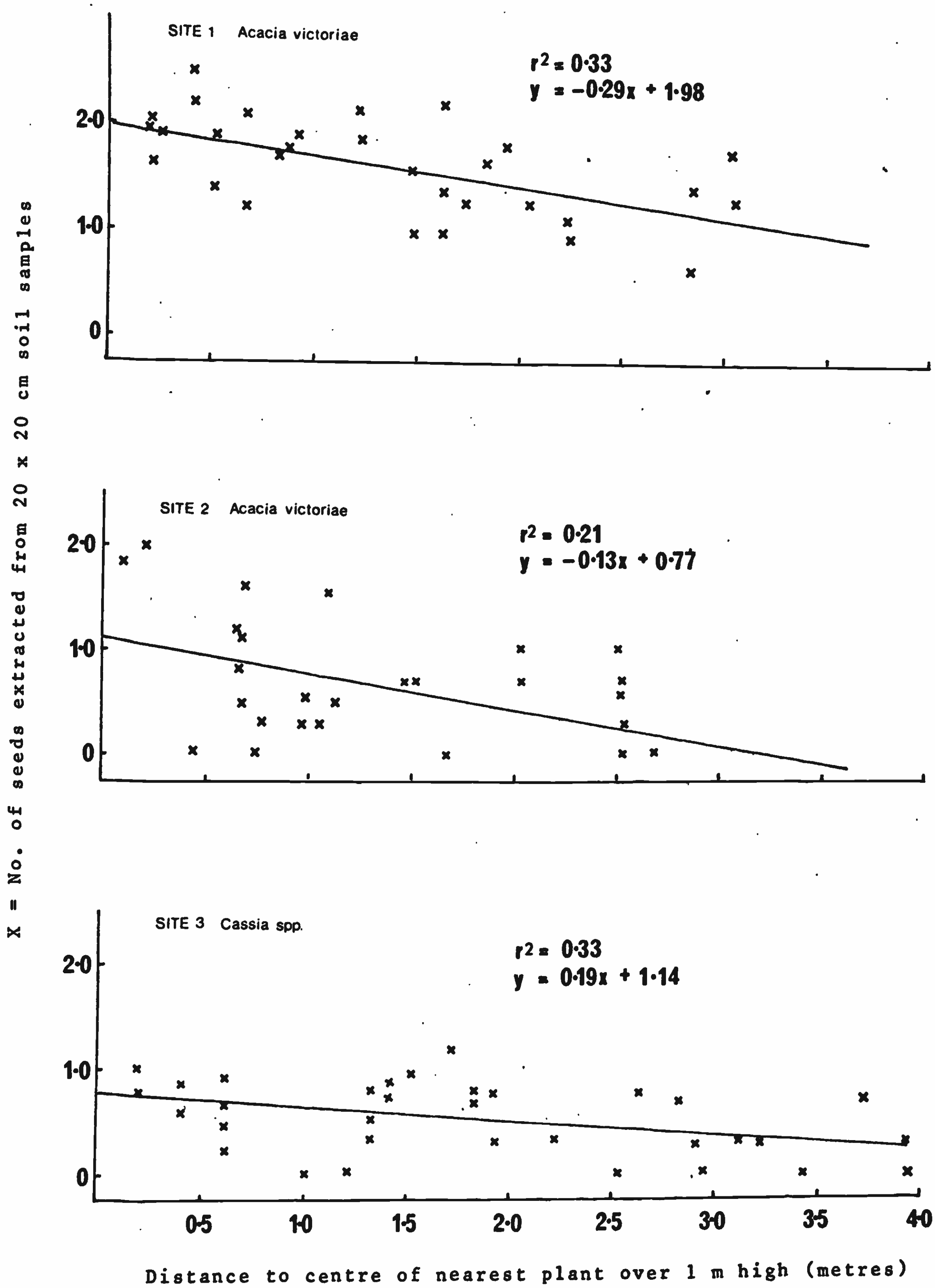
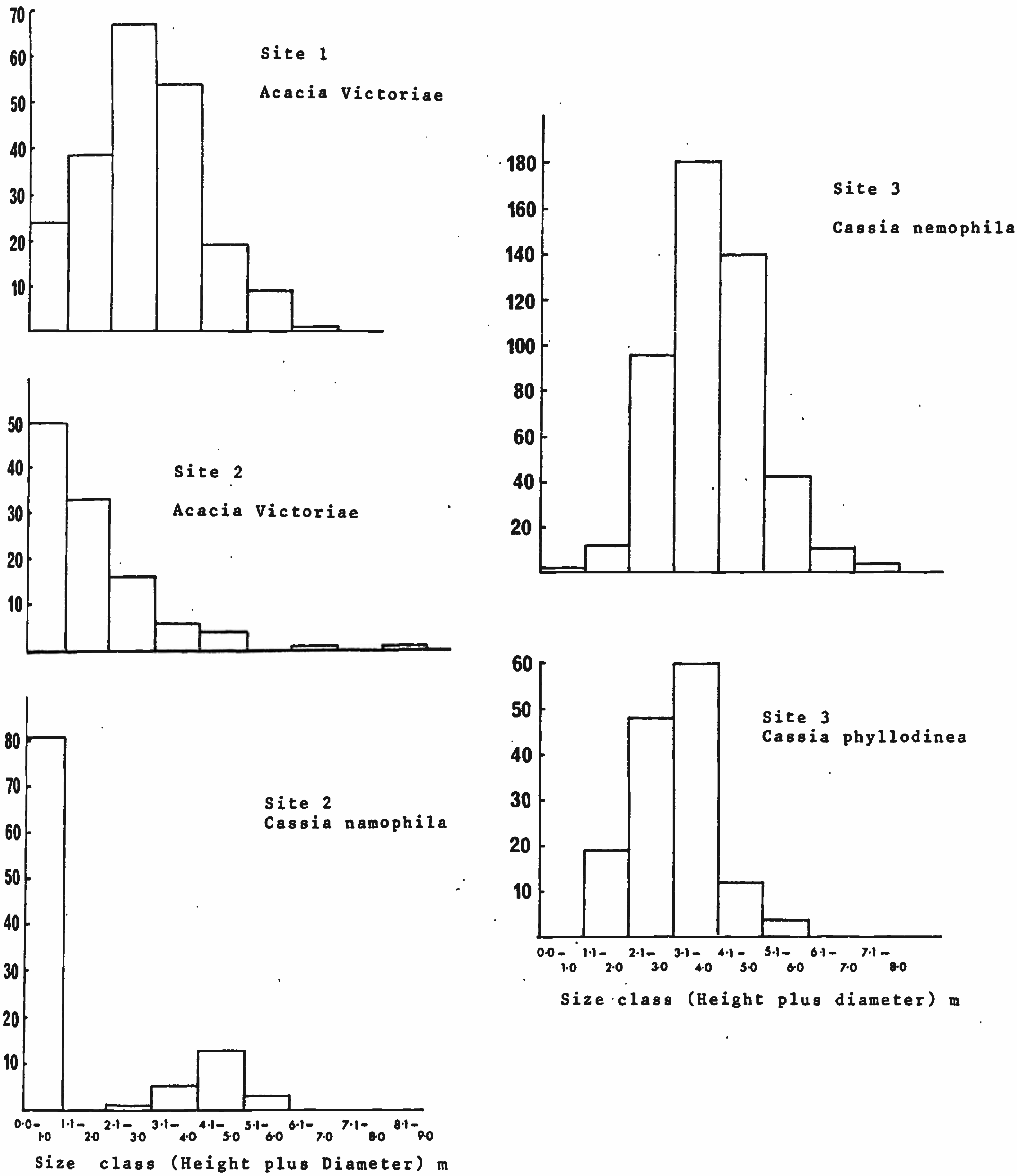


Fig. 4. Size class frequency distributions for Acacia victoriae at sites 1 and 2, Cassia nemophila at sites 2 and 3 and C. phyllodinea at site 3.



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WATER ACCEPTANCE BY SOILS SUPPORTING DIFFERENT VEGETATION SYSTEMS

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Introduction

Increased understanding of the hydrology in range lands will assist in management decisions regarding plant response to various stocking rates, rehabilitation programmes and the improvement of engineering structures designed for the collection and redistribution of surface waters. This information could also be used for the location of land use units on any property by the selection of watering points and fences.

Recently (Gifford 1978) has reviewed rangeland hydrology in Australia. His final conclusion was, there is very little information available and that multidisciplinary efforts are required. He further suggested that research areas needed to be investigated in this fashion were the hydrological cycle, in particular techniques for influencing run-off so that water may be redistributed and the relationship between water and nutrients.

This paper attempts to develop the sparse knowledge of rangeland hydrology in Australia by applying simulated rainfall to several adjacent land vegetation systems at Mt. Victor station which is approximately 80km north-east of Yunta, South Australia.

Methods

The rainfall simulator has been described by Grierson and Oades (1977) and was programmed to deliver 51mm per hour over an area of 1 metre x 1 metre. The rainfall intensity was determined from the meteorological data contained in the Handbook of the Australian Institute of Engineers and is the intensity which could be expected for a 20 minute storm occurring once in every 5 years. For each site sediment load and total run-off for the rainfall event was recorded.

At each site the soil characteristics of texture, presence or absence of calcium carbonate, soil salinity on a 1:5 soil water suspension and colour were determined. The nutrient deficiency rating was measured using wet chemical methods in combination with visual colourimetric observations.

Slope was measured using an inclinometer whilst density was recorded from a neutron density probe and gravimetric topsoil moisture was determined upon return to the laboratory.

Soil characterization and a single twenty minute event was carried out on each of the following vegetation systems.

Vegetation Systems

The vegetation of Mt. Victor mapped in Fatchen (1975), is summarized in Table I. The classification was devised by interpretation of aerial photographs supplemented by ground survey. The following notes outline significant features of those units inspected in the present study.

Units 2a-2b: cores were taken on an ecotone between *Acacia victoriae* tall shrubland and *Maireana pyramidaka* low shrubland. The site was at the southermost point of the main drainage system on Mt. Victor, and had previously been observed to carry a high biomass of legumes following flooding.

Units 3aii and 3aiii: both sites were relatively lightly stocked. The vegetation differences relate to the percolation barrier of sheet limestone in 3aiii, with the consequent and well reported (Carrodus et al 1965) predominance of M. sedifolia low shrubland.

Unit 3b: ephemeral herblands in this unit and particularly at the site investigated result largely from past overstocking. From surveyors' records, this appears to have once been a shrubland of either Axriplex vesicaria (3ai) or A. vesicaria and M. astrotricha (3aii), although notes of T.G.B. Osborn from the 1920's indicates that it had already reached its present status by then. Severe gullying occupies approximately $4Km^2$ close to the site investigated. It would be reasonable to assume a major loss of nutrients with the topsoil and plant cover as indicated by Charley and Cowling (1968).

Unit 4b: much of this unit comprises sandy outwash alluvium from neighbouring hill systems. The grassland appears to be natural in most cases, not a stocking effect.

Unit 4aii: apart from soil structure, this unit is equivalent in vegetation structure, biomass and species to unit 3aii. The site was lightly stocked.

Unit 4ci: the Acacia aneuca woodlands of this unit display a marked grove/intergrove pattern, with, at the sites in question, M. astrotricha low shrubland in intergroves.

Results and Discussion

Tables 2 and 3 give the soil properties and experimental data respectively,estimated water runoff and soil loss values in Table 4 are calculated from area obtained by using a planimeter on aerial photographs.

The runoff values given in Table 3 show the same wide range of water regime characteristics as found by other workers in this field Gifford (1978) Walker and Cunningham (1976). The first of these workers used a similar but much smaller system than described in this paper, while a second group of workers used fixed plots maintained on the one location for 10 years. Neither of these groups of workers have determined soil loss during their experimentation.

Vegetation System 2a, 2b

Soluble salts (Table 1) were visible at the surface. More than 30% of the simulated rain was runoff in this watershed situation (Table 2). The high sediment load indicates the heavy textured surface soil was prone to erosion while preventing infiltration of the simulated rain. After rain this system shows a rapid response by the appearance of medics in the watercourse, indicating an availability of phosphorus and the fixation of nitrogen (Table 2).

Vegetation System 3aii

The second highest runoff and the highest soil loss was recorded for this vegetation system, 3aii. The cemented sand surface soil Table 1, is prone to erosion while maintaining effective barrier against water entry. The absence of calcium in this surface soil suggests that the phosphorus in this horizon is available to plants, Table 1.

Vegetation System 3aiii

The calcium in the surface soil ensured good infiltration and therefore low runoff characteristics of the soil, while the B horizon of sandy clay loam ensures adequate drainage. There is no apparent application for the relatively high fertility in nitrogen, phosphorus and potassium of this soil.

Vegetation System 4a

Dogwood paddock shows large gullies caused, probably, by earlier overgrazing as the vegetation cover now is composed mainly of annuals with little or no perennials. Both runoff and soil loss values are high. The small areas of this vegetation system makes it a minor component for the total station. The deficiencies in nitrogen, phosphorus and potassium support the evidence of topsoil removal.

Vegetation System 4b

Soil description for this vegetation system Table 1 suggested a skeletal soil, that is, one which has lost the surface by erosion. Supporting evidence is gained from the slide to be shown which indicates herbaceous cover and not a shrub cover which would be more typical in the non-erosion situation. The high relative deficiency of nitrogen and phosphorus as in Table 1, would confirm the loss of the surface soil. Finally, a dam constructed in this particular paddock has rarely filled with water, the runoff data would verify this high infiltration rate, low runoff and low soil losses (Table 3).

Vegetation System 4aii

This system may be regarded as the control for the northern half of Mt. Victor station since it is still widely covered with low saltbush and bluebush shrub lands. The runoff and soil loss were both relatively high, but little vegetation is found between the bushes to improve these soil characteristics. The median nutrient ratings for nitrogen, phosphorus and potassium suggest the nutrients have been accumulated in the biomass.

Vegetation System 4ci

This system may be divided into two distinct types; the intergrove between the patches of *Acacia* and the grove within the groups of *Acacia* species. Soil descriptions, runoff and sediment loads are similar for both systems. However, the nutrient assessments indicate the importance of the vegetative cover. In the grove system the nitrogen values are relatively high since the acacia species and genus is capable of fixing nitrogen. Phosphorus is low since this element would be accumulated in larger biomass in the grove system. The intergrove situation indicates the reverse situation; lower amounts of available nitrogen and higher amounts of available phosphorus.

General Discussion

Table 4 must be interpreted with many reservations. However, it does indicate most of the vegetation systems are prone to erosion in a short twenty-minute storm of moderate 5cm per hour rain. The total runoff figures indicate where engineering and water harvested techniques are the most successful namely vegetation systems 2a, 2b and 3aii. The soil loss figures are indicative of the relative importance of each vegetation system of the whole property, however, those such as watershed, with a low total area and a high soil loss should not be used for heavy grazing. However, areas such as 4C are unlikely to become badly eroded while the current vegetation stand is maintained.

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TABLE 1 VEGETATION SYSTEMS ON MT. VICTOR STATION

KEY	STRUCTURE* & CHARACTER SPECIES		AREA (Km^2)
1.	Hill System : skeletal sandy soils		
1a	Low shrubland : Atriplex vestcaria		16
1b	Tall open shrubland : Acacia aneura with A. tetragouophyllic		30
2.	Floodplain system : deep loams		
2a	Low shrubland : Maireana pyramidala with Nitraria schoberi		15
2b	Tall shrubland : Acacia victoriae with M. pyramidata and M. brevifolia		40
3.	Southern Plains System : texture contrast soils		
3a	Low shrubland:		219
	3ai	A. vesicaria	
	3aii	A. vesicaria and M. astrotricha	
	3aiii	M. sedifolia	
	3aiv	M. astrotricha	
3b	Ephemeral herbland : grasses and Bassia spp		21
3c	Low open woodland :		60
	3ci	Myoporum platycarphum	
	3cii	Casuarinca cristata	
	3ciii	M. platycarpum and A. aneura	
4.	Northern Plains System : sandy gradational soils		
4a	Low shrubland :		65
	4ai	Matreana astrotricha	
	4aii	A. vesicaria with M. actrobricha	
4b	Ephemeral herbland : grasses		74
4c	Low open woodland :		157
	4ci	Acacia aneura	

4cii	Eremophila duttonii with E. sturtii
4ciii	Casuarina cristata

* Structure as defined in Specht (1972)

TABLE 2 THE SOIL PROPERTIES FOR EACH VEGETATION SYSTEM

VEGETATION SYSTEM	PADDOCK NAME	Profile Description						NUTRIENT DEFICIENCY RATING FOR TOPSOIL*		
		Depth (cm)	Texture	pH	TSS mv/cm	Colour	$CaCO_3$	N	P	K
2a	Dandaraga	0-22	silty loam	8.3	8.0	5YR5/8	* *			
-2b		22-	loam fine sandy	8.5	5.0	5YR5/6	***	3	4	3
3aii	Marshes	0-14	cemented sand	9.0	.05	5YR5/6	-			
		14-52	sandy clay loam	9.2	.18	5YR4/6	-	3	1	3
		52-	sandy clay loam	9.2	1.50	5YR6/6	***			
3aiii	Cons	0-8	light sandy clay loam nodular limestone on surface	9.3	.4	5YR6/6	***	2	2	1
		8-30	sandy clay loam limestone rubble	9.1	.1	5YR7/4	***			
		30-	sheet limestone							
3b	Dogwood	0-8	fine sand clay loam	9.8	.08	5YR7/6	***	5	5	3
		8-	sandy clay	9.8	.18	7YR7/6	***			
4b	Glenorchy	0-27	loamy sand	8.3	.05	5YR4/6	-	4	5	2
		27-54	sandy loam	9.1	1.00	5YR5/6	-			
		54-	light sandy clay	9.3	1.14	5YR6/6	***			

4aii	Springs	0-17	sandy loam	8.9	.1	5YR5/8	-			
		17-34	sandy clay loam	9.5	.12	5YR5/8	* *	3	3	3
		34-	fine sandy clay loam	10.0	.4	5YR6/8	***			
4ci	Nth Toweroo	0-14	sandy loam	9.0	.25	5YR6/8	* *			
		14-40	loam fine sandy	9.6	.55	5YR5/6	***	3	4	3
		40-	light clay	8.8	2.0	7.5YR/6	***			
4ci	Grove	0-29	light sandy clay	9.1	.1	5YR6/8	***			
		29-45	loam fine sandy	9.0	.25	5YR7/8	***	3	5	3
		45-	fine sandy clay loam	9.1	.23	7.5YR7/6	***			

* 1 least deficient - 5 greatest deficiency

TABLE 3 SLOPE, RUNOFF AND SOIL LOSS DATA FOR EACH VEGETATION SYSTEM

VEGETATION SYSTEM	PADDOCK NAME	SLOPE °	RUNOFF IN 20 min ml^{1}	% RUNOFF	SEDIMENT LOAD gl^{-1}
2a-2b	Watershed	0	6000	36	4.0
3aii	Marshes	1	4000	24	4.5
3aiii	Cons	1½	1220	7	3.0
3b	Dogwood	1	2700	16	4.5
4b	Glenorchy	1	0	0	0
4aii	Springs	½	3000	18	2.5
4ci	North Toweroo	0	1700	10	2.5
4ci	Grove	1	2800	17	3.0

TABLE 4 ESTIMATED WATER RUNOFF AND SOIL LOSS FROM 1 HECTARE AND THE TOTAL AREA OF EACH VEGETATION SYSTEM

VEGETATION SYSTEM	PADDOCK	LAND UNIT AREA Km^2	RUNOFF $M^3\ ha^{-1}$	SOIL LOSS $1000kg\ ha^{-1}$	TOTAL RUN OFF $m^3 \times 10^4$	SOIL LOSS 1000 kg
2a-2b	Watershed	15 (2%)	60	2.4	90	360
3aii	Marshes	165 (24%)	40	1.8	66	3000
3aiii	Cons	54 (7½%)	12	0.4	6	220
3b	Dogwood	21 (3%)	27	1.2	6	250
4b	Glenorchy	74 (10½%)	0	0	0	0
4aii	Springs	65 (9½%)	30	0.8	20	520
4ci	Intergrove))Toweroo	126 (18%)	17	0.4	20	500
4ci	Grove	31 (4½%)	28	0.8	9	250

A COMPARISON OF RAMS BRED IN THE ARID ZONE WITH RAMS IMPORTED FROM STUDS

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Introduction

In 1973 a nucleus type ram breeding flock was established at Fowlers Gap Research Station, to study the feasibility of breeding rams and compare the breeding value of homebred rams and rams purchased from outside the arid zone.

This report deals with the results from the first year of a study of possible adaptational advantages of rams bred in the arid zone compared to rams imported from higher rainfall country.

Materials and Methods

The experiment was conducted at Fowlers Gap Research Station, latitude 25.56 S, longitude 133 E, approximately 110 km N of Broken Hill. Mean annual rainfall for the station is 195 mm, but in 22 months prior to the 1st joining period, only 132 mm of rain was recorded. The region experiences hot dry summers and cool winters.

Joining

Rams from the Fowlers Gap Bungaree ram breeding group and purchased stud rams of a comparable age were mated to approximately 300 Collinsville and Bungaree mixed age ewes. The purchased rams had been on the station for over 12 months prior to joining. The ewes were randomly divided into four groups of which two were joined in December/February and the other two in March/May, 1978.

Two rams were joined with each group in adjacent paddocks with saltbush/annual grass pastures. The rams were fitted with 'Sire-Sine' raddle harnesses and raddle marks on ewes were recorded every 17 days, when the raddle colour was changed.

Libido Test

The libido of six rams from each source was assessed on 15/12/77 prior to the early joining. The rams were placed individually in a pen with three ovariectomised ewes for 15 minutes. Ewes were injected with 25 mg Progesterone on days one and three, and 200 µg Estradiol Benzoate on day five to induce oestrus on day six. The time interval between introduction of the ram and first mount, number of mounts, number of services and level of interest were recorded.

Rectal Temperature

Rectal temperatures of the rams were recorded on 15/12/77 and 17/1/78. Temperatures were taken with a standard thermometer inserted approximately 10 cm into the rectum.

Respiration Rate

On 17/1/78, four rams from each source were walked at a moderate pace for 1 km and when returned to yards, respiration rates were recorded by observing the time taken for 60 flank movements. Each measurement was duplicated and taken mid-morning, noon and mid-afternoon. The values, expressed in respiration per minute, are the means of all measurements.

Results

Joining

The raddle data are given in Table 1. In the early joined groups, the ewes were anoestrus for the first raddle period; in the second and third raddle periods, Fowlers Gap rams raddled significantly more ewes than the imported rams, while in the last raddle period, the imported rams started their major mating activity. Significantly more ewes were raddled by Fowlers Gap rams ($P < 0.05$). In the late joining groups, the mating activity of the two ram groups was similar.

The lambing percentage (expressed as a proportion of ewes at marking) is given in Table 2. There were significantly more lambs from Fowlers Gap rams in the early joining period, and no difference between sire source in the late joined groups. Overall, the Fowlers Gap rams produced significantly more lambs than the imported rams ($P < 0.05$).

Libido Test

The results of the libido tests are given in Table 3.

The differences are not statistically significant, though there was a tendency for the active Fowlers Gap rams to have a higher activity level than the active imported rams, and a quicker reaction time.

Rectal Temperatures

Rectal temperatures recorded before joining were:
Fowlers Gap 39.82 ± 0.13 and Imported 39.82 ± 0.20, and temperatures taken one month later were
Fowlers Gap 39.51 ± 0.15 and Imported 39.35 ± 0.17.
Differences were not significant.

Respiration Rates

The respiration rates are given in Table 4. The Fowlers Gap rams had significantly lower respiration rates during all three periods.

Discussion

Summer joining is practised by many pastoralists in the West Darling region of New South Wales (Chudleigh, 1971) and the suitability of rams reared on improved pastures in more humid areas, and transferred to the arid zone, must be questioned. Morgan (1967) demonstrated that locally-bred rams had superior reproductive performance to rams imported into the Pilbara region of Western Australia. The conditions under which this experiment was conducted were particularly adverse because of the very low rainfall in the previous 22 months.

During the more stressful summer period, the Fowlers Gap rams were active earlier in the joining period, raddled more ewes and sired more off-spring than the imported rams while, during the cooler autumn months, no differences were observed. The large difference in lambing percentage in the early joining was striking, and explanations other than differences in rams were sought. However, corroborative evidence was obtained from the remainder of the joinings on the Station. From 809 ewes joined with imported rams only 171 lambs were marked - 21% lambing. The remaining 1762 ewes were joined with at least 50% of sires from Fowlers Gap, and 1055 lambs were marked - 60% lambing.

Although there were no differences in rectal temperature between sire source, the differences in respiration rates indicate that the locally bred rams may be physiologically better adapted to the environment. In the tropical semi-arid zone adapted sheep had lower mean rectal temperatures and lower respiration rates, and adapted ewes had higher liveweights and pregnancy rates (Hopkins et al. (1976). This aspect will be further explored at Fowlers Gap, along with further studies on the offspring of the two sire sources.

Our conclusions are tentative because of the small sample of rams involved, however there are indications that under stressful conditions locally bred rams can be superior to imported rams in reproductive performance.

TABLE 1. NUMBER OF EWES MATED BY FOWLERS GAP AND IMPORTED RAMS DURING TWO JOININGS

Period	No. of ewes raddled Fowlers Gap	Imported	χ^2
Early Joining			
20/12 - 6/1	0	0	P < 0.001
6/1 - 23/1	21	1	P < 0.001
23/1 - 9/2	46	3	P < 0.001
9/2 - 26/2	4	35	P < 0.05
Total	71	39	
No. of ewes joined	75	75	
Late Joining			
17/3 - 4/4	45	39	NS
4/4 - 21/4	14	15	NS
21/4 - 10/5	2	0	NS
10/5 - 26/5	0	2	NS
Total	61	56	
No. of ewes joined	67	66	

TABLE 2.

Joining	Lambing % Fowlers Gap	Imported	P
Early	82	33	< 0.01
Late	90	85	NS
Overall	86	57	< 0.05

THE LAMBING PERCENTAGE EXPRESSED AS A PROPORTION OF EWES AT MARKING

TABLE 3.

Measurement	Source of Ram Fowlers Gap	Imported
Proportion showing interest	4/6	5/6
" mounting	4/6	4/6
" serving	1/6	1/6
Mean reaction time to mount	2 min. 45 sec.	3 min. 30 sec.
" " " " serve	1 min. 30 sec.	3 min.
Mean number of mounts (of those mounting)	7	3.75

RESULTS OF LIBIDO TESTS

TABLE 4.

Time of observation	Mean respiration per minute (±SD) Fowlers Gap	Imported	P
Mid-morning	125 ± 28.07	145 ± 19.45	< 0.001
Noon	116 ± 9.85	132 ± 14.71	< 0.001
Mid-afternoon	88 ± 17.39	115 ± 8.81	< 0.001

COMPARISON OF RESPIRATION RATES

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CATTLE AND SHEEP PRODUCTION ON SALTBUSH

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Introduction

The saltbush and bluebush vegetation that covers wide areas of the rangelands of N.S.W., S.A. and W.A. is mainly grazed by sheep. However, there are times, usually the years of above average rainfall, or occasions when market prices favour cattle, when large numbers of cattle are grazed. This occurred in 1971/72. At that time there was concern in the western Riverina of N.S.W. about deaths of cattle from impaction in the large intestine that was attributed to the grazing of saltbush (*Atriplex vesicaria*) and bluebush (*Maireana sedifolia*). Also, it was the general opinion of graziers that saltbush country was unsuitable for cattle, as they are thought to be unable to obtain sufficient forage when the vegetation is short. A grazing trial, which compared the performance of sheep and cattle, was conducted at Booligal, N.S.W. to provide information on the comparative forage selection, diet quality, weight gain and water intakes.

Methods

A uniform area of saltbush was fenced into duplicate plots of 10, 15, 35 and 52.5 ha. Each of the smaller plots was grazed by 6 Merino ewes, giving stocking rates of 1.7 and 2.5 ha/sheep. The others were grazed by three Hereford cows, giving stocking rates of 11.7 and 17.5 ha/cow. The ewes and cows were joined to lamb and calf at about the same time (May-July). The rams were Border Leicesters.

The weight of the ewes, cows, lambs and calves was recorded monthly over a four-year period. The lambs were weaned at 4 months and the calves at 7-8 months, and these were then grazed for another 12 months in adjoining paddocks. The composition and quality of the diet was measured by introducing oesophageally fistulated steers and wethers to the plots from time to time. The amount of water consumed by the animals on each treatment was recorded on a monthly basis.

Results

The average weight gains of the calves and lambs at three dates is shown in Table 1. This shows that the lambs made the major part of their growth in the initial period to weaning, while cattle were continuing to make substantial growth to two years of age. More importantly, in the years of lower rainfall (1975-77) the weight gains were less than in the wetter years (1973-75), but the ratio of calf gains to lamb gains was about the same.

The bodyweight production per hectare is shown in Table 2. Overall there was little difference between the sheep and cattle. The differences was much less than the difference between stocking rates.

The water intakes of the sheep and cattle are shown in Table 3. The cattle drank 14 times as much water as the sheep. When allowance is made for their greater size (9 sheep = 1 cow, in this trial) the water consumption of the cattle was still 50% greater than that of the sheep.

The proportion of grass and saltbush in the diet is shown in Table 4. The sheep consistently ate more green grass than the cattle, while the cattle ate dry grass (when it was available) or saltbush. The quality of those diets, in terms of the digestibility of organic matter (measured in vitrol) and the crude protein content, is shown in Table 5. On a number of occasions the quality of the cattle diets was lower than that of the sheep. In November 1976 the cattle diets were of even lower digestibility (51% v 57%) when the cattle were grazed temporarily in the sheep grazed plots.

No deaths from impaction occurred in the trial area or on surrounding properties for the duration of the trial.

Conclusions

These results show that cattle are often unable to eat the small grasses and forbs that grow beneath the saltbush. These are the mainstay of the sheep diets and as a result the quality of the forage they eat is often better than that of cattle. Nevertheless, there was no indication of the cattle doing relatively less well than the sheep in the drier years. Overall we conclude that cattle and sheep are similar in terms of body-weight production. However, on an economic basis, the sheep also produce a return from wool and are likely to be the more profitable animal in most years.

There are two other disadvantages of cattle. The first is that they need much more water than sheep and this may be an important factor where animals are dependent on ground tanks. The second is that cattle may not do well if placed in competition with sheep for sparse grasses. The sheep appear to eat it down to a level where it is no longer available to cattle.

TABLE 1. DAILY WEIGHT GAIN OF THE CALVES AND LAMBS (G/DAY) FROM THE FIRST WEIGHING DATE AFTER BIRTH (JULY - SEPTEMBER)

Year	To December			To April			To September		
	Cattle	Sheep	Ratio	Cattle	Sheep	Ratio	Cattle	Sheep	Ratio
1973/74	960	199	4.8	900	115	7.8	850	112	7.6
1974/75	1040	223	4.7	900	123	7.3	660	93	7.1
1975/76	970	185	5.2	670	108	6.2	590	84	7.0
1976/77	860	169	5.1	540	88	6.2	-	-	-

TABLE 2. BODYWEIGHT PRODUCTION OF LAMB OR CALF (KG/HA)

MEAN OF FOUR YEARS

		To Weaning	12 months after weaning
Cattle	High S.R.	15.1	19.4
	Low S.R.	10.6	12.9
Sheep	High S.R.	17.3	20.1
	Low S.R.	12.4	13.4

TABLE 3. WATER INTAKES OF SHEEP AND CATTLE

	Sheep	Cattle
Summer 1975/76	6½	90 1/day
Summer 1976/77	12	140 1/day
Year 20.4.76 to 26.4.77	3 300	46 000 1/year

TABLE 4. THE PROPORTION OF GRASS AND SALTBUSH IN THE DIET OF THE CATTLE AND THE SHEEP.

Date	Green grass		Dry grass		Saltbush	
	C	S	C	S	C	S
Dec. 1973	14	38	51	17	3	12
Feb. 1975	32	56	0	0	60	8
Sept. 1975	15	37	29	13	53	41
Apr. 1976	5	69	0	0	94	19
Nov. 1976	14	60	8	4	75	29

TABLE 5. DIGESTIBILITY AND PROTEIN CONTENTS OF THE CATTLE AND SHEEP DIETS

Date	Digestibility (%)		Crude Protein (%)	
	Cattle	Sheep	Cattle	Sheep
Dec. 1973	51	53	6.5	8.3*
Feb. 1975	50	53	7.4	9.7*
Sept. 1975	55	62*	10.0	12.0*
Apr. 1976	51	55*	9.1	7.7
Nov. 1976	57	64*	12.4	13.7

*Difference statistically significant

GRAZING USE OF RANGELAND COMMUNITIES BY CATTLE IN CENTRAL AUSTRALIA

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Highlights

A major difficulty in managing the extensive rangelands of arid Australia is the lack of quantitative information on the actual use which the free ranging herbivores make of the variety of communities available to them. Preferential use by cattle of range communities in Central Australia has been shown to fluctuate in relation to changes in forage conditions and disturbances caused by climatic conditions and changes in location of drinking water (Low, Dudzinski and Muller, unpubl. ms., Hodder and Low, 1978).

Distribution of free ranging cattle was determined by aerial survey at fortnightly intervals during the morning grazing period on seven major and four minor range communities over a 4.5 year period between 1970 and 1975. Preliminary results were presented by Low (1972) for the first two years of the study. In this report the results for the whole study are summarized by seasons (a convenient interval).

Densities of cattle were calculated for each survey and the numbers of days of use of each community were calculated by assuming that sequential changes in community use occurred at the mid-point of the interval between surveys, unless a significant rainfall intervened, then the date of the rainfall was taken as the point of change-over.

Mean density of cattle on the 170 km^2 paddock ranged from 2.2 beasts/km^2 to 6.9 beasts/km^2 during the study owing to changes in herd numbers due to reproduction or management. The densities of cattle observed on the communities in the paddock are shown in Table 1. An average of 70% of the cattle were seen on the surveys (S.D.= 13.1). Correction factors were developed for the wooded communities and corrected numbers will be used in the presented paper to account for the numbers not observed. On the major communities, the observed mean density ranged from 0.3 beasts/km^2 on the drought refuge mulga-perennial grass (MP) community to 5.5 beasts/km^2 on the more preferred foothill fan (FF) community. Maximum density in the major communities ranged from 1.5 beasts/km^2 in MP to 21.8 beasts/km^2 in the occasionally preferred gilgaied plains (GG) community. In the minor communities, mean densities ranged from 2.1 beasts/km^2 in foothill mulga annual grass (FM) community to 16.9 beasts/km^2 in the very small area of perennial grass (TM) at the foot of the floodplain of Kunoth Creek. Maximum densities on these small communities were very high, ranging from 30 beasts/km^2 in the Calcareous woodland (CW) and FM to 157 beasts/km^2 in the TM during the periods when these communities were preferred.

The numbers of cow-days spent on each community during seasonal intervals will be presented.

A discussion of the factors affecting the densities of cattle on different communities and ways in which the density might be controlled will be presented.

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TABLE 1. DENSITY OF CATTLE ON RANGE COMMUNITIES IN CENTRAL AUSTRALIA.

	Major communities							Minor communities				Whole Paddock	
	MA	MP	WL	FP	HL	FF	GG	CW	FM	RI	TM	Obsrv.	Known
Area	47.0	44.0	22.0	21.7	13.2	8.8	8.7	1.6	1.3	1.2	0.3	170	170
Mean Dens	1.7	0.3	4.9	4.7	1.2	5.5	3.8	3.2	2.1	5.6	16.9	2.4	3.5
Max. Dens	4.3	1.5	12	14.7	10.2	18.3	21.8	30.6	30.8	62.5	157	5.0	6.9
Min. Dens	0	0	0.3	0.3	0	0	0	0	0	0	0	1.3	2.2

Note: MA = mulga annual grass, MP = mulga perennial grass, WL = Woodland,
FP = flood plain, HL = hills, FF = foothill fans, GG = gilgaied plains,
CW = calcareous woodland, FM = foothill mulga, RI = riparian,
TM = treeless mulga perennial grassland.

DIETARY PREFERENCES OF CATTLE GRAZING THREE MAJOR RANGELANDS IN CENTRAL AUSTRALIA

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Introduction

Detailed knowledge of the botanical composition and nutritive value of the diets of animals on rangelands is essential for management of both the animals and the pasture. The land manager must know the species and quantity of plants eaten at different seasons in order to effectively design systems of management to favour desirable species. Knowledge on the nutritive content of the diet is needed to manage the animals to meet their nutritional needs.

The questions of "what do grazing animals eat?" and "in what proportions?" are vital.

Some information on cattle dietary preferences in Central Australia has come from studies by Chippendale (1968), Low and Low (1973) and Low, Birk, Lendon and Low (1973) but no simultaneous comparison of several communities has been made. The present paper presents results from a one-year study on three contrasting rangeland types in the Alice Springs district. This study, part of a CSIRO investigation of arid land eco-systems, examines botanical and chemical composition of cattle diets on mulga, Mitchell grass and open woodland plant associations.

Study area

The study was conducted on three cattle stations (Hamilton Downs, Milton Park and Amburla) which are situated on the northern side of the McDonnell Ranges near Alice Springs. The region has a mean annual rainfall of 250 mm (Slatyer 1962) but during the study period 457 mm were recorded (Fig.1). The land systems and soils have been described by Stewart and Perry (1962) but briefly they consist of acid red earths which support the mulga shrubland communities and neutral red earths which support woodlands. The Mitchell grass is confined to red cracking clays. Descriptions of the structure and floristics of the three plant communities examined in this study are to be found in Lendon and Ross (1978). The sites chosen for study were all in Fair condition as assessed by the STARC method of Lendon and Lamacraft (1976).

Procedure

Pasture characteristics - Estimates of yield and botanical composition of forage on offer were made at each site prior to the entry of the test animals. Twelve quadrats (I m^2) were clipped to ground level after ranking according to the method of McIntyre (1952). The weight of each species present was determined and the moisture content assessed. A sample of each species was retained for chemical analysis.

Diet selection - The diet chosen by cattle was assessed by using surgically-altered cattle into which an oesophageal fistula had been installed. Four such animals were used in this study. They were grazed in succession over the three vegetation units studied.

Animals and management - Shorthorn cattle, reared in the district were used in this study. They were normally grazed in a 250 ha paddock comprising units of mulga and open woodland communities and were transferred to the study site several days prior to sampling. During collection the animals were confined to about 5 ha. The samples were collected, after an overnight fast, during a period of about 1 hr soon after dawn. Three separate collections were made during this period from each animal. Grab samples were taken from each collection bag and the sample was retained for chemical and botanical analysis.

Sample analysis - Standard procedures were used to assess dietary nitrogen levels of the extrusa after freeze drying. The botanical analysis followed a procedure developed by Chamrad and Box (1964) and involved identification of plant fragments which were demarcated by cross hairs. The frequency of occurrence of fragments of each species was used as a measure of contribution to the diet. These frequencies were expressed as a percentage. Preference by the cattle for a particular plant species was assessed by comparing the percentage in the diet with the percentage of a given plant among the forage on offer. A formula reported by Taylor (1973) was used. This formula expresses preference as an index (PI) as follows :

$$PI = \frac{\% \text{ in diet} - \% \text{ available}}{\% \text{ in diet} + \% \text{ available}} \times 10$$

Where % in diet and % available refer to the proportion of a given forage species in the diet and in the pasture on offer respectively. The index has a scale from -10 to +10 indicating relative preference. A value about zero would indicate selection in proportion to availability.

Results

Forage on offer - The amount of forage available throughout the year varied and showed some relationship to rainfall. Generally the effect of rain was to encourage the growth of annual grasses and forbs. In the mulga and woodland sites these were mainly the grass *Aristida contorta*, and forbs such as *Helipterum* spp., *Portulaca oleracea*, *Tribulus* spp. The generally wetter season had the effect of promoting perennation in the *Enneapogon* spp. Similarly perennial forbs such as *Sida* spp., *Boehavia diffusa* and *Goodenia* spp. responded well to rain. The amounts of forage on offer varied from about 300 kg/ha to over 3 000 kg/ha. The higher values were from the Mitchell grass site.

The major contributors to the biomass (in the field layer) at each site were as follows: The mulga site was dominated by *Enneapogon polyphyllus*, *Digitaria brownii* and *Aristida contorta*; the woodland site by *Enneapogon polyphyllus*, *E.avenaceus*, *Aristida contorta* and *Indigofera dominii*, while the Mitchell grass had mainly *Astrebla pectinata* and *Eragrostis falcata*.

Diet quality - The nitrogen content varied seasonally and showed some relationship to rainfall incidence (Figs. 1 and 2). Generally the levels of dietary nitrogen were similar for woodland and mulga communities. Both were adequate to meet the animal's nutritional needs. Diets on Mitchell grass were generally poorer with levels falling to values far below those considered adequate to maintain animal productivity.

Dietary components - About 20 species were available for selection in both the woodland and the mulga communities. On average only 9 species were offered in the Mitchell grass. Of those species on offer only about 6 were eaten by the cattle on a regular basis. For convenience, I have grouped the dietary components into 3 major categories and the relative contribution of each is shown in Figure 3. The major contributors to the diet are shown in a series of graphs in figure 4.

Preference indices were calculated and are shown in Table I. It was not possible to provide a PI for the shrubs and trees in the diet because no data were available on the amounts of such species actually on offer. A feature of the data is that rarely was a plant eaten with equal relish on all occasions. PI values varied from negative to positive throughout the year for some species while others, e.g. Sida spp. in Mitchell grassland always had high positive PI, indicating a definite preference for this plant.

Discussion

The study was conducted during a period of above-average rainfall and toward the end of a sequence of better than normal years. This means that the animals had a larger than usual biomass of forage to choose from but, more importantly, that they had a greater variety. This variety arose from several sources; more annuals, more perennial forbs and more perennial grasses. In general, the cattle preferred annual grasses and forbs to the longer-lived components in the three communities. Shrubs (topfeed) did contribute significantly to the diet (about 25%) in the autumn of 1977 when the flush of annuals had passed. This finding is of some significance in the light of the Chippendale (1968) conclusion that topfeed species were relatively unimportant even during drought.

Diets of cattle on both mulga and woodland communities were similar. This is not surprising when one considers the array of species on offer and the fact that most of the biomass in both communities was composed of biannuals. A different story could emerge if the comparison was repeated during drought. Diets on Mitchell grassland reflect the high availability of *Astrebla* and the more limited choice (cf. Table I).

Despite the high proportion of the diet which Astrebla comprised it has a relatively lower preference on most occasions. More highly preferred species such as Panicum decompositum were generally limited by availability. Low diet quality generally coincided with periods when the two perennial grasses Astrebla pectinata and Eragrostis falcata made up 80% of the diet. The importance of forbs and annual grasses in supplementing the nitrogen level is clear (Figure 4b).

As we see a return to "normal" rainfall patterns and a decline in the proportion (and biomass) of annuals it is likely that diet quality will suffer. The nutritive value of many of the perennial grasses is low (Siebert, Newman and Nelson (1968)). These elements of the community provide landscape stability and as such are vital to the long-term future of the pastoral industry but lower stocking pressure (to allow more selectivity by cattle) will be necessary when rainfall is lower. Some of the more palatable elements in the communities are already under great selective pressure (PI values above +6). An example is Enteropogon acicularis in the mulga habitat. Digitaria ceonicola, though less avidly sought is also under constant pressure. Management of these woodland communities should seek to preserve such valuable perennial grasses and diet studies of the type outlined here can provide evidence of the nature and extent of pressure being applied by cattle.

Acknowledgements

Thanks are due to W.A. Low for some initial planning, to C. Lendon for site selection and to K. Jones for help with the field collections. D.A. Little installed the oesophageal fistulas and D. Tongway did the chemical analyses. The cooperation of the landholders is much appreciated.

TABLE 1

DIETARY PREFERENCES BY CATTLE ON THREE CENTRAL AUSTRALIAN RANGELANDS

COMMUNITY	SPECIES	PREFERENCE INDEX * MAR.	JUNE	SEPT.	DEC.
WOODLAND					
Grass	Enneapogon polyphyllus	+4.4	+3.9	+0.9	+0.9
	Enneapogon avenaceus	-4.3	-	-	-
	Aristida contorta	+2.4	-2.9	-2.4	-0.1
	Enteropogon acicularis	+3.1	-5.7	+6.7	+3.8
	Digitaria coenicola	+3.9	+4.0	+0.9	+3.7
	Tripogon loliiformis	-4.5	-	-	-
	Triraphis mollis	+8.6	-	-	-
	Cymbopogon obtectus	-	+0.4	+6.8	-1.8
	Digitaria brownii	-	-2.3	-3.0	-2.5
Forbs	Sida spp	-	-4.1	+5.0	-0.9
	Boehavia diffusa	-	+1.3	+0.9	+5.5
	Pterocaulon sphacelatum	-	-	+6.4	-
	Indigofera dominii	-	-	-	-4.5
	Helipterum apiculatum	-	-	-	+9.0
Shrubs	Acacia aneura	-	+	+	+
	Acacia kempeana	-	+	-	-
Other	Fimbristylis dichotoma	-	-	-	-3.5
MULGA					
Grass	Aristida contorta	+1.1	-6.4	-1.3	+0.4
	Enneapogon polyphyllus	+5.9	+1.8	+2.6	-1.3
	Enneapgon cylindricus	+2.6	-	-	+9.5
	Panicum decompostum	+6.8	-5.3	+7.4	-0.1
	Aristida obscura	-	+9.6	-	-
	Enteropogon acicularis	+9.0	+9.6	+9.5	-
	Digitaria brownii	+2.0	+9.3	-	+2.2
	Digitaria coenicola	-2.0	+9.0	+1.8	+2.8
	Enneapogon avenaceus	-	+8.4	-	+9.8
Forbs	Boehavia diffusa	-	+0.5	-	-0.6
	Helipterum floribundum	-	-	-1.6	-
	Euphorbia drummondii	-	-	+0.5	
	Calotis latiuscula	-	-	-	+6.00

TABLE 1 (Contd.)

DIETARY PREFERENCES BY CATTLE ON THREE CENTRAL AUSTRALIAN RANGELANDS

COMMUNITY	SPECIES	PREFERENCE INDEX *			
		MAR.	JUNE	SEPT.	DEC.
MULGA					
Shrubs	Acacia aneura	+	-	+	+
	Acacia kempeana	+	-	+	-
MITCHELL GRASS					
Grass	Astrebla pectinata	+4.2	-0.1	+4.2	+3.0
	Iseilema membranicum	+6.6	+3.1	+5.2	-2.8
	Eragrostis falcata	-3.2	-2.5	-3.8	-2.0
	Dichanthium affine	+9.0	+3.3	+9.8	-
	Eragrostis kennedyae	-	+7.1	-	+9.8
	Panicum decompositum	-	-	+5.7	+5.9
	Enneapogon avenaceus	-	-	+9.8	+9.8
Forbs	Sida spp	-	+9.0	-	-

* Preference Index after Taylor (1973) see text

≠ No measure of shrub availability. The + signs indicate the degree of use

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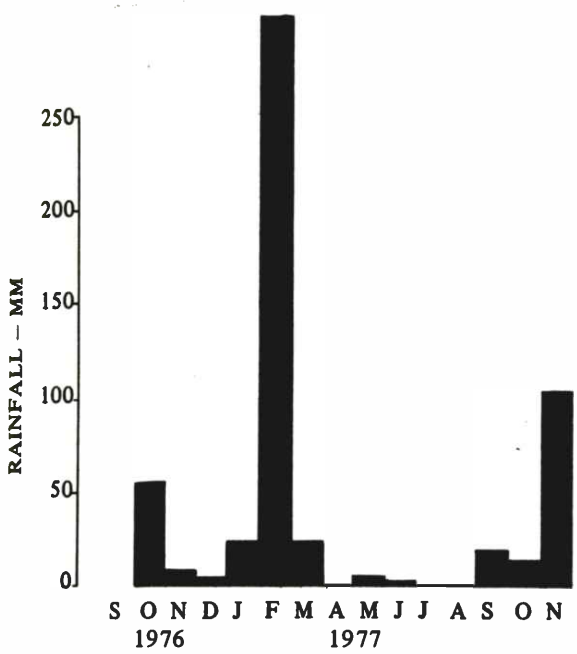


FIGURE 1: Rainfall registrations during the study period. There were slight differences between the sites but the pattern was the same.

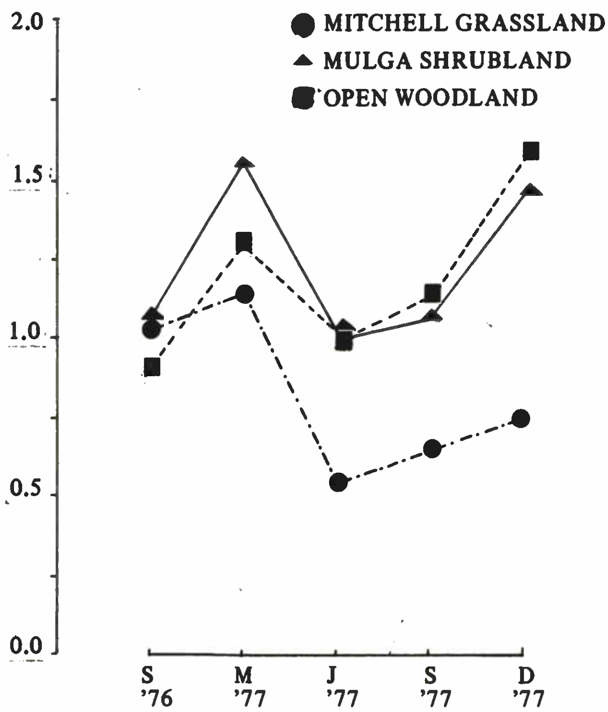


FIGURE 2: Seasonal changes in level of nitrogen in cattle diets on three plant communities in Central Australia.

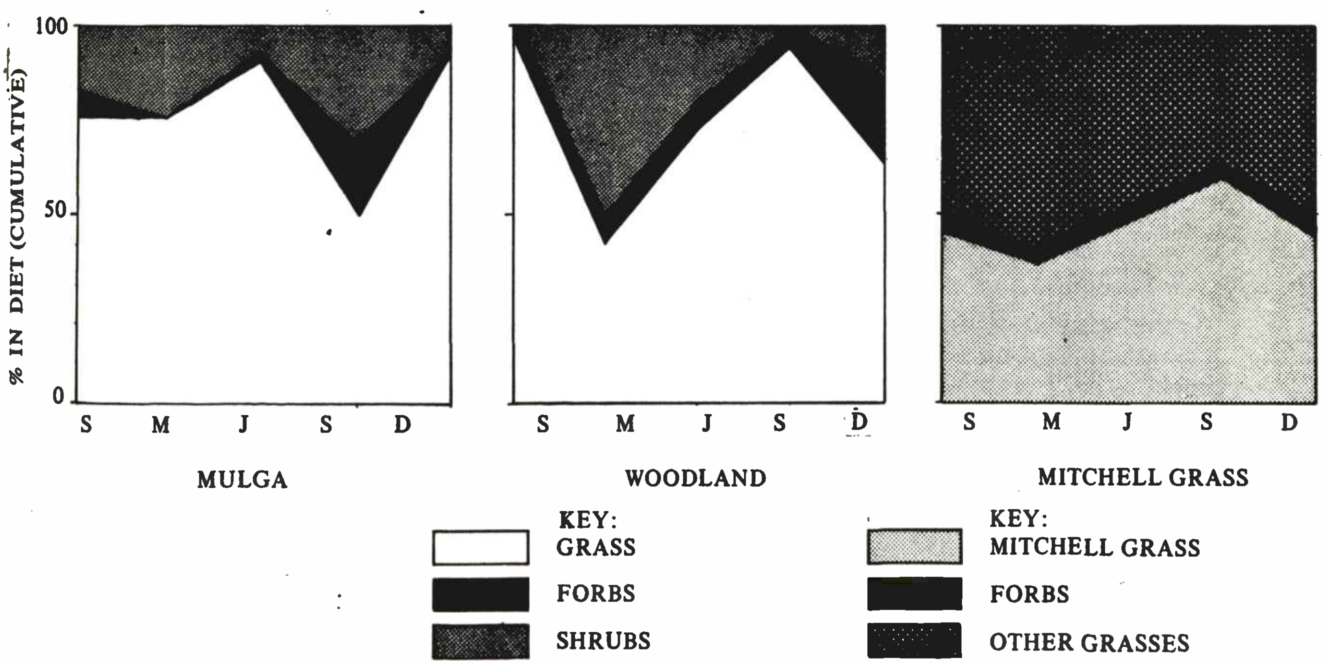
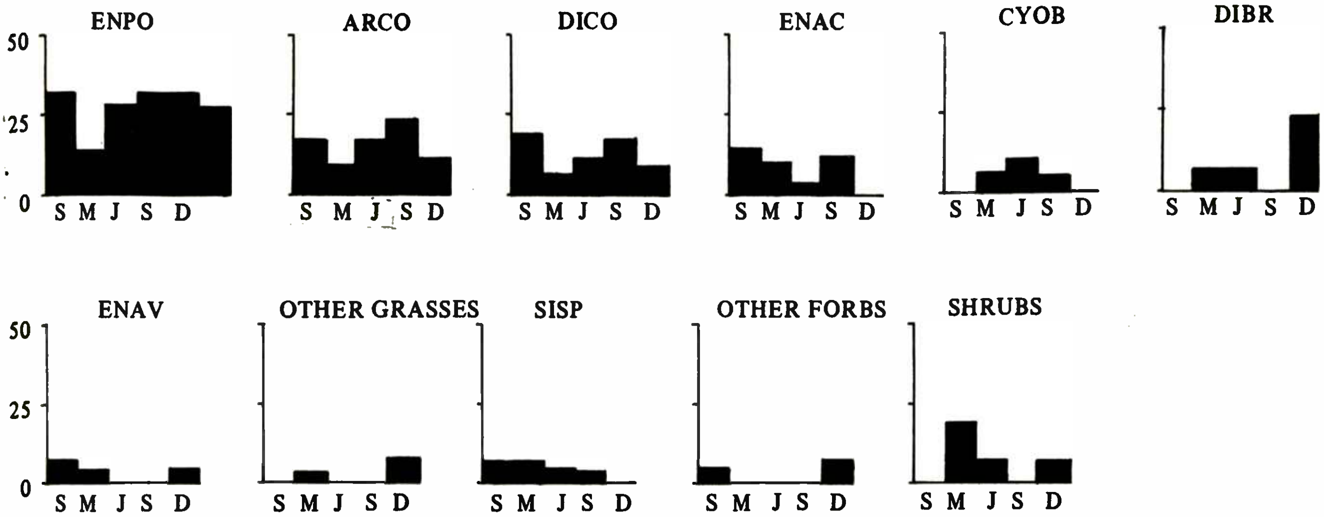


FIGURE 3: Seasonal variation in the contribution to the diet of cattle grazing three plant communities in the Alice Springs district.

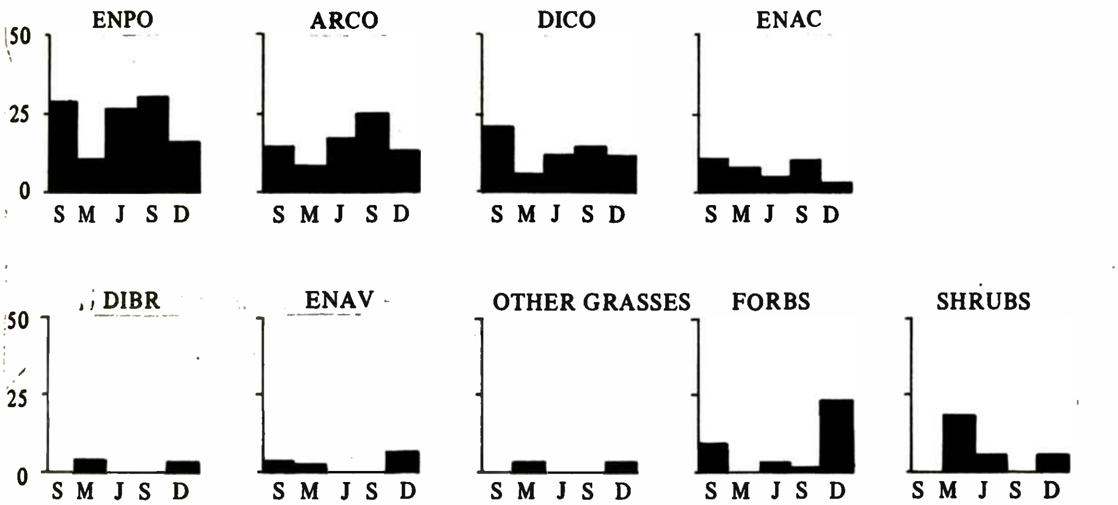
MULGA SHRUBLAND



KEY: ENPO *Enneapogon polyphyllus;* ARCO *Aristida contorta* DICO *Digitaria coenicola;* ENAC *Enteropogon acicularis;* CYOB *Cymbopogon obtectus; Digitaria brownii;* ENAV *Enneapogon avenaceus;* OTHER GRASSES mainly *Panicum decompositum, Tripogon loliiformis. Dicanthium sericeum;* SISP *Sida* spp.; OTHER FORBS mainly *Boerhavia diffusa, Euphorbia drummondi, Helipterum apiculatum;* SHRUBS mainly *Acacia aneura, Acacia kempeana*

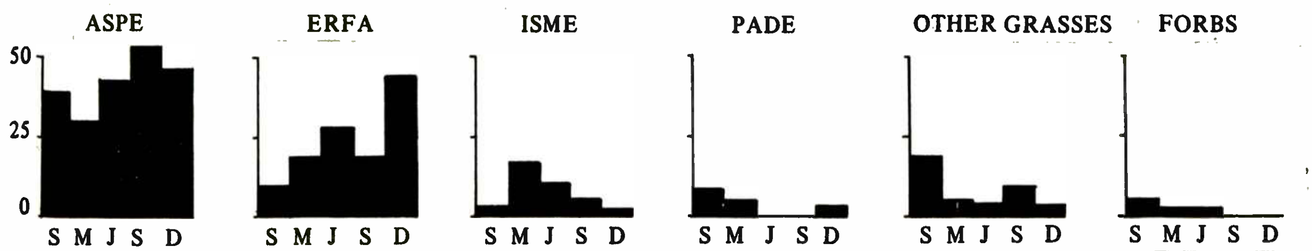
Figure 4. Seasonal variation in the diet selected by cattle on (a) Open woodland (b) Mitchell grassland and (c) Mulga shrubland in the Alice Springs district.

OPEN WOODLAND



KEY: ENPO *Enneapogon polyphyllus;* ARCO *Aristida contorta;* DICO *Digitaria coenicola;* ENAC *Enteropogon acicularis;* DIBR *Digitaria brownii;* ENAV *Enneapogon aveneaceus;* OTHER GRASSES mainly *Cymbopogon obtectus, Aristida inequiglumis;* FORBS mainly *Indigofera dominii, Helipterum apiculatum, Boehavia diffusa;* SHRUBS *Acacia aneura*

MITCHELL GRASSLAND



KEY: ASPE *Astrebla pectinata;* ERFA *Eragrostis falcata;* ISME *Iseilema membranaceum;* PADE *Panicum decompositum;* OTHER GRASSES mainly *Eragrostis exerophila, Enneapogon avenaceus;* FORBS mainly *Rhynchosia minima, Goodenia* spp., *Swainsona* spp.

ALTERNATIVE ENTERPRISES IN ARID NORTHERN TERRITORY

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Abstract

The history of traditional land use in the arid parts of the Northern Territory, based primarily on beef cattle, is examined, with particular reference to the major problems encountered by industries in the arid areas of Australia. Current land utilization is outlined and the potential of traditional and alternative enterprises suitable for this area are discussed with reference to the pastoral, agricultural, tourist and mining industries. The changing patterns of land ownership are also discussed.

Introduction

Australia's arid and semi-arid areas constitute almost 75% of the continent (Moore 1970), yet house only 2-3% of the population (Day 1976, Freer 1978). These areas have variously been termed Australia's 'arid zone' (CSIRO 1956), 'grazing lands' (Moore (1970), 'pastoral zone' (Lay 1976, Perry 1977), or more generally, 'rangelands' (Perry 1967). Nearly half the arid zone is unoccupied by European man and his livestock; the rest has been settled for livestock grazing for 80 to 120 years (Perry 1977). Despite this short period of settlement, many people are concerned about the current state of our rangelands. The Australian Biological Resources Study Report (Department of Science 1978, p.22) says, "The pasture lands of Australia....are mostly under such pressure from intensive grazing or too frequent burning that regeneration of many elements of native vegetation is inhibited". Day (1976 p.107) comments, "Over-grazing and land degeneration in some places has reduced productivity of the land for all time." Perry (1977, p.497) states, "....the more sensitive land and vegetation types have degenerated to poor condition, the more robust types remain in good condition and intermediate types are in moderate condition." Time magazine (Anon. 1977, p.22) reported from the first international Conference of Desertification in Nairobi that "The (Gascoyne) basin is being destroyed. By the 1950's, six decades of heavy grazing had left only 33% of the land fit for use. This concern is reflected in the CSIRO (1976, p.3) statement that "it seems that in Australia we have yet to come to terms with the difficulties of using our vast arid zone..."

These comments are particularly pertinent to the Northern Territory which covers one-sixth of the continent, and has two-thirds of its area classed as arid (Askew and Mitchell, 1978).

The history of settlement, and hence of productive endeavour in the Northern Territory is comparatively short when compared with eastern Australia. During this time there have been exploits of both success and failure, and even today many of the enterprises being undertaken can be considered of a 'pioneering' nature, either because of their remote location - the uranium deposits in Arnhemland - or innovative technology - the solar-powered microwave link between Tennant Creek and Alice Springs.

This paper looks briefly at the history of primary industry in the Northern Territory and examines several potential enterprises which could be suitably developed for the southern parts of the area.

Problems

Apart from the inherent problems of harshness and isolation, several tangible problems can be readily identified.

Transport

High transportation costs have hampered several enterprises and reduced market advantages in others.

The Port of Darwin has been troubled with labour problems, and is now by-passed by major shipping operators. Overseas beef exports are being sent through Wyndham Port which will soon be fully containerised.

The Darwin-Larrimah railway was closed in 1977, and the new high-speed Tarcoola-Alice Springs rail-link will not be completed until the early 1980's.

The Stuart Highway still remains unsealed between Pimba and the Northern Territory border, and though the Barkly Highway is fully sealed, it is often impassable in the 'wet'.

Air services to the Territory, although regular and reliable are extremely expensive.

Water

The provision of adequate and suitable water supplies has often been a problem in the outback. Extensive studies undertaken by the Water Resources Unit (NT) in 1978 have located an area between the Ooraminna and James Ranges (to the south of Alice

Springs) which "may provide excellent potential for farming development from the water resources point of view" (Macqueen 1978a). Several other promising areas have been located but need to be investigated further before any final recommendations can be made. The Ti Tree basin (to the north of Alice Springs) is also being re-examined. Work on the Tennant Creek basin (to the west of the town) has shown up some quality problems because of high fluoride and nitrate levels though it is still suitable for agriculture. Within the Alice Springs Town area, the unusually high water table in the town basin has been causing local salinity problems. Although the quantity and quality of water may not be a restriction, cost could well be, as the actual cost of supplying domestic water to Alice Springs is about double that actually paid by consumers (Macqueen 1978b).

Marketing and Infractructure

With the population of Alice Springs approx. 15 000* there are limited marketing opportunities within the area. The nearest larger centres are Darwin, Mt. Isa and Adelaide. Once transport costs are added to the cost of production, it is often not worthwhile

*1976 Census figures - 14 775.

attempting to market in these centres. For local consumption of fruit and vegetables, for example, retailers are reluctant to purchase off local growers unless continuity of supply can be guaranteed.

The new Territory Government has not yet encouraged alternative enterprises, particularly in primary industry, relying on the sale of traditional products. The first Northern Territory Trade Mission (Northern Territory Government 1978) to South East Asia and the Middle East concentrated its efforts in traditional areas such as cattle (both live and slaughtered), stock feeds and fisheries. There was only passing reference in the report to tourism, and none to alternative agriculture. Rather than determining what goods and services the Territory could supply, the Mission concentrated on selling traditional products. The Report noted that Singapore, Hong Kong and Japan appeared to be the only major viable markets because of their higher living standards, and whilst acknowledging several important constraints on successful trade, were not able to offer viable solutions to them.

The Pastoral Industry

Cattle

In the Centre, the greatest single boost to development was the completion of the Overland Telegraph in 1872. The first lease was taken up in the same year (Kirke, pers.comm.) and the industry in Central Australia progressed slowly, peaking at about 360,000 head in 1958 before crashing to below 120,000 following the 1957-65 drought (Newman and Condon 1969). With a depressed beef market and a run of exceptionally good years, properties in the Centre are now critically overstocked, carrying something like 200,000 head in excess of the 'normal' cattle population of 300,000 (Division of Primary Industry 1978). The beef industry in Australia has always followed a 'boom or bust' cycle due to the vagaries of both climate and markets. The restrictions placed on overseas markets (particularly the U.S.) were a severe blow in the Centre, especially as the allocation of an over-seas quota to the Alice Springs abattoir was a promise of increased prices to producers and the injection of $100,000 a week into the local economy (Department of the Northern Territory 1978b).

As the Bureau of Agricultural Economics (1978) points out, over half the pastoral properties (Australia-wide) made a cash loss in 1975-6. Hooper (1978) notes the situation that most stations in the Alice Springs District would be in debt to the tune of $100,000. Yet, despite this bleak economic outlook (the OECD predicts another beef glut for 1982), the Lands Administration, in the Northern Territory has persisted in granting a new pastoral lease in a marginal area.

The gross value of pastoral production in the Northern Territory has fallen from a high of $28.6 million* in 1972-3 to $9 million* in 1975-6, placing the industry third in importance behind mining and tourism. (Table 1).

The grazing of natural pastures is the only economic endeavour suitable for much of arid Australia, but it must be managed more efficiently to prevent further soil erosion and degradation of vegetation (Robinson 1978).

Sheep

Despite glowing predictions for a sheep industry put forward by Payne and Fletcher (1937), viz., 35,000

*Source - Australian Bureau of Statistics plus head for Central Australia, 1 million for the Victoria River District and 1.25 million for the Barkly Tablelands, this did not eventuate, for a variety of reasons, and there are only a handful of sheep present in the Territory today.

Agricultural Industries

Cropping

Large scale cropping enterprises have only been undertaken in the Top End* and have usually been 'an exercise in frustration' (Bauer 1978). Two examples are the rice project at Humpty Doo and sorghum at Willeroo. Across the border in Western Australia, the Ord River Project has not proved to be as successful as anticipated.

Forestry

Forster (1960, p29) commented that 'no forest resources of economic consequence exist'. Whilst that may be somewhat of an overstatement, results of experimental work carried out on suitable timber species in the Top End are not yet available.

*usually designated as that area of the Territory north of the fifteenth parallel, and outside the arid zone proper.

In Alice Springs, trials are underway on firewood production using sewerage effluent. Results to date show river red gum (<u>Eucalyptus camaldulensis</u>) to be the most satisfactory. It is eventually hoped to have over 50ha. planted (Territory Parks and Wildlife Commission 1978, p3). As in most arid areas, firewood is a scarce commodity in Central Australia and harvesting should be strictly controlled (Eckholm 1975). All available supplies at Ayers Rock have been depleted and coach-camping tours are now required to bring their own firewood into the park.

Lucerne

The cost of growing lucerne, except for special purposes, has generally been regarded as unprofitable (Forster 1960). Hyde (1978) has shown that quality lucerne hay for feeding cattle in transit, station horses, stud cattle, supplementary feeding for breeding stock, etc., can be produced on a station property for a lower cost than equivalent imported hay. Blue-green lucerne aphid was discovered in Alice Springs stands in June 1978. However, the aphid does not yet appear to have affected yields.

Fruit and Vegetables

There are problems such as continuity of supply, quality and cost, and the need for suitable varieties. However, it should be remembered that Alice Springs once supplied nearly all its own produce. In 1944 the army farms produced 1 481 tons, of vegetables (Forster 1960). In 1960, a small but active and profitable vegetable industry was thriving in the region (Forster 1960). In the last ten years, commercial vegetable production in the Alice Springs District has fallen from six tons per week to virtually nil (Division of Primary Industry 1978). The Alice Springs Farmers Association (ASFA) has called for the Division of Primary Industry (NT) to change its direction from "a traditional farming for the Alice outlook', to one of, What's on in farming in our time, the 1980's" (ASFA 1978). The potential is certainly there. Surveys carried out in Alice Springs by the Herbarium of the Northern Territory during the Mediterranean fruitfly eradication campaign of 1976/7 place a conservative value of the potential citrus production alone at $800,000 (Henshall and McKey, pers. comm.). It would not be hard to visualise a potential value of some $2 million for all home fruit and vegetable production in the District.

A private farm, established at Ti Tree (some 200km to the north of Alice Springs) in 1975, has already proved a commercial success, growing a variety of cucurbits, salad vegetables and grapes. With the dry hot weather and low humidity, crops ripen 4-6 weeks ahead of southern areas, giving a distinct marketing advantage (Department of the Northern Territory 1978a).

The Division of Primary Industry (1978) (NT) has initiated several horticultural projects at the Arid Zone Research Institute and other areas in the Alice Springs District.

Pistachio

This project is still in initial stages but shows promise of yielding $20 000 per ha. (Shaw 1978).

(Simmondsia chinensis)

The Jo Joba has been hailed as one of the new 'wonder' crops. Trials will commence in late 1978, following an original planting at Santa Teresa in 1969.

Utilization of Sewerage Effluent

Work is continuing at a planning stage to determine what plants would be most suitable for this project.

Some date palms have already been planted.

Other

Several new varieties and species have been introduced to test their suitability for the Alice Springs District.

Wine

As well as table grape production at Ti Tree and Alice Springs, there is also a commercial vineyard located on the outskirts of the Alice. Although only into its first vintage of 6,000 bottles, the vineyard should yield enough for some 100,000 bottles each year (Department of Industrial Development 1978).

Native Plants

Besides the low though sustained trade in native plants and seed to interstate markets, there is also an opportunity for the exploitation of the economic properties of many of the native plants of the area (e.g. Southwell and Maconochie 1977).

Other

Feasibility studies into apiary activities and large scale commercial egg and poultry production in the Alice Springs District have been initiated.

Tourism

Without doubt, the two best known of Australia's natural features would be the Great Barrier Reef and Ayers Rock. Referring to Alice Springs Webb (1969, p.179) says, "few centres in Australia are as widely known internationally or nationally". It must be remembered though that the tourist industry is a relative new-comer to the Territory. In their 1957 report on the Alice Springs area, Stewart and Perry (1962, p.18) comment, "with the development of more and better facilities tourism could rival the cattle industry in earning power". Tourism developed rapidly and is now the Territory's second largest industry, worth some $30 million annually (Northern Territory Tourist Board).

There is a need to improve visitor facilities and this is being accomplished with developments such as the proposed casino complex in Alice Springs and the proposed new recreational lake to the north of the town.

All the well-known major physical attractions *are under the control of the Territory Parks and Wildlife Commission (TP&WC). As part of the Commission's

*With the notable exceptions of Kukadu and Uluru (Ayers Rock - Mt. Olga) National Parks.

charter, it is required to 'conserve and protect the human and natural environment of the Northern Territory' (TP&WC 1978, p.1). This should ensure that the areas under its control are protected from too rapid or overdevelopment, ensuring a continuing resource. Already, visitor numbers to Ayers Rock are restricted to ensure facilities are not overloaded.

Mining

Although the mining sector is the biggest dollar earner in the Northern Territory (see Table 1), it is poorly represented in the arid zone with only one major mining operation located at Tennant Creek. Peko mines copper at the Tennant Creek deposits, also recovering gold and silver.

However, with a depressed copper price, the smelter was closed down early in 1978 and the mine's future is a little uncertain. The other known major mineral deposits of bauxite, manganese, silver, lead, zinc and more recently, uranium, are all located in the Top End. However, this is not to say the Centre is devoid of mineral potential. The original gold strike in the Territory was at Arltunga to the east of Alice Springs, uranium deposits are located to the west of Yuendumu and oil drilling has recommenced in the Simpson Desert.

Oil and natural gas were discovered at Mereenie in 1964 and natural gas at Palm Valley in 1965. The developer of these fields, Magellan Petroleum, has been unable to commence its proposed mini-refinery, first mooted in 1967. Feasibility studies have shown that it has the potential to supply the Alice Springs-Tennant Creek region with petroleum products. This includes supplying the NT Electricity Commission's generators (currently powered by fuel oil) directly with Mereenie crude (Hopkins 1978).

There is also potential for the development of alternative power sources. Windmills are a well-known feature of the Australian outback and Telecom has taken the lead in solar applications with the construction of the fully solar-powered microwave link between Tennant Creek and Alice Springs. The Australian National Railways will extend this link south to Tarcoola along the new rail-link.

Aboriginal Lands

With the passage of Aboriginal Lands Rights legislation and an increased awareness on the part of Aboriginal peoples, large areas of the Northern Territory may be subject to a change in ownership.

Some 30% of the Northern Territory is currently held by or under claim by Aboriginal groups. For the Alice Springs District this figure is 33% (Wasilensky 1978), and several other areas may shortly be subject to claim. It should also be remembered though, that Aborigines account for 93% of the total rural population of Central Australia (Griffin, pers. comm.). Under the terms of the Act, all unalienated crown land outside town boundaries is open to claim except where administered by a Trust or Statutory Authority. This legislation has been a great boost to the 'outstation movement'* and is assisting some groups in their efforts to return to a more traditional lifestyle. Much of the conflict between black and white over this issue has stemmed from white man's ignorance of the traditional Aboriginal's relationship with the land, a concept not present in Western culture.

The establishment of these outstations will require the provision of new facilities and services such as bores, housing and technical advice, and will mean a different form of land/administration (and tenure) to that experienced up to date. Locally, cattle raising and horticultural production will be important for these groups.

*the movement of Aboriginal people back to their homelands from settled areas.

<u>Conclusion</u>

The Payne-Fletcher Report (1937, p.85) commented, "the Northern Territory is not yet ready for self-government....The Commonwealth Government will need to continue for many years to come if not for all time." And whilst they considered it (p.87) "difficult to visualize much development in the way of closer settlement, mixed farming, or agriculture on the lands of the Northern Territory", it can be seen that there is potential in the Territory. Traditional activities such as beef cattle have a definite, if depressed, future; agriculture shows much promise for expansion in both traditional and alternative applications; tourism looks like growing into a healthy and sustained industry; mining has strong prospects; and power technology may well provide the Territory with new industries.

The criticism in 1937 (Payne and Fletcher, p.84) was that 'the government of the Northern Territory falls far short of what is needed.' At the third Northern Australia Development Seminar, the Chief Minister, Paul Everingham (1978) stated,..."The Commonwealth Administration of the Northern Territory failed to achieve anything more than very minor economic development, the task now lies ahead of the Northern Territory Government. We take up that challenge cheerfully knowing as we do that it will lead the Territory forward politically and socially as well".

Acknowledgements

I would like to thank those of my colleagues who were prepared to comment on the drafts of this paper; however, I would point out that the opinions expressed are those of the author.

TABLE 1. GROSS VALUE OF PRIMARY PRODUCTION IN THE NORTHERN TERRITORY ($'000)*

Activity	Years		
	1972-3	1974-5	1975-6
Pastoral	28 708	9 445	9 025
Agricultural	1 773	960	1 972
Other	846	1 774	1 984
Forestry	35	11	..
Fisheries	4 617	3 736+	..
Hunting	39	..	..
Mining	..	139 000	..

+ preliminary figures for 1977 (Department of NT) show all fisheries activities in the Northern Territory returned a gross value of $17.8 million.

*Source - Australian Bureau of Statistics

TABLE 2. VISITOR NUMBERS AND GROSS VALUE OF TOURISM IN THE NORTHERN TERRITORY **

Year	Visitor Numbers	Income ($'000 000)
1964[1]	28 000	4
1966[1]	41 000	13
1971[2]	69 000	19
1978[3]	120 000	30

** Sources: 1. Costin and Mosely (1969).

2. Department of the Interior, Northern Territory Report 1970-1.

3. Northern Territory Tourist Board.

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HORTICULTURE FOR THE PASTORAL AREAS

M.B. SPURLING

Roseworthy Agricultural College

It has been said that agriculture makes life possible but horticulture makes it more enjoyable and I do believe that there is a place for horticulture in the pastoral areas.

Horticulture covers the whole range of:

* fruit and vegetable production,
* growing trees and shrubs for ornamental and aesthetic purposes, and
* the growing of trees for shade, shelter, fence posts and other non forestry uses.

Each of these aspects of horticulture has an application in the pastoral region.

Limitations to Growing Horticultural Crops

The growing of any crop is dependant upon satisfactory soil and climatic conditions.

In the case of annual crops, farmers plan for variations from season to season in climatic factors. They accept paddock variability and good seasons and bad seasons, even crop failures, as part of the management associated with agricultural crop production. However, the growing of perennial crops requires that provision is made to ameliorate the soil and climatic conditions to enable the crops to at least survive from season to season.

The important climatic factors affecting perennial crops are solar radiation, water supply and wind.

Solar Radiation

The temperature regime of a region can only be ameliorated to a limited extent so that we find the perennial crops classified as cool temperate, warm temperate, sub tropical and tropical crops. For example the commercial growing of cool temperate crops like cherries and the berry fruits is confined to regions like Tasmania, southern Victoria and the Adelaide Hills. Tropical crops like bananas and pawpaws are only found growing commercially on the northern coasts of Australia. This does not mean that these crops cannot be grown outside these regions for home garden purposes for which some loss of production due to less than optimum growing conditions is acceptable. The amelioration of temperature conditions is relatively difficult although in some regions of the world, shade crops are used to enable crops with a lower temperature requirement to be grown. In the Imperial Valley of California citrus are grown under a shade crop of date palms. The modification of tree shape by pruning can provide some protection against sunburn.

Frost damage can usually be avoided by not planting in frost liable sites such as low-lying hollows and, for farm gardens, by planting close to the house or other buildings which provide some protection against frost.

Wind

Protection from wind is relatively easy by the provision of adequate wind breaks and this should be regarded as an essential part of the planning for farm gardens.

Soil

Soil and water are the two most important factors to be considered in the growing of horticultural crops. Lighter textured soils are usually preferable to heavier soils and for perennial crops the soil must be well drained to avoid water logging. Deeper sandier soils should be selected in preference to the heavier soils. In the case of fruit and vegetable gardens, the high value of the crops justifies carting in sand to improve the soil conditions in what is otherwise an acceptable site for the garden close to the house and other buildings.

A minimum depth of one metre (3 feet) of sand to sandy loam soil is desirable for the growing of trees and vines to provide an adequate root zone soil volume for holding the water supply of the tree.

Water

An adequate water supply is the most criticial consideration for the growing of perennial crops. Two approaches can be made - water harvesting to improve the supply in a limited rainfall area and secondly, ways of conserving a limited supply.

In the case of trees being grown for shade and shelter or fence posts, the natural rainfall can be harvested by collecting and concentrating the run off from slopes as is normally done in the management of farm dams. The harvesting of water in this manner is used in Israel to grow commercial fruit crops in 100-125 mm (4-5 inch) rainfall country. The run off from hills and rocky slopes is collected by means of furrows at the base of the slopes and run into border checked orchard plantings at the foot of the hills to give an effective rainfall of 625-750 mm (25-30 inches) which is sufficient for commercial growing of these crops. The same principle may be used in the pastoral areas for growing shade trees and timber trees. The growing of some crops such as tropical nuts and date palms commercially using this technique may be considered.

The quality of underground water supplies in the inland areas of Australia is usually not good enough for the growing of perennial fruit crops and the harvesting of surface water must be considered as the alternative. Generally speaking the rain water from the buildings associated with the house is fully utilised for domestic purposes but sometimes the rain water from the out buildings is not fully utilised. The main source of a substantial quantity of rain water is obtained by building dams on ephemeral creeks or by pumping from such creeks into tanks or turkey nest dams adjacent to them. The pumping of water from shallow aquifers under or adjacent to such creeks may be the most appropriate source of water.

A limited water supply can be conserved by using drip irrigation or by using a perforated pipe sunk into the ground along side each tree for watering. The use of a surface mulch of farm manure, grass and leaves or even pebbles and rocks is essential in areas of limited water supply to reduce the evaporation losses from the soil.

Pests and Diseases

There are other problems such as birds and white ants which are problems in the growing of fruits and vegetables in the garden associated with the inland homestead. However, the isolated garden has an advantage in relation to other pests and diseases. Dry, hot conditions mean that most of the diseases are avoided and the isolated conditions mean that most of the pests can either be avoided or controlled biologically with a little care.

What to Grow

For shade and shelter the most appropriate trees to grow are those which are found growing naturally in the region. However, by using the principle of water harvesting suggested, trees from higher rainfall regions can also be grown quite satisfactorily. The most likely source of suitable trees to grow is from regions with a similar climate. In the pastoral country there are many perennial trees and shrubs which are seen only in periods of above average rainfall or found growing along water courses. These species can be assumed to be adapted to the temperature conditions of the region and grown successfully with provision of a better water supply than is obtained from the natural rainfall.

A wide range of fruits and vegetables have been grown commercially with considerable success at several places in the inland of Australia. At Wiluna in Western Australia, at Ernabella in South Australia and at Alice Springs, most of the temperate and tropical crops have been grown at least on an experimental basis by careful selection of the site to provide suitable soil conditions and ameliorating the climatic conditions in the ways which have already been mentioned but particularly by the provision of water for irrigation.

In the case of vegetable crops there are some like tomatoes and the cucurbits which can be grown relatively easily while others like beans and lettuce are more particular in their water quality demands. Similarly there are very few localities where grapevines cannot be grown, and, with a little care, oranges and lemons and other citrus fruits. The warm temperate deciduous fruits like apricots and peaches and some of the plums can be grown under a wide range of conditions.

Is It Worth The Trouble?

I believe that with modern methods of fruit storage and processing, some crops like beans and peas which can be obtained as quick frozen ready-to-use products and some of the canned fruits which are available in an easily stored and conveniently used form are the last that we might consider producing in the station house garden. At the other extreme, fresh grapes which are usually not available at long distances from the areas of commercial production but which can be grown easily and fruits like lemons and oranges which are most welcome as readily available, fresh off the tree whenever they are wanted, and similarly some of the vegetables like tomatoes and cucumbers which can be grown easily and are most welcome fresh from the garden are worth the effort of growing them in a garden near the homestead.

The planting of trees and shrubs for shade, and beautification near the house and around the other buildings may not increase the income directly but is fully justified as one step towards improving the appearance and the general living conditions of the station homestead.

Further Information on Horticulture

During the last two years a course on Horticulture for farmers' wives has been developed here and presented in the mid north and on the west coast with considerable success. The course is designed to encourage the use of horticulture in farming/pastoral regions.

I believe that horticulture does have a place in the pastoral regions of inland Australia as one means of improving the quality of living and reducing the dependency on obtaining fruit and vegetables at considerable cost from elsewhere.

GROWING TREES IN THE ARID ZONE

K.D. Afford

Eringa Park Station, Olary, S.A.

Reasons

- Shade
- Windbreak
- Fuel
- To purify air
- Attract birds which in turn help control garden pests
- Control weeds
- Break monotony of the arid landscape

Where

My experience is drawn from a limestone soil area in the 200 mm rainfall belt, where there is a marked summer incidence of effective rainfall and where as little as 60 mm, to as much as 600 mm, has fallen in one year.

Although some of the species which are successful here may not adapt to other soil types, I am sure my principles can be adapted to any area where rainfall is marginal or unreliable.

Rainfall and spacing relationship

Because seedlings are so small it is too easy to underspace at planting time. Hence a good rule of thumb is:

$$\frac{230}{\text{Rainfall in cms.}} = \text{Plant spacings in metres.}$$

This will give a distance between trees which will ensure optimum growth rates on relatively flat country. Naturally if run-off can be harvested into drains or pools this distance can be lessened dramatically. I find it a very effective guide. Viz. Where your rainfall equals 10 cms. P.A. minimal spacing would be 23 metres or 25 cms. rain spacing at approximately 9 metres.

Where to Plant

No area is so flat that it will not run water or receive water from another area. The roofs of sheds, overflow from tanks, low lying areas of roads all yield primary examples of the best places to initiate plantings. Naturally one should attempt to overcome any local problems in initial plantings - i.e. break up prevailing winds, provide shade, add contrast, etc.

Having chosen a site excavate a hole 600 x 600 x 100 mm and leave the up hill side open. If a bulldozer or any other machinery able to shift soil is available - contour ripper, grader etc., use these to advantage to harvest water, either to draw water to your chosen site or to excavate alongside so that in the event of a big rain local water is collected and made more effective for the nearby plants. A quick fall of rain can provide many hundreds of litres for the tree if a little pre-thought is given. Trees that may not survive on a given rainfall will do so admirably if a little thought is given to the harvest of water. Harvest that water!

On very flat areas it may be necessary to run small division drains several metres on one or both sides of the hole. Observation of run off during rain is a great help. Get out in the rain and take pieces of wire, sticks, or any other temporary marker and leave these inserted in the ground at points of water run - you may have to get up in the middle of the night: it is worth it, as it will eliminate guess work.

There is no getting away from a bit of pick and shovel work and therefore it is a lot easier to prepare next year's plantings after a rain and maybe months before - this is really beneficial.

Time to Plant

The best time is in March and if possible immediately following a rain. Plants are readily available, soil is warm and inducive to growth before the winter cold, and chances of effective rain are high.

Whilst March is acknowledged as the best time - largely the nurseryman's point of view - seasons in the Arid Zone tend to vary so much that local knowledge is necessary to make that final important decision. There should be a back up of water to see your plants through their first twelve months and if for example, dams are dry in March and not filled until October; plant then. I have lost plants for two reasons:

1) Planted without adequate water back up;
2) Planted where I have harvested water too well - drowned.

My best plantings have ranged from February through to September.

Guards

In most of the arid zone rabbits, goats and kangaroos prevail. Domesticated animals such as horses and the milking cow have inquisitiveness deleterious to plants - one bite for curiosity, a quick spit out for unpalatibility and six months hope down the drain. Effective guards are necessary.

These should be wide enough to allow the tree to naturally bush out. Wire netting is too expensive and does not afford wind protection in the vital early stages. Drums tend to burn off the seedlings. Five line sheep cyclone made into 400-500 mm diameter cages interlaced with turpentine (Eremophila sturtii) is ideal, cheaper, a little slower, but really one of the best guards available as it can be made quite rabbit proof, is a good wind protector preventing drying out of the soil in the shade-mulch-form, and will last for at least five years at which time with a little more lacing will give service for new plants.

At Planting

Take a pick, a shovel - preferably one cut down to 100 mm wide with the shoulders of the spade/shovel left wide enough for the foot and the digging part not much larger than the hole required for the tube.

Do not break up more ground than is necessary as this can cause air pockets which may dry out the plant roots and result in losses.

Getting the plant into its natural surroundings immediately is important. Do not try digging holes with post hole borers or filling with soil from elsewhere - use your own environment.

At planting, water with 20-40 litres of water and be sure to label each tree with botanical name and date. Don't rely on memory. B or 2B pencil on weathered galvanised iron makes lasting labels (10 years);tie these to a steel stake with tie wire.

A further watering at 2 weeks and then at monthly intervals is necessary without effective rainfall.

Effective rainfall cancels any planned watering which will be dated from the last rain. The guide of monthly watering of 20-40 litres for the first twelve months is quite adequate.

In the event of a drought waterings can be ceased in March the following year and the plants will carry on quite well in the following Autumn through the Spring and beyond.

I have had plants do this with only 100 mm of rain for 13 months and with only one water run and no fall over 8 mm. It is under those circumstances that well chosen natives planted in this manner thrive.

Tables 1 & 2 list species planted at Eringa Park and comment on their suitability.

TABLE 1. LIST OF TREES PLANTED AT ERINGA PARK BEFORE 1972 WITH COMMENTS ON THEIR SUITABILITY

Name	1978 Measurements Height (m)	Age (Yrs.)	Comments
Acacia			
beckleii	0.9	9	Indeterminate.
Oswaldi	1.2	10	Slow. Native to area.
pendula *	3	10	Excellent.
pycnantha ⁜*	4.6	9	Excellent.
saligna	3	7	Excellent in watershed.
Wattsiana	3	5	Cut out as nuisance in the garden.
Brachychiton			
populneus (N.R.)	4.6 +	20 +	Slow/hardy. Dirty.
Casuarina			
cristata	1.5	7	Slow - native to area.
glauca	6.1	10	In favoured position.
stricta	3.7 +	10	Worthwhile.
Eucalyptus			
astringens *	4.6 +	8	Excellent.
brockwayi *	3.7	8	Excellent.
burdettiana ⁜*	4.6	10	Excellent.
camaldulensis *	7.6 +	20	Excellent but needs run-off.
Cambageana	4.6	9	Excellent. Needs run-off.
Campaspe	3	9	Excellent.
cladocalyx - var. nana	3.7	8	Excellent.
Clelandi *	4.6	9	Excellent.
Comitae Vallis - var. brachycorys	2.7	10	Excellent. Needs run-off.
decipiens	2.4	10	Doubtful.
diptera * ⁜	3.7	9	Excellent.

* - Highly recommended.
⁜ - Attractive flowers.
N.R. - Not recommended.

Name	1978 Measurements Height (m)	Age (Yrs.)	Comments
Eucalyptus			
dumosa *	3.7	9	Excellent. Hardy.
Dundasi *	4.6	8	Excellent.
Ebbanoensis	3	9	Worthwhile.
erythrocorys	-	-	Killed by -5°C Frost. Retrying.
erythronema	3	15 +	Worthwhile.
erymophila	4.6	10	Excellent.
erythronema - var. marginata	3	15 +	Worthwhile.
falcata	-	-	Failed. One still struggling.
Flocktoniae *	3	10	Worthwhile.
foecunda	1.2 +	10	Slow. Indeterminate.
Forrestiana	1.2	10	Slow. Indeterminate.
Gardneri	4.6	10	Excellent.
gomphocephala	7.6 +	20 +	Excellent. Subject to borers and die back.
goniocalyx	3	10	Name in doubt.
goniantha	2.4	10	Prolific flowers.
gracilis	2.4	8	Excellent.
grossa	2.4	10	Straggly. Prolific & long flowerer. Indeterminate.
intertexta	2.4	8	Worthwhile.
Landsdowneana	2.4	8	Worthwhile.
largiflorens	2.4	8	Name in doubt.
Le Souefii	4.6 +	9	Excellent.
longicornis	2.4	7	Name in doubt.
macrocarpa	-	-	Failed. Retrying. Doubtful.
microtheca	3	9	Excellent.
Morrisii	2.1	9	Indeterminate.
nutans	1.2	10	Indeterminate.
oleosa v. Rochii	2.1	9	Excellent. Windbreak.
oleosa v.plenissima	2.1	9	Excellent. Windbreak.
orgadophila	3	9	Worthwhile but needs a favoured spot.

* Highly recommended.

Name	1978 Measurements Height (m)	Age (Yrs.)	Comments
<u>Eucalyptus</u>			
panda	0.6	10	Failed. Only one tried.
pileata	-	-	Failed in 1978 at 2.4m.
platycorys	3	10	Satisfactory.
pyriformis	-	-	Failed. Will retry.
salmonophloia	3 +	9	Worthwhile.
salubris *	4.6 +	10	Excellent.
redunca - v. melanophloia *	4.6 +	10	Excellent.
Sargenti	3	8	Worthwhile.
spathulata	3 +	8	Worthwhile. Windbreak.
socialis	2.4	7	Excellent.
steedmanii	3	8	Excellent.
stoatei ⁜	2.4	8	Excellent.
Stricklandi * ⁜	3 +	9	Excellent.
torquata * ⁜	3 +	10 +	Excellent.
torwood * ⁜	4.6	9	Excellent.
transcontinentalis	3	9	Excellent.
trivalis	0.9	8	Doubtful.
uncinata	2.4	10	Excellent. Windbreak.
Urrbrae gem	3	10 +	Excellent.
viridis	6	10	Excellent on favoured spot.
Wandoo	3.7	8	Worthwhile.
Woodwardi * ⁜	4.6 +	10	Excellent but variable.
<u>Melia</u>			
azedarach	4.6	10	Needs supplementary water.
<u>Pittosporum</u>			
phyllyreoides	1.5	8	Excellent. Native to the area.

* Highly recommended.

⁜ Attractive flowers.

TABLE 2. LIST OF TREES PLANTED AT ERINGA PARK SINCE 1972

Name	Year of Planting	Height (m)	Comment
Acacia			
argyrophylla	1976		
calamifolia	1974	1.5	Garden only.
cyanophylla	1976		
calicola	1976		
imbricata	1976		
implexa	1976		Quick.
iteaphylla	1976		Does well in gardens.
Murrayana	1976		
salicina	1976		
tarculensis	1976		
Callistemon			
teretifolius	1976	-	Failed.
Callitris			
columellaris	1976		Slow.
Cassia			
artemoides	1974	0.9	Garden only.
Eucalyptus			
Clelandi	1974	2.1	Good. Orange flowers.
caesia	1978		
presii	1974	-	Failed.
pimpiniana	1978		
erethrocorys	1978		
Lehmannii	1978		
maculata	1978		Retry.
Hakea			
laurina	1974	-	Failed.
Melaleuca			
armillaris	1974	1.5	Good. Needs water.
halmaturorum	1978		
nesophylla	1974	1.2	Garden only.
Pinus			
halepensis	1974	0.6	Indeterminate.

TABLE 2.

Footnote:

As 10 years is deemed necessary to give a guide to a tree's worth, this list will be of most interest to those familiar with the plants' names and who can associate them with other areas.

However, due to the extended drought from October 1976 to December 1978 (time of writing), any tree planted before then and still growing must receive serious consideration for further plantings as there was only 75 mm of rain in the period 14th October 1976 to May 1978 and most trees received no additional water after February 1977.