FINAL REPORT

TO

THE AUSTRALIAN WOOL CORPORATION

ANIMAL PLANT INTERACTIONS IN
NATIVE PASTURES OF WESTERN QUEENSLAND
(W.R.T.F. K/2/900C)

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QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

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ANIMAL PLANT INTERACTIONS IN NATIVE PASTURES OF WESTERN QUEENSLAND

Project number K/2/900 (C)

(Previously part of K/2/900 (originally W.R.T.F. Project 6) - Pasture Improvement and Forage Cropping)

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ABSTRACT

When this project began, there was little detailed knowledge of the soil-water-plant-animal complex and their interactions in western Queensland. In the course of the project the state of knowledge of this complex has been expanded greatly. It has increased our appreciation of the productivity potential of the area and of the effect of drought on both production and land stability. The value of this project is indicated by the large number of associated publications dealing with management in the mitchell grass and mulga regions, and the successful extension of this information to graziers.

Management requirements are summarized below:-

(i) Environmental determinants of animal production.

* Rainfall variability in amount and effectiveness is the primary factor limiting pasture growth and hence animal production.

* Ninety percent of potential grass production in mulga pastures occurs in the October-March period.

* Mitchell grass soils are inherently fertile while mulga soils are quite infertile, being characterized by a strongly acid profile, low nutrient availability (notably phosphorus) and surface sealing which contributes to significant rainfall run-off.

* Woody plants tend to dominate rangelands, especially on infertile soils. As the environment becomes harsher,shrubs will tend to dominate rather than trees, where the physiologically more efficient life form of the shrub is needed for persistence.

* In induced grasslands or savannah there is an inverse curvilinear relationship between woody plant density and pasture yield. But unlike higher rainfall regions, many of the trees and shrubs of the inland are important sources of browse for domestic animals.

* Surface water is generally not a problem in mitchell grass and mulga systems and the underlying artesian basin ensures relatively even use of these rangelands.

(ii) Managerial determinants of animal production.

* Pasture stability and animal productivity on semi-arid rangelands are affected by many factors such as soils, vegetation type, rainfall, stocking pressures, industry economics,etc. Of these factors, the most readily manipulated by the grazier are concerned with his stock e.g. types of animals being grazed, stocking pressures and time of shearing.

* Stock numbers should be adjusted to the feed available. In practice this means that carrying capacity is largely determined by the numbers that can be safely carried in poor seasons.

* Animal production, as opposed to liveweight maintenance, is largely influenced by the availability and accessibility of broad leaf plants ('nutrient accumulators') in the pasture.

* The need to improve animal productivity has to be balanced against the need to promote stability through the maintenance of a high proportion of perennial grass in the pasture. There is clear evidence that interseasonal variation is markedly greater where the vegetation is comprised of mostly annual species. For this reason, along with the difficulty of establishing grass species on infertile soils, basal area will generally override composition as the principal determinant of grassland condition.

* Utilization levels should be adjusted so that consumption does not exceed 20 percent of end-of -summer production in mulga grasslands and 30 percent of this in mitchell grasslands. In practice, stocking levels should be such that 12 months after grass growing rain has fallen there is still a good coverage of stubble on the pasture. There is little evidence that rotational or other grazing systems in Australian rangelands improve vegetative cover or animal production over continuous grazing systems. By corollary, as far as it is practical, animals should be segregated within herd or flock structures but allowed freedom of movement within uniform land units.

* The minimum requirement of animal management is disease and parasite control. Mineral supplementation is beneficial in certain situations but it is not a panacea to nutritional stress in mulga and mitchell grass systems.

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SECTION I. PRECIS FOLLOWING A.W.C. SUGGESTED FORMAT

TERMINATED PROJECT K/2/900 (C)

Animal,Plant Interactions in Native Pastures of Western Queensland

(a) Definition of the Project

This project aimed to establish production functions for semi-arid grasslands and shrublands by integrating animal production levels, pasture utilization levels and pasture stability. This would allow the assessment of the most economic grazing strategies, while protecting the land resource.

Experiments associated with K/2/900 (C) were located at "Burenda", of Augathella, "Arabella", near Charleville, the Charleville Pastoral Laboratory and Blackall. Research associated with W.R.T.F. Project 6 also took place at Cloncurry, Richmond and "Toorak" near Julia Creek (Figure 1).

(b) Objectives

This project was originally part of a much larger project that started in 1957 as W.R.T.F. Project 6 - Pasture Improvement and Forage Cropping. The broad aim of this project was "to achieve a better understanding of the soil-water-plant-animal relationship in the sheep grazing and wool growing areas of Queensland. In particular the practical end point was the production of a more continuous supply of higher energy and /or protein forage for sheep, greater stability of numbers and higher efficiency of wool production" (W.R.T.F. Project 6 Report, 1969). Project 6 was renumbered K/2/900 in 1973.

K/2/900 (C) was split off this larger project (K/2/900) in 1978. Its objectives were:-

(i) To monitor the reaction of perennial grasses to various grazing pressures and mechanical defoliation levels and frequencies.

(ii) To determine the influence of grazing pressure on wool production and wool growth rate.

(iii) To examine and compare the diets selected by sheep and cattle on established mulga pastures and of sheep on mitchell grass pasture.

iv) To define the nutritional value of mulga and mitchell grass pastures for sheep.

Work carried out in these fields prior to 1978, that has not been covered in a final report to the A.W.C., is also included.

(c) Outcome

This project involved some 74 experimental programmes from 1957 to 1983 (Appendix 1). These have been subdivided into five subsections, the main findings of which are highlighted below.

(1) Germination and Establishment Studies with Native Species.

* Native legumes are normally hard-seeded and need scarification before they will germinate. Grasses germinate better as caryopses, but, in this form, Thyridolepis and Monachather are susceptible to pathogenic attack during germination.

* Most native pasture species will germinate over a wide range of temperatures (15-35^{o} C), with no strong requirement for alternating temperatures or light.

* The most effective scarification for mulga seed is immersion in boiling water for 1 minute.

* In the field, emergence of native species is common after falls of rain greater than 25mm, except in mid-winter.

* Very few grass seedlings ever emerge in the field between June and mid-September.

* From 3 major germination events in the 30 months of 1969/71 an average of 10% of seedlings survived to first flowering, though grasshoppers damaged many. Aristida spp. averaged 125 days to first flowering, while other perennials took 193 days. Annuals needed only 60 days to flower.

* Vegetated areas have a much higher seedling emergence than adjacent bare areas, though a slightly higher % of those established survive on bare areas.

* Native forbs lose hard-seededness slowly in the field. Most species (including grasses) retain a significant amount of dormant seed after 12 months.

* Only saltweed seeds lose viability rapidly when held in dry laboratory storage.

(2) Growth Studies in Glasshouse and Field

* Phosphate fertilizer is rapidly fixed in mulga soil (3 - 6 months).

* Rate of water loss from mulga soil is similar to that from free water until the surface dries visibly, then the rate of loss diminishes rapidly. Differences in profile depth did not affect the initial rate of loss.

* Maximum summer growth rate for Aristida spp. was 92 kg DM ha^{-1} d^{-1} with winter rates 10% of this. Maximum summer herbage produced was 3600 kg ha^{-1} (compared with a winter value of 570 kg ha^{-1}), with a summer root production of 1065 kg ha^{-1}.

* Aristida spp. had a greater reproductive capacity than Thyridolepis mitchelliana or Digitaria ammophila. The exotic Anthephora pubescens yielded more but grew more slowly.

* Water use efficiency of the exotic grass A. pubescens was higher than for T. mitchelliana, Aristida spp. and D. ammophila.

* Differences in the pattern of root development between species may be related to differences in seedling drought survival on infertile soils.

* The optimum temperature for growth for Thyridolepis (mulga mitchell grass) was 25° C, while that for Astrebla (mitchell grass) and Cenchrus ciliaris (buffel grass) was 30° C. Phosphorus supply and soil moisture deficits reduced growth rates.

* Photosynthesis response curves to light intensity and carbon dioxide concentration showed mulga mitchell to be a C_3 grass.

* Buffel grass (and to a lesser extent mitchell grass) showed a much larger yield response to increasing phosphorus supply than did mulga mitchell, and the latter had a lower relative growth rates. Mulga mitchell required lower external phosphorus concentration for optimum growth. This was attributed to a superior system for absorbing and transporting this element from low concentrations.

* Yield response of Astrebla spp. and Aristida leptopoda increased up to 30° C, and then declined. At that temperature, their relative growth rates were 0.33 and 0.22 g g^{-1} d^{-1} and seedling root extensions of 257 and 89 cm d^{-1} respectively. Root standing crops were 4 360 and 1 610 kg ha^{-1} respectively, with over 75% of this root mass in the top 40 cm.

* There are substantial differences in relative growth rate and dry matter accumulation rates for grass species from south west Queensland. Buffel grass (C. ciliaris) accumulated 10 times the dry matter of mulga oats (M. paradoxa) or mulga mitchell (T. mitchelliana). C. ciliaris and Astrebla lappacea (mitchell grass) had the highest proportion of roots and the smallest of inflorescences, while A. jerichoensis was the reverse.

* Clipping caused a reduction in root growth of grasses such that, 4 weeks after clipping, root weights were similar to those at the time of clipping. Tops recovered much faster than did roots.

* T. mitchelliana has its embryonic leaves and inflorescences raised further above ground than does A. jerichoensis, and is therefore more vulnerable to heavy grazing.

* Regrowth of T. mitchelliana after clipping lagged behind that of A. jerichoensis. T. mitchelliana was unlikely to survive 80% defoliation at 10 weeks of age, implying the need to destock at times of seedling regeneration to preserve it.

* Burning, clipping and the application of nitrogenous fertilizer did not reduce populations of Aristida armata without adversely affecting those of T. mitchelliana and M. paradoxa.

* Grazed mulga seedlings were essentially the same height after 3 years as at the start of the experiment, whereas ungrazed ones had grown sufficiently for the lower branches to be out of reach of sheep. Overall 35% of these trees died, following protracted periods of dry weather, with grazing seeming to have little effect.

(3) Studies on Plant And Animal Production in the Field

* Cultivation to 125 mm depth reduced populations of both *Aristida latifolia* (feathertop) and *Astrebla* spp. (mitchell grass). Light cultivation, mowing, burning and fertilizer treatments made no difference to species composition. Heavy stocking, followed by complete rest, may have been the cause of the reduced feathertop population and a 20 fold increase in mitchell grass.

* Mulga communities yielded up to 1320 kg ha^{-1} of air-dried pasture, in one summer season, with 2240 kg ha^{-1} from mitchell grass areas. Sown buffel grass pastures yielded more.

* Buffel grass grows better under canopies of poplar box (*Eucalyptus populnea*), due to higher soil fertility levels. Areas under canopies (up to 7%) produce up to 20% of the total herbage available on a per hectare basis.

* The occurrence and vigour of mitchell grass appears to be influenced by surface micro-relief.

* Total defoliation of mitchell grass causes an initial increase in plant population due to break-up of tussocks, along with a decrease in plant cover and dry matter production. Removal of 50% of current years stem growth did not reduce plant vigour.

* Fire in mitchell grass increased tussock number, without affecting basal area. Dry matter production, two years after burning, was similar in burnt and unburnt plots. Most mitchell grass tillers died within three years of being produced. Very low and very high rainfall resulted in reduced formation of new tillers in the unburnt areas. Flowering and seed-set were stimulated by fire. Emergence of flinders grass (*Iseilema* spp.) seedlings was lower on burnt areas.

* Buffel grass is better at colonizing bare areas than black spear grass (*Heteropogon contortus*).

* Buffel grass pastures had higher peak standing crop for green forage and roots (1940 and 5250 v/s 1220 and 1110 kg ha^{-1}) than did native pasture, with maximum growth rates of 3.4 and 2.4 g m^{-2} d^{-1} respectively. Root production over summer was about 200 g m^{-2} for buffel and 70 g m^{-2} for the native pasture.

* Increased grazing pressure reduced foliage cover of *Astrebla* spp.. Heavy grazing reduced its basal area . Tussock sizes and densities were affected by grazing pressure, and the amount of other perennial grass was greater under light pressure. The frequency of two undesirable broad-leaf plants was greater with heavy stocking. Above-average rainfalls increased basal area and foliage cover of *Astrebla*.

* Irrigating mitchell grass pastures was not a practical method of improving the nutrition available for pregnant ewes.

* There is a curvilinear relationship between plant basal area and yield of pastures that can be used as a guide to their condition.

* Nutritive value of both mitchell grass and mulga pastures is adequate when they are growing, but both become sub-optimal as they dry off.

* Sheep preferentially select broad leaf forb species while they are available. On mitchell grass, they increase the amount of grass in their diet as the forbs become less available. In mulga, they tend to substitute mulga for the forbs.

* Neither heavy stocking for short intervals, nor exclosure for 2 years, increased mitchell grass seedling number compared to normal continuous stocking.

* Stocking rates that utilize about 30% of the end-of-summer pasture yield in mitchell grass produced greater pasture stability and similar animal production to that obtained from heavier usage.

* Stocking rates that utilize about 20% of the end-of-summer pasture yield in mulga country promote growth of the better pasture species, increase pasture yield in the longer term, and give increased animal production compared to heavier usage.

* Heavy grazing with cattle in the late dry season over several years results in break-up of old mitchell grass tussocks, lower ground cover of mitchell grass, reduced forage yields and a reduction in the amount of feathertop, an increase in the annual grasses, especially Flinders grass (Iseilema spp.) and an increase in forb species.

(4) Forage Cropping

* Water spreading schemes can be used to increase production from native pastures. Forage cropping on them is marginal.

* Cropping in the south-west is an opportunistic operation.

(5) Integration of Research Findings

* Management recommendations for the area have been formulated from the information gained from this project and those with which it has been associated.

(d) Implementation and Extension

A number of basic principles of particular value to pasture and animal management have emerged from this project:

(i) Variability in the amount and effectiveness of rainfall is the primary limiting factor in pasture growth.

(ii) Over 90% of mulga pasture production occurs in the October-March period.

(iii) Mulga soils are quite infertile. They are characterized by a strongly acid profile, low nutrient availability (notably phosphorus) and surface sealing which contributes to significant run-off to rainfall. In contrast, mitchell grass soils are inherently fertile.

(iv) On infertile soils, woody plants tend to dominate rangelands. In harsher environments, shrubs tend to dominate rather than trees, as they are physiologically more efficient.

(v) An inverse curvilinear relationship between woody plant density and pasture yield arises in induced grasslands or savannnah.

(vi) Availability of surface water is rarely a problem, and the underlying artesian basin ensures relatively even use of mitchell grass and mulga rangelands.

(vii) Stock numbers should be adjusted to suit the available quantity of feed. In practice, this means that carrying capacity is determined by the numbers that can be carried safely in poor seasons.

(viii) Liveweight gain is largely dependent on the availability and accessibility of broad-leafed plants in the pasture.

(ix) Improved animal productivity has to be balanced against the need to promote pasture stability through the maintenance of a high proportion of perennial grass in the pasture. Interseasonal variation is markedly greater where the vegetation is comprised of mostly annual species, so basal area overrides composition as the principal determinant of grassland condition.

(x) Consumption should not exceed about 20% of end-of-summer production in mulga grasslands and about 30% in mitchell grasslands. There is little evidence that rotational or other grazing systems in Australian rangelands improve vegetative cover of animal production, although animals should be segregated within herd or flock structures and allowed freedom of movement within uniform land units.

(xi) Mineral supplementation is sometimes beneficial, but it is not a panacea in mulga and mitchell grass systems.

(e) Further Work

This project has indicated the need for further work in both mulga and mitchell grass areas, and a number of programmes have been initiated :-

(i) Grazing management and its effect on reproduction (K/2/1018).

(ii) Susceptibility of woody weeds to fire and impact of fire on ground flora composition and production (K/2/1030).

(iii) Native forbs in mitchell grass and mulga pastures (K/2/1042).

(iv) Ecology and control of white spear grass in mitchell grass (K/2/1044).

(v) Effects of grazing utilization in mitchell grass pastures at Julia Creek (K/2/1045).

The results from the grazing utilization trial at "Arabella" have shown that the 20% utilization treatment promotes the growth of the better pasture species, increases pasture yield and increases animal production over heavier usage treatments. Evidence from mitchell grass areas shows that optimum stocking rates produce higher lambing percentages than do heavier rates. Lambing percentages in mulga areas are around 50%, and this indicates the need for information on the effect of stocking rate on lambing percentages as a potential means of producing self-sustaining flocks in mulga country.

Work is also needed on the effect of competition or complementarity of mixed grazing with sheep and cattle to determine the effects of such management on pastures and animal production. There are indications of better production from mulga areas under such management.

There is also a need for studies on the population dynamics of the most important of the mulga grasses.

(f) Cost

Total cost to the Trust Fund is about $461 000. This project was initially part of W.R.T.F. Project 6, and was not costed separately until it became K/2/900 (C). The total expenditure represents about 14.4% of the W.R.T.F. Production Research expenditure in Queensland since 1957, in an area that includes some 65% of the sheep population of Queensland

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SECTION II

DETAILED PROJECT REPORT

ACKNOWLEDGEMENTS

Since this project was commenced in 1957 by Agriculture Branch of Queensland Department of Primary Industries, it has involved a number of centres and a larger number of staff, both graduate and technical. In this report acknowledgement has been made of those who contributed significantly to the research programme. Dr J.P. Ebersohn provided ideas and inspiration that lead to the establishment of the Charleville Pastoral Laboratory, which has established a reputation world wide as a centre for arid zone research. He was also responsible for overseeing the programme in its period of expansion.

The financial and moral support of the Australian Wool Corporation and of senior officers of the Queensland Department of Primary Industries have ensured that the team effort at this Laboratory continues. The co-operation of other Branches in Q.D.P.I. is also acknowledged. These include Agricultural Chemistry Branch, Beef Cattle Husbandry Branch, Biochemistry Branch, Biometry Branch, Botany Branch, Clerical and General Branch, Economic Services Branch, Entomology Branch, Extension Services Branch, Land Resources Branch, Plant and Animal Pathology Branches, Sheep and Wool Branch, Standards Branch, Veterinary Services Branch and The Animal Research Institute, Yerongpilly.

A large number of experiments was conducted during the period covered by this report. For details of them a number of sources have been used, the main ones being:-

(i) Agrostology Technical Annual Reports (QDPI)
(Pasture Agronomy Technical Annual Report 1982 on)

(ii) Published papers

(iii) Departmental records

(iv) "Review of Research in western Queensland", South - Western Research Committee, QDPI Mimeo. 1975.

Suitable project summaries have been used where applicable. The authors , who may not have been identified and may not be cited in the text, are acknowledged for their contributions.

HISTORY OF K/2/900 (C) -

ANIMAL PLANT INTERACTIONS IN NATIVE PASTURES OF WESTERN QUEENSLAND

Project commenced: 1957 Terminated: June 1984

NOTE This project began as part of a large, ongoing project (W.R.T.F. Project 6 - Pasture Improvement and Forage Cropping). In 1973 the project number became K/2/900 and in 1978 this blanket project was subdivided into several component parts, with separate titles and suffix letters.

Locations:

The main sites in this project have been Charleville, Augathella and Blackall. Smaller experimental sites were also located at Cloncurry, "Toorak" via Julia Creek and Richmond (Figure 1).

Staff involved in Project K/2/900 (C):

(i) Officers-in-Charge:

(Charleville)	1957 - 1962	Dr L.R. Humphreys, Mr. R.G. Wilson
	1962 - 1964	Dr J.P. Ebersohn
	1965 - 1973	Dr W.H. Burrows
	1973 - 1974	Dr A.J. Pressland
	1974 - 1975	Dr B.R. Roberts
	1976 - 1980	Dr W.H. Burrows
	1980 - 1984	Dr I.F. Beale
(Blackall)	1961 - 1965	Mr D.L. Purcell, Mr J.K. Cull
	1966 - 1969	Mr G.R. Lee
	1970 - 1972	Mr T.W.G. Graham
	1973 - 1984	Mr D.M. Orr
(Cloncurry)	1957 - 1959	Mr D.I. Sillar
	1959 - 1960	Mr P.J. McKeague
	1965 - 1970	Mr H.G. Bishop
	1971 - 1978	Mr T.J. Hall/ Mr J.C. Scanlan
(Toorak)	1961 - 1967	Mr E.J. Weston
	1967 - 1968	Mr J. Peart
(Richmond)	1961 - 1969	Mr E.J. Weston
	1969 - 1970	Mr D.G. Cooksley
	1970 - 1976	Mr J.F. Clewett

(ii) Graduate Staff T.E. Telford, Dr E.K. Christie, Dr R.G. Silcock, J. Peart, Dr R.F. Brown, M.T. Sullivan, Janelle R. Day

(iii) Technicians Flora T. Smith, G.N. Batianoff, P.J. Rowen, B.J. Caffery, R.G. McIntyre, Lynn (Corbett) Williams, C.L. Palmer, K.J. Lehane, M.F. Olsen, D.F. Edwards, D.E. Crowther, P.S. Bowly, C.J. Evenson, J. Dixon, D.C. Cowan, J. Mander - Jones, K. Rundle, D.L. Shirley, P. McIntyre.

Allocation from W.R.T.F.: Approximately $461 000 (not costed separately prior to 1978)

Allocation from Q.D.P.I.: Approximately $1 250 000. (Most of this was for salaries and support staff)

WESTERN QUEENSLAND

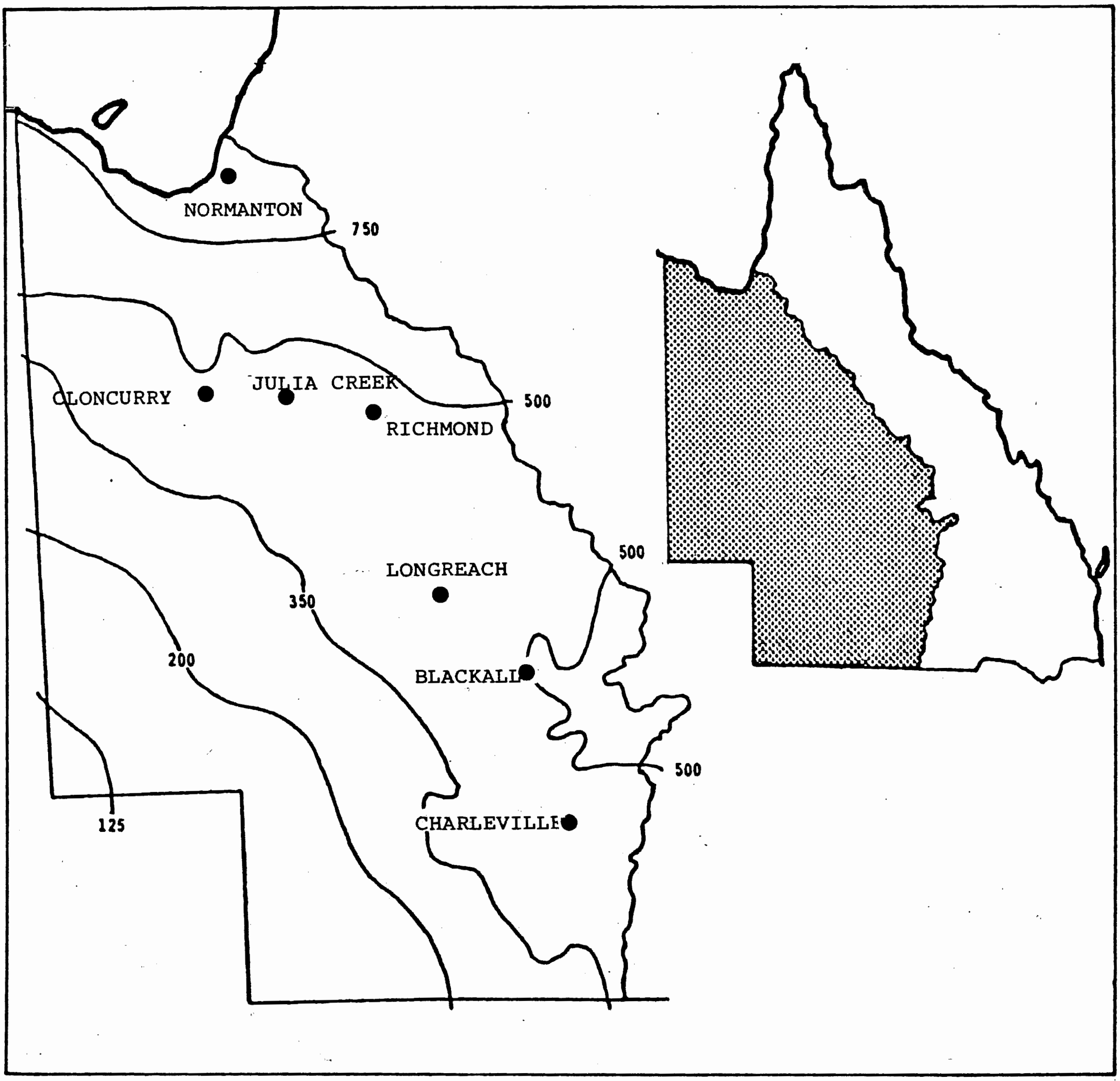


Figure 1: Location of main towns in Western Queensland.

A. INTRODUCTION

This project had its beginnings as part of a larger project (W.R.T.F. Project 6 - Pasture Improvement and Forage Cropping). In 1973 this was re-numbered to K/2/900 and in 1978 sub-divided into five sections :-

K/2/900 (A) Plant Introduction, Evaluation and Establishment of Introduced and Native Pasture Species (Report 1984)

K/2/900 (B) Grazing Land Productivity and Stability (Report 1985/86)

K/2/900 (C) Animal - Plant Interactions in Native Pastures of Western Queensland (Report 1985)

K/2/900 (D) Adaptation and Productivity of Annual Medics (Report 1985 /86)

K/2/900 (E) Evaluation of Shallow Water Storage Cropping in North West Queensland (Report 1981)

The bulk of the pasture work undertaken from 1957 to 1978 (when separate projects were introduced) that has not been covered in the report on K/2/900 (A) (Silcock 1984) falls into K/2/900 (C). Research areas involved in K/2/900 (C) are :-

(i) Germination and establishment studies with native species. (Some of these overlap with K/2/900 (A)).

(ii) Growth studies in glasshouse and field - involving growth rates, defoliation levels and plant nutrient requirements.

(iii) Studies on plant and animal production in the field - measuring plant and animal responses and aimed at evolving management systems for pastures in the area. These have often included co-operative trials funded from sources other than K/2/900 (C). Summaries are included for completeness.

(iv) Forage cropping - this research programme which terminated in 1974 is also included, as it was largely aimed at the production of alternate forage sources. These were largely rain-grown, though there was some irrigation and some grown on water diversion systems.

(v) Integration of research findings from (i) - (iv) to produce management recommendations for graziers in the geographic area covered by the project.

B. DESCRIPTION OF THE AREA

The major centres involved in this project were Charleville, Blackall, Richmond, "Toorak" via Julia Creek and Cloncurry (Figure 1).

Climatic features of the area (Table 1) can be summarized as :-

* Predominantly summer rainfall, with an increasing winter component towards the south

* High summer temperatures

Table 1. Seasonal rainfall and temperature at selected centres (Data from Bureau of Meteorology, Melbourne) (Pressland 1984)

	Rainfall (mm)			Temperature (°C)			
	Summer	Winter	Annual	Summer		Winter	
Location	(Oct-Mar)	(Apr-Sept)		Max	Min	Max	Min
Longreach	327	115	442	36.1	20.7	26.8	10.7
Barcaldine	364	150	514	34.5	20.2	26.1	11.5
Blackall	382	157	539	34.9	20.1	25.8	10.3
Tambo	351	163	514	33.2	17.6	24.4	7.0
Charleville	297	154	451	34.4	19.0	24.1	7.8
Quilpie	236	108	344	34.3	20.5	23.6	9.5
Cunnamulla	188	129	317	33.7	19.2	22.5	8.8
Thargomindah	176	92	268	34.1	20.7	22.6	9.4

From Hall, T.J. (1984). Plant Introduction Workshop. Qd. Dept. Prim. Ind.

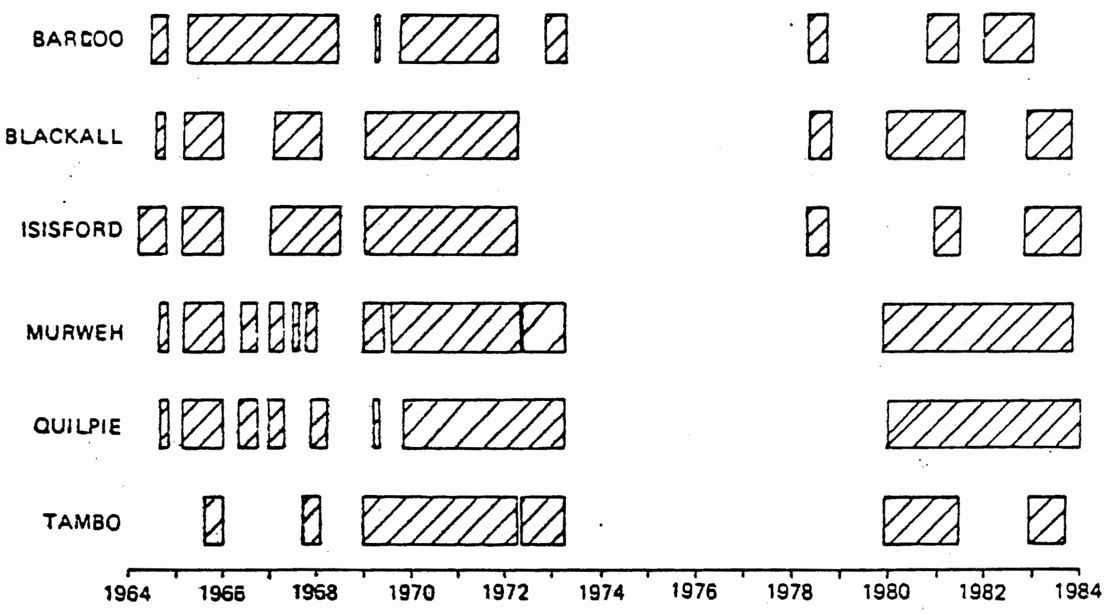


Figure 2: Declared drought periods 1964-1983 for 6 western Queensland shires. (Pressland 1984).

* Increasing incidence of frost towards the south

* High evaporation rates

* Frequent incidence of drought (Figure 2).

The major vegetation types are the mitchell grasslands on fertile grey-brown cracking clay soils and the mulga scrublands on infertile red earths.

C. PROJECT LIST, DESCRIPTIONS AND RESULTS

Project K/2/900 (C) involved 74 separate experimental programmes. (See Appendix). The review of these programmes has been conducted by use of summaries where they are available from final reports or publications. The grazing trial work at "Burenda" and "Arabella" made up the major portion of the latter stages of the project. This work has not been reported in detail previously and is included in this report. Following each project title the reference number of the project is given.

1. GERMINATION AND ESTABLISHMENT.

Ebersohn (1969a)discussed the potential for the introduction of pasture plants into western Queensland and cited references that suggested that there was a limited potential for the success of such projects. He emphasised "vacuum" situations into which plants could potentially be introduced (although reseeding with desirable native species was not discussed). Outside of these "vacuum" sites was a large area in which native species were the sole source of animal production for about 65% of the Queensland sheep population plus cattle.

By 1965 establishment failure in plant introduction trials had suggested that native vegetation was likely to continue as a major contributor to animal production. Results of the plant introduction programme in western Queensland to date (Silcock 1984) show that introduced plants so far tested in the area do not generally persist under grazing.

Thus a programme of investigation of characteristics of native species was developed along with the plant introduction programme. Native species were used as companion species in trials to assess the the field performance of introduced plants. Knowledge of conditions needed for germination and establishment of the native species also helped in the selection of introduced species with potential for the area. Moreover, development of a base of information on the best native species also has prospects for developing reseeding techniques for these adapted species.

Research projects in this sub-section were :-

Seed Germination Studies (CLE-P60-WR).

(i) Seed viability changes of native pasture plants in laboratory storage

The aim of this work was to assess changes with time in the germination of seed from native pasture species.

Seeds from 28 native species (4 legumes, 4 herbs and 20 grasses) were tested in petri dishes in a laboratory germinator at 25/35^{o}C. Seeds were tested in natural condition and as naked caryopses. Germination tests were done at 0, 6, 12 and 24 months of age and annually thereafter for a total of 8 years.

In some cases the assessed viability of caryopses was lower than that of the whole dispersal unit (the diaspore) e.g. *Eulalia fulva*, *Bothriochloa ewartiana* and *Cymbopogon obtectus*. This was due to excessive pressure being applied when rubbing out the caryopses, leading to damage to the embryos. When *E. fulva* caryopses were hand extracted, their viability after 8 years was 26%, slightly higher than the diaspore figures. It was very hot and dry at the time that this trial was done, so the caryopses were probably exceptionally brittle at 8 years of age.

Iseilema had exceptionally good viability after 8 years and grasses with fair viability included Astrebla lappacea, Bothriochloa ewartiana, and Digitaria diminuta. Grasses with no viable seed included Aristida jerichoensis, Astrebla pectinata and Monachather paradoxa.

The legumes retained a high degree of hard seed and, in some cases, very good viability. Seed should be scarified to overcome hard seededness. Atriplex muelleri seed was non-viable after two years, a common feature of saltweeds.

Species which continue to show low levels of germination, despite the apparent good seed quality, were Halorhagis odontocarpa, Dactyloctenium radulans, Themeda australis, Panicum decompositum, Eragrostis eriopoda, Paspalidium rarum and Sporobolus actinocladus. Dry heating of some of these species enhanced their germination. Scarification with sandpaper significantly increased the germination of D. radulans. T. mitchelliana and M. paradoxa were susceptible to attack by pathogens during germination.

Good quality seed of many native pasture species could be readily collected in season in the field, though the Andropogoneae were sometimes troublesome. Seed should be stored at least 12 months before use to achieve high germination results. Legume seeds should be scarified.

(ii) Optimum temperatures for germination of pasture species.

This project aimed to produce as quickly as possible reliable guides to the optimal germination temperatures for a wide range of species. This was done by germinating seed in the laboratory on a thermo-gradient plate germinator.

Most native pasture species germinated over a wide range of temperatures (10 - 40°C) but germination was usually quickest around 25 to 30°C. There were no confirmed cases of an obligate requirement for alternating temperatures, light or darkness.

(iii) Other studies carried out in this project were:

(a) Germination of mulga

The most effective scarification method to promote germination was boiling seed in water for 1 minute. Seed will emerge from depths of up to 25 mm in the field.

(b) Germination of kapok bush (Aerva javanica)

Highest germination - 61% - was obtained by mechanical removal of the fluff.

(c) Germination of D. giganteum

Germination of seed stored under room conditions improves with age:- 3 weeks, 1%; 3 years, 64%.

Publications:- Silcock and Williams 1973, 1975a,b,c,d.

Factors affecting the establishment of native species on mulga soils. (CLE-P43-WR).

(i) Climatic influences.

This project aimed to follow the normal pattern of seedling regeneration on mulga soils under bare soil conditions where livestock were excluded.

This was done in the field at Charleville by regular counts of marked seedlings of native species and was continued until they flowered .

It was found that emergence is common after rainfall events of more than 25 mm. There were 3 major germination events in 30 months, with an average of 10% of seedlings surviving to flowering. Grasshoppers severly damaged many seedlings. Perennial grasses were slow growing and took on average 57 days to tiller and 193 to flower. Aristida spp. averaged 125 days to first flowering.

(ii) Establishment of native species on densely timbered and well grassed mulga soils.

This project aimed to ascertain if existing vegetation and litter can appreciably alter the level of germination and establishment of native species compared to bare soil.

Emerging seedlings of native species were marked with pins and their survival followed after major rainfall events at 2 sites where a variable bulk of forage existed due to difference in frequency of defoliation.

Vegetated areas had much greater seedlings emergence than on adjacent bare areas, which usually were more unfavourable for germination of most mulga country species. Seedling survival was much lower on vegetated areas than on bare areas. There are adequate seed reserves in sandy mulga landsystems for good pasture regeneration in favourable seasons. Poor pasture regeneration was mostly the result of poor survival of emerged seedlings.

Publications:- Silcock 1973, 1977; Silcock and Williams 1976.

Temporal Change in the Germinability of Pasture Seeds Exposed to Field Conditions (CLE-P79-WR).

This project aimed to determine how rapidly freshly ripened seed (harvested November1978) became conditioned for germination in the field and how rapidly it might lose its viability thereafter. Surface exposure, heavy shading and burial were compared against laboratory storage for six species - Cenchrus ciliaris, Monachather paradoxa, Thyridolepis mitchelliana, Digitaria ammophila, Glycine canescens and Haloragis odontocarpa.

After 24 months (during a drought) neither G. canescens nor H. odontocarpa had lost much of their hardseededness under any conditions and viability remained high. M. paradoxa was the only grass to retain any significant dormancy after laboratory storage for 18 months. In the field, species reacted differently to the three environments but all except T. mitchelliana retained a significant amount of dormant seed after 12 months. By 18 months only 8% of buried C. ciliaris seeds were viable, and only about 8% of M. paradoxa and 13% of T. mitchelliana seeds exposed on the soil surface were still viable. However, despite the drought, many seeds of the last two species had germinated and established. Seeds of D. ammophila appear to move from the dormant to the germinable pool fairly steadily and to be lost at a steady rate, so no major peaks of germination occurred.

2. GROWTH STUDIES IN THE GLASSHOUSE AND THE FIELD

In semi-arid conditions plants are in a situation where drought is normal and moisture a rare event. Rate of growth of seedlings can mean the difference between establishment and failure. A number of investigations were undertaken into aspects of growth rate of both desirable and undesirable grasses, including *Thyridolepis mitchelliana* and *Monacather paradoxa*, (two of the better grasses from mulga country), *Astrebla* spp. (mitchell grass), *Aristida* spp. (problem species in both mulga and mitchell grass) and *Cenchrus ciliaris*, the most successful introduced species.

These projects were :-

Assessment of the phosphate fixation capacity of a mulga soil (CLE-P57-WR).

The aim of this project was to ascertain whether phosphatic fertilizer applied to the surface of mulga soil is rapidly immobilised under pot conditions.

Soluble phosphate was added to the surface of sieved mulga soil in pots at a rate equivalent to 250 kg superphosphate/ha.

Surface applied phosphorus is fixed within 2.5 cm of surface. Phosphorus fertilizer is rapidly fixed by the soil once it is in solution. It is therefore not likely to be leached away from where it is placed and thus is sparingly available to plants.

Moisture utilization in mulga under six ecological situations (CLE-P50-WR).

(i) Rate of loss of soil moisture by evaporation from mulga soil.

This project aimed to ascertain how rapidly moisture is lost from mulga soil by evaporation and to relate this to loss from a free water surface and to the depth of wet soil profile.

Clean mulga soil was packed into cylinders with a surface area of 50 cm^2 either standing on a bench in the glasshouse or sunk into the ground. Some pots were competely wetted to field capacity and others only wet for 2/3 of the profile (30 cm). Pots were weighed daily as were control pots of water.

Until the soil surface visibly dried, the rate of water loss was similar to that from a free water surface. Once the surface dried, the rate of loss diminished rapidly. Differences in wet profile depth had no significant effect on initial rate of loss prior to visible soil surface dryness. Thus, on unvegetated areas, the rate of loss of soil moisture from subsurface layers is relatively slow once the surface layer dries.

(ii) Production and water use of a wiregrass (*Aristida* spp.) pasture in south western Queensland.

The production of wiregrass (*Aristida* spp.), which is abundant and of low value in mulga lands, was observed on one field site under soil water conditions adequate for growth. Maximum growth rate in summer was 92 kg DM ha^{-1} d-1, winter rates were 10% of this. Maximum herbage produced in November to February (summer) was 3600 kg ha^{-1}, compared with 570 kg in April to June (winter). Standing root crop in mid-summer was 1065 kg ha^{-1}. Because of their potential to rapidly produce a large biomass above ground, and new inflorescences within 30 days after rain, wiregrasses will continue to be harmful species unless management techniques, based on weaknesses in their life cycle, are evolved.

Publications:- Pressland and Lehane 1980.

Water stress on four grass in pots (CLE-P67-WR).

(i) Effects of water stress

A series of glasshouse experiments was designed to study the effect of water stress on three grasses native to the mulga (*Acacia aneura*) lands of south-west Queensland, (*Aristida jerichoensis*, *Digitaria ammophila* and *Thyridolepis mitchelliana*) and one exotic grass (*Anthephora pubescens*). Both the above and below ground mass of plant matter decreased, but root:shoot ratio increased as the degree of water stress increased.

The ability of a seedling to grow rapidly and develop a perennating crown, or to set seed even under adverse conditions, was an important attribute in an arid environment. *Anthephora pubescens* outyielded, but grew more slowly, than the three native species. *Aristida* spp. had the capacity to flower under adverse conditions and consequently have a greater reproductive capacity in the field than either of the the other two natives grasses (*Thyridolepis mitchelliana* and *Digitaria ammophilla*) and *Anthephora pubescens*.

(ii) Water use efficiency

The water use efficiency (WUE) of the above grasses was evaluated in a pot trial. The WUE of the exotic was greater than that of the native species, though when additional phosphorus was supplied to the pots there was no difference between the WUE of *Anthephora* and *Digitaria*. Additional phosphorus increased the WUE of all species, but only in *Digitaria* was the response significant.

The study indicated that more effort could be directed towards evaluating and improving the WUE of exotic and native pasture species for rangelands in Australia.

Publications:- Pressland 1982a,b.

Growth studies with semi-arid grasses (CLE-P35-WR).

(i) Root growth of semi-arid grasses

The environmental factors which possibly exert the greatest influence on the establishment of semi-arid grasses are the supplies of phosphorus and water. Uptake of phosphorus and water is thought to occur most readily through the regions near the root tips, and may be related to the number of root tips and the rate of elongation of the root system. It has also been found that the survival of buffel seedlings in south-west Queensland is related to the depth of root penetration.

During the seedling and early vegetative growth stages, the pattern of root growth suggested that the emergence of axes, their extension and distance between branches remained fairly constant for each component of the root system. Phosphorus deficiency did not greatly affect the length of the seminal axis or the number of its primary laterals, but resulted in a significant reduction in the length of these laterals. The length and number of nodal roots were also greatly reduced. Species differences in the pattern of root development may be related to difference in seedling drought survival on infertile soils.

The maintenance of leaf turgidity and survival of seedlings in xeric habitats is facilitated by the depth and spread of their root systems. Because the maximum depth of penetration of the root system was found to be controlled by the nodal system, the ability of range grass seedlings to produce a nodal root system, may be an important factor in drought survival on infertile soils, such as the red earths of south-western Queensland.

(ii) The influence of temperature and soil water supply on growth

The two major factors likely to influence plant growth in semi-arid environments are temperature and soil water supply. Both factors vary within wide extremes.

The optimum temperature for vegetative growth of mulga grass was about 25 ^{o}C, and for mitchell and buffel grasses 30^{o}C. Buffel grass had the highest yield at all temperatures, partly because of its higher growth rate which in turn can be ascribed to both a higher nett assimilation rate and the diversion of a greater proportion of dry weight into leaf area.

Seedlings with an ample supply of phosphate had higher relative growth rates than phosphorus-deficient seedlings at the commencement of the soil drying cycle, but the former group's growth rates declined more rapidly as the soil water potential fell. This decline was associated with a reduction in the rate of phosphate absorption as well as a decrease in the tissue phosphorus concentration.

Natural propagation of plants following surface germination is greatly handicaped under semi-arid conditions, because of rapid drying of the surface soil. The drought tolerance and establishment of seedlings will be closely related to their rate of root growth at high water potentials and to the maximum depth of penetration and rate of extension of the root system. It is clear that when the soil nutrient supply was non-limiting, buffel grass had advantages in establishment over the native grasses, especially at high temperatures. Where the soil phosphorus supply was limiting, no such species differences existed. Therefore, seedling survival during a period of protracted water deficit would be closely related to changes in the plant's internal water content; this in turn would be affected by species differences in the maximum depth of penetration of the root system and in particular the nodal system and differences in leaf stomatal resistance.

(iii) Leaf photosynthesis in semi-arid grasses

Earlier studies showed that buffel grass (*Cenchrus ciliaris*) had a much higher relative growth rate than the native grasses *Thyridolepis mitchelliana* (mulga grass) and *Astrebla elymoides* (hoop mitchell grass).

Buffel grass is a known C_4 species but there is some doubt about the nature of the photosynthetic pathway in both native grasses. The anatomy and cholorplast structure of leaves of each species were therefore examined. In addition, the effects of irradiance, carbon dioxide concentration and leaf age on carbon dioxide transfer by leaves of mulga and buffel grasses were explored.

Photosynthesis response curves of mulga and buffel grasses to irradiance level and to carbon dioxide concentration, together with studies of leaf anatomy and chloroplast structure, showed that the former was a C_3 and the latter a C_4 species. This is held to account for the large differences in growth rate between the two species. Although mitchell grass has the anatomy of a C_4 species, its photosynthetic responses were not examined. As its nett assimilation rate is high at high temperatures, its generally low growth rates are associated with the poor development of its leaf surface.

Grassland communities in semi-arid Queensland either possess the C_3 or C_4 photosynthetic pathway. Therefore community differences in light, temperature and water-use efficiency will exist which will have a profound influence on primary production and hence carrying capacity.

(iv) Growth of semi-arid grasses in relation to phosphorus supply

Although it has been established that semi-arid native plant communites have a lower production than sown buffel pastures, the physiological bases underlying these differences have not been explored, and little is known of the response of native species to environmental factors.

The soil phosphorus concentration of the mulga communities of south-west Queensland is much less than that of the mitchell grasslands of central-western Queensland, but little is known of the physiological responses of these grasses to phosphorus supply. This work examined the effect of phosphorus supply on the growth of, phosphate absorption by, and transport in Thyridolepis mitchelliana (mulga mitchell), Astrebla elymoides (hoop mitchell grass) and Cenchrus ciliaris cv. Biloela (buffel grass). Experiments were carried out under controlled conditions to investigate the physiological bases for species differences in yield and nutrient responses to variations in phosphorus supply.

Buffel grass, and to a lesser extent mitchell grass, showed a much larger yield response to increasing phosphorus supply than mulga mitchell. Mitchell and mulga mitchell had much lower relative growth rates than buffel grass. Mulga mitchell required a lower external phosphorus concentration for optimum growth than mitchell and buffel grasses; this was attributed to its superior system for absorbing and transporting phosphate from low concentrations, but was not associated with any yield advantage.

A close correlation has often been found between nutrient culture responses and the observed distribution of various grass species in the field, in relation to soil phosphorus concentration. In these experiments the optimum concentrations in solution compared well with those in the soil. For example, the available phosphorus concentration of the soil group on which mulga mitchell occured has been reported as 5-15 ppm (mean 8 ppm), and that of the soil group on which mitchell grass is found in central-western Queensland as 2-306 ppm (mean 121 ppm). Buffel grass requires a minimum concentration of 25 ppm available phosphorus to establish successfully on mulga soils, and its establishment and rapid spread has only occurred on soils with high phosphorus concentrations such as the gidyea (Acacia cambagei) soils of central-western Queensland, where available concentrations vary from 15 to 164 ppm (mean 104 ppm). The differences between species in external phosphorus requirements for growth suggested that response to phosphorus is one aspect of the physiological adaptation of populations to soil conditions. Photosynthetic ability, however, was also important, as was response to other mineral nutrients and soil physical conditions.

(This project was conducted by E.K. Christie in association with a W.R.T.F. supported Ph.D. programme).

Publications:- Christie 1973, 1975a,b,c,; Christie and Moorby 1975.

Ecophysiological studies of semi-arid grasses (CLE-P74-WR).

This project examined some of the autecological factors influencing the population fluxes of white spear grass (Aristida leptopoda) in the mitchell (Astrebla spp.) grasslands of western Queensland.

A growth analysis study was carried out over a 28-day period. Each species was grown in a controlled environment chamber at constant temperatures of 20° C, 25 °C, 30°C and 35 °C. Yield response of both species increased up to 30° C and then declined. Yield response, particularly at 30° C, was much greater in Astrebla than Aristida. At 30° C the maximum relative growth rates were 0.33 $g\ g^{-1}\ d^{-1}$ and 0.22 $g\ g^{-1}\ d^{-1}$ for each species respectively. These growth rates were associated with seedling root extension rates of 257 and 89 cm d^{-1} for Astrebla and Aristida respectively. At 25° C little difference in yield and growth rate existed and seedling root extension rates also were around 50 cm d^{-1} for both species. The results suggest that Astrebla has a competitive advantage over Aristida at high temperatures only, so that the time of year at which rainfall occurs may be an important factor controlling species composition in degraded mitchell grasslands.

Root standing crop (10 - 100 cm) values recorded at 'Burenda', Augathella, were 4 360 and 1 610 kg ha^{-1} for an Astrebla and Aristida community respectively. Over 75% of the root mass of each community occurred in the surface 40cm of the soil profile. Consequently, the absolute root mass of Astrebla community especially at depths below 60 cm, was greater (up to six times) than that of the Aristida community.

Publications:- Christie 1979b.

Defoliation studies of the grasses of south-western Queensland (CLE-P75-WR - see Cle-P76-WR also)

(i) Glasshouse growth analysis

a. This project aimed to provide benchmark data to supplement defoliation experiments on the grasses of south-western Queensland. Eight grasses were investigated in a growth analysis experiment. Plants were grown in pots and harvested at weekly intervals for 11 weeks, commencing 4 weeks after sowing.

Substantial differences in relative growth rates and dry matter accumulation were found. At the end of the experiment, Cenchrus ciliaris had accumulated 10 times as much dry matter as either Monachather paradoxa or Thyridolepis mitchelliana, which accumulated the least. C. ciliaris and Astrebla lappacea had the smallest proportion of inflorescences and greatest proportion of roots, whereas the reverse occurred in Aristida jerichoensis.

b. This project aimed to show the effect of removal of foliage by clipping on C. ciliaris, A. lappacea, T. mitchelliana, A. jerichoensis and Digitaria ammophila), grown in pots in the glasshouse. At 6 weeks of age, they were clipped at a height of 3 cm, thus removing 76% to 89% of the tops. Clipped and unclipped plants were harvested at 6, 8 and 10 weeks of age.

Clipping caused a reduction in root growth such that, 4 weeks after clipping, root weights were similar to those at the time of clipping. Tops recovered after clipping much faster than roots. After a 2-week lag phase, the relative growth rates of the clipped tops exceeded those of the unclipped tops. Clippings stimulated tillering only in C. ciliaris.

(ii). Field observations of defoliaion

To establish rates of plant death and recruitment under field conditions and under different rates of pasture utilization, 50 permanent quadrats (1 m2) were established in each of the 0%, 20%, 35%, 50% and 80% utilization paddocks at the Arabella grazing trial (CLE-P76-WR). Within each quadrat and at approximately 4-monthly intervals, commencing January 1979, the position of each representative of the genera Aristida, Thyridolepis, Digitaria and Monachather was recorded.

Large numbers of new plants appeared between January 79 and May 79, some of which died between May 79 and September 79. BothM. paradoxa and Digitaria spp. had the ability to produce green shoots from old crowns previously believed to be dead, whereas the other species did not. Survival of mature grasses and their seedlings was more strongly influenced by seasonal conditions than by grazing, although heavily grazed pastures fared worst. After two years of very dry weather, very few of the plants initially present were still alive. Subsequent pasture regeneration was heavily dependent on seedlings, apparently recruited at the end of the dry period. Undesirable grasses re-established more readily than the principal desired ones.

(iii) Observations on developmental morphology

More than 80 tillers of A. jerichoensis and T. mitchelliana were microscopically examined to determine the state of inflorescence development. Tiller age ranged between 2 and 27 days. A. jerichoensis tillers commenced inflorescence development once the apical meristem was 2 mm or more from the base of the tiller, whereas T.mitchelliana did so at a height of 20 to 25 mm. Once commenced, inflorescence development proceeded more rapidly in A. jerichoensis than in T. mitchelliana. The results indicated that T. mitchelliana was more vulnerable to heavy grazing than A. jerichoensis, as the embryonic leaves and inflorescences were raised further above ground level and spent a longer period of time in that position than those of A. jerichoensis, and so were more likely to be removed by the grazing animal.

(iv) Glasshouse Defoliation Studies

To establish the effect of defoliation on T. mitchelliana and A. jerichoensis, glasshouse plants were subjected to 80% or 50% defoliation at 7, 10, 13, 16 or 19 weeks of age, regrowth being assessed at 10, 13, 16, 19 and 22 weeks of age, as well as one week after the single defoliation. Regrowth of T. mitchelliana lagged behind that of A. jerichoensis after defoliation. Unlike A. jerichoensis, T. mitchelliana was unlikely to survive 80% defoliaton at 10 weeks of age, implying the desirability of destocking at times of seedling regeneration to preserve it.

(v) Field observations of the effects of clipping, burning and fertilizing.

The effects of burning, clipping, applying nitrogenous fertalizer and protection from grazing on populations of three perennial grasses were monitored over four years in permanent quadrats in a mulga woodland pasture near Charleville. The grasses were the weedy invader Aristida armata and two desirable grasses, Thyridolepis mitchelliana and Monachather paradoxa. They comprised 70%, 16% and 12% respectively of the understorey at the start of the experiment. Rainfall had a greater effect on plant numbers, especially for A. armata, than did any treatment other than repeated clipping. Most A. armata plants died during a protracted dry period between March 1982 and April 1983, but the losses were more than compensated by mass germination during April 1983. The other two species responded in a similar but less marked fashion.

Repeated clipping caused attrition of all three species but failed to improve pasture composition. Pasture recovery after burning was slow and accompanied by a deterioration in pasture composition as measured by the proportion of A. armata plants. Both initial survival and subsequent seedling recruitment were reduced by slashing a week prior to burning. Overall, no treatment curbed populations of A. armata without adversely affecting T. mitchelliana and M. paradoxa.

(vi) Mulga survival under different levels of pasture consumption.

This experiment monitored the progress of 300 mulga saplings distributed through the six paddocks of the Arabella grazing trial (Cle-P76-WR). The saplings chosen were large enough to be permanently tagged but small enough to be within the browsing range of sheep. Initial measurements were undertaken in March 1980. The average sapling was 78 cm high with a stem diameter of 6.3 mm at 20 cm above ground level.

Grazed mulga was essentially the same height at the end of the experiment as it had been at the start. Ungrazed trees had grown sufficiently that the lower branches were no longer within the reach of sheep. Stem diameters nearly doubled in ungrazed mulga, while much smaller increases occurred in grazed plants.

Overall, 35% of the young trees died. Most deaths occurred during the winter of 1980 and the summer of 1982/83. Both of these periods were preceded by long periods of dry weather. Grazing seemed to have little, if any, effect on death rates.

Publications:- Burrows 1973, Brown 1979, 1981b, 1982a,b.

3. FIELD STUDIES RELATING TO PLANT AND ANIMAL PRODUCTION

Production of plant material in semi-arid areas is influenced by climatic and soil conditions. Moisture is most commonly the limiting factor, though in mulga areas soil physical and chemical status cause additional limitations. The amount of plant material available affects the level of production of animal products.

The development of management strategies for the region requires a knowledge of how much is likely to be grown, how much of this can be removed for use by animals without causing pasture degradation and how much animal production is obtainable in the long term.

Projects in this area were :-

Management of mitchell, white spear, feathertop and yabila grass pasture: feathertop (CLE-P3-WR).

This project aimed to assess the effects of cultivation, fertilizers and mowing on control of feathertop (*Aristida latifolia*) in mitchell grass pastures.

Cultivation to a five-inch depth with a mouldboard plough was effective in reducing not only feathertop, but also mitchell grass. Mowing, burning, light cultivation and fertilizers, after an interval of three years, left no measureable response on the species composition. Heavy stocking, followed by complete rest probably was responsible for lower feathertop density and a twenty-fold increase in mitchell grass. Argument was advanced for feathertop to be regarded as a constituent of the climatic climax, and the degradation of the association to a biotic sub-climax may effect its eradication.

Productivity of semi-arid pastures in south-west Queensland (CLE-P5-WR).

Increasing interest in pasture improvement in semi-arid Queensland necessitated assessment of the productivity of introduced grasses against that of native plant communities.

Based on a single harvest at the end of a period of high summer rainfall, semi-arid native pasture communities gave air-dried pasture yields of 1320kg ha-1 fromlandformerly undermulga scrub and 2240kg ha^{-1} from mitchell grassland. Sown buffel pastures gave 2240kg ha^{-1} on land formerly under mulga scrub, 3100kg ha^{-1} from land formerly under poplar box forest and 6200kg ha^{-1} on such land which benefited from run-on water.

The higher yield potential of buffel grass pasture, compared with native mulga grassland, indicates that buffel grass may play an important role in maintaining stability of animal numbers in the mulga zone.

Estimates given for stocking rate based on these presentation yields were:

2.0 ha/sheep:	open native mulga grassland
1.2 ha/sheep:	mitchell grass; buffel grass/mulga
0.8 ha/sheep:	buffel grass/box (no run-on)
0.4 ha/sheep:	buffel/box (with run-on)

Publications:- Ebersohn 1970c; Silcock,Williams,Lehane and Smith 1985.

Box trees and buffel grass production (CLE-P7-WR).

Buffel grass has been observed to colonize beneath the canopies of deep rooted mature Eucalyptus populnea (poplar box) trees in mulga shrublands in south-west Queensland and the open eucalypt woodlands in central-western Queensland. Little spread occurs in the adjacent inter-tree area. This project aimed to find the cause of this growth pattern and to measure the productivity potential of buffel grass in these areas.

Soil analysis showed higher available phosphorus and exchangeable potassium levels under mature poplar box and other trees. A positive association between pH and trees existed in some, but not all areas.

The microhabitat beneath a mature box tree sown with buffel grass is almost three times more productive than native pasture (in good condition) growing in the intercanopy area. Almost 7% of each hectare of mulga shrubland may be comprised of poplar box microhabitats. Because of their higher production when sown with buffel grass these sites have potential to produce around 20% of the total available herbage per hectare. Where grassland condition, and hence production, in the inter-tree areas has deteriorated, the contribution made by these microhabitats may be even more significant.

If areas of mulga shrublands are thinned in strips to promote grass growth, provision should be made to maintain some mature poplar box trees in the cleared areas. Further work is required for open eucalypt woodlands to determine an optimal tree density commensurate with near maximal herbage production within the community. The microhabitats represent important herbage production sources as well as buffel seed loci, from where seed can be disseminated throughout the community where it may establish with time.

Publications:- Ebersohn and Lucas 1965; Christie 1975d;Silcock 1980.

Surface micro-relief and vigour of mitchell grass (TRK-P3-WR).

A mitchell grass stand containing marked denuded areas was surveyed on a 4.6m grid, and scored according to vigour of the perennial grasses along the same grid. Low lying areas with a low gradient supported only annual growth. Bulk densities and pH were taken of three pasture conditions: healthy mitchell, annual growth between tussocks and in denuded areas. The percentage of available moisture varied from 22% in a healthy area, to 15% in a denuded area.

Defoliation of mitchell grass (RMD-P5-WR).

This project aimed to study the effect of various levels of defoliation on mitchell grass. Dormant plants were clipped in August each year from 1962 to 1967, and observations made on their reactions.

Total defoliation caused an initial increase in plant population through breaking up of tussocks, but this was concurrent with a decrease in plant cover and dry matter production. Removal of 50% of current year's stem growth did not reduce plant vigour. Total dry matter production over the 5 years was not significantly less than that from total defoliation, although less of the plant bulk was clipped.

The work demonstrated the hardiness of mitchell grass plants, but also indicated possible deterioration when total defoliation, such as in cases of severe grazing, occured.

Fire in the mitchell grass of north west Queensland (CLN-P39-MR).

(i) Changes in tiller and tussock characteristics of Astrebla lappacea (curly mitchell grass) after burning.

Tiller and tussock characteristics of Astrebla lappacca (curly mitchell grass) were studied at nine locations burnt by wildfires in north-west Queensland.

Tussock number increased after burning, although basal area was not affected. New tiller numbers (per quadrat) were not related to either tussock basal area or post-fire rainfall on burnt plots. Production of new tillers in unburnt plots was inversely related to the number of old tillers. New and old tiller weights were negatively related to tiller number per unit basal area. New tillers from burnt plots had higher leaf:stem ratios than new tillers and axillary shoots from old tillers in the unburnt plots.

Dry matter production, two years after burning, was similar in burnt and unburnt plots despite the presence of more old tillers and fewer new tillers in the areas burnt by wildfires. Most tillers died within three years of being produced.

(ii) Effects of spring wildfires on Astrebla (mitchell grass) grasslands in north-west Queensland under varying levels of growing season rainfall.

The response of Astrebla (mitchell grass) grasslands to burning was determined in relation to the amount of rainfall received in the following growing season. Nine A. lappacea and three A. pectinata locations in north-west Queensland were studied.

For both species, fire tended to increase the number and total dry weight of new tillers, although the individual tillers were smaller. Very low and very high rainfall resulted in sub-optimum tiller formation in unburnt areas of A. lappacea. Flowering and seed set was also stimulated by wildfires. The nitrogen content of new tillers in burnt treatments was higher than for those in unburnt treatments under low growing season rainfall and lower under high growing season rainfall. Dry matter production from burnt A. lappacea, relative to unburnt areas, decreased under low rainfall and increased under high rainfall. Burning at a time of high soil moisture resulted in higher dry matter production and higher nitrogen content than burning during the spring period when soil moisture was low.

(iii) Effect of spring wildfires on Iseilema (flinders grass) populations in the mitchell grass region of north-west Queensland.

The effect of spring wildfires and consequent ashbeds on the emergence and survival of the annual Iseilema spp. (Flinders grass) was studied in field and pot experiments during favourable growing conditions between December 1976 and April 1977.

Emergence of Iseilema seedlings was lower on burnt, than unburnt treatments, when the amount of litter present at burning was 1000 kg ha^{-1} or more. Litter had a major influence on emergence in unburnt areas. Initially there was a rapid increase in emergence with increasing litter, followed by decreased emergence with a further increase in litter. Microtopography had no effect on emergence in unburnt treatments, but there were significantly more seedlings in depressions (750 m^{-2}) than on flats or rises (240 m^{-2}) in burnt areas. The number of tillers per plant was greater in burnt areas than in unburnt areas at the same density, especially when the density was lower than

500 m^{-2}. At higher densities, the number of tillers per plant decreased in both treatments. Seedling survival was greater in burnt areas in the early stages in establishment but, by maturity, survival was highest in the unburnt areas.

Publications:- Scanlan 1980, 1983; Scanlan and O'Rourke 1982.

Feathertop in mitchell grass (BKL-P14-WR).
and
Burning and stocking trial on feathertop (BKL-P18-WR).

Aristida latifolia is an undesirable species in mitchell grass grasslands. Its density and that of *Dichanthium sericium* fluctuate with seasons. In 1963 burning, plus planned heavy stocking, did not reduce the population of *Aristida*.

Astrebla spp. are more drought resistant than *A. latifolia*, which in turn is more drought-resistant than *D. sericium*. Protracted drought reduces dramatically the population of the more drought-susceptible species, with *Astrebla* remaining relatively stable.

Publications:- Purcell and Lee 1970.

The spread of buffel and black speargrass, "Duneira" (BKL-P23-WR).

Natural spread and aggregation of buffel grass (*Cenchrus ciliaris* cv. Gayndah) and of black or bunch spear grass (*Heteropogon contortus*) on a sandy levee of the Barcoo River in the Blackall district were measured.

Buffel grass was markedly better than black spear grass in colonizing areas previously unoccupied by either species. Over 5 years, buffel grass invaded and replaced low-density stands of black spear grass, while it only partially invaded high-density stands.

Publications:- Cull and Ebersohn 1969.

Productivity and biomass transfer in range grasslands (CLE-P61-WR (i, iii-v)).
and
Production and stability of a grazed range grassland (CLE-P66-WR (i,ii)).

Resource management of rangelands is dependent on net primary production per unit area of ground and the maximum amount of this energy which can be transferred to livestock and still maintain community stability.

Since animal numbers in semi-arid environments are closely correlated with rainfall, and hence net primary production, the obvious first step in any study on animal utilization of rangelands is to quantify the rainfall/soil water supply/plant production system per unit area of ground. To extrapolate, with confidence, to the ecosystem, a simulation model is desirable.

Two communities, a native pasture and a sown buffel grass pasture, with different dry matter distribution and in particular the standing root crop were used. Peak standing crop for green forage and root were 1220 and 1110kg ha^{-1} for the native community and 1940 and 5250kg ha^{-1} for buffel. Community growth rates were at a maximum immediately following rain and then declined with time. The maximum rates recorded were 2.4 and 3.4 g m^{-2} d^{-1} for the native and buffel communities respectively. Active root growth occurred over the four-week period following summer rain before reaching a relatively constant value. Root production over summer was about 70 g m^{-2} for the native and 200 g m^{-2} for the buffel community.

Maximum litter production and disappearance rates occurred over summer and decreased to a minimum over winter. Seasonal litter production rates varied from 0.8 to 2.5 g m^{-2} d^{-1} and instantaneous litter disappearance rate, 4 to 20 mg g^{-1} d^{-1}. For any point of time the amount of nitrogen and phosphorus in the herbaceous components (green forage, standing dead, stubble, litter and root) represented 11-16% of the total soil nitrogen, but only 0.1-0.2% of the total soil phosphorous pool. Estimates for the amount of nutrients circulating within the ecosystem over the summer growing period were 1.0kg P ha^{-1} and 18.5kg N ha^{-1}.

The data obtained on dry matter production rates, basal area/yield relationships and grassland water balance, allowed a simulation model to be developed in which herbage production per unit area of ground was estimated in relation to precipitation.

Publications:- Christie 1975e,f; 1976a,c; 1978a,b; 1979 a.

Utilization zones in three grazed paddocks at Blackall (BKL-P54-WR).
and
Dynamics of grazed *Astrebla* spp. pastures (BKL-P55-WR).

(i) Effects of grazing pressure and livestock distribution.

The effects of grazing pressure on plant responses and livestock distribution in *Astrebla* grassland were determined from paddocks subjected to commercial grazing by sheep at light, medium and heavy grazing pressure.

Increased grazing pressure reduced the projected foliage cover of *Astrebla* spp. the basal area of which was similar under light and medium grazing pressure, and was reduced under heavy grazing pressure. Differences in the density and size of *Astrebla* spp. tussocks were apparent under the three grazing pressures. Other perennial grasses, notably *Aristida latifolia* and *A. leptopoda* were most frequent under light grazing pressure.

Numerical classification of the sampling sites, which were arranged on a regular grid, allowed the grazing pattern to be established. Heavy utilization was shown to be associated with wind direction, shade availablity and watering facilities.

(ii) Effects of seasonal rainfall.

The response of *Astrebla* grassland pasture to summer rainfall was measured at sites in commercially grazed paddocks which were subject to different grazing pressures. The inter-relationship between forage use and plant variates was examined by regression analysis.

Above-average rainfall resulted in increases in basal area and projected foliage cover of *Astrebla* spp. under grazing pressures equivalent to 50% forage use of *A.lappacea*. Increased forage use in the dry period before this rainfall reduced the basal area and projected foliage cover of *Astrebla* and resulted in lower yields of *Astrebla* following the rainfall. These lower yields of *Astrebla* were associated with higher yields of annual grasses and forbs than where forage use had been light. *Astrebla* yields were highest under light forage use.

The frequency of two undesirable species, *Amaranthus mitchellii* and *Tribulus terrestris* were highest under heavy forage use, and was associated with a decline in the number of other annual grasses and forb species.

Publications:- Orr 1975a,c; 1978; 1979; 1980a,b.

Irrigation of mitchell grass pasture (CLN-P37-WR).

The aim of this work was to quantify the response of mitchell grass pastures to irrigation, nitrogen, slashing and season; and on this basis determine the feasibility of feeding a flock of pregnant ewes on material produced by mitchell grass irrigated from a shallow storage dam. Treatments were: irrigation - 0, 10 and 20 cm; nitrogen - 0, 40 kg ha^{-1}; season - winter (April to July) and spring (July to October); and slashing - zero and to a height of 10 cm. Three harvests were taken at monthly intervals for each season.

The unslashed treatments gave no total DM increases; green material and protein yield in the green increased due to irrigation and nitrogen; and phosphorus yield in the green material was increased by irrigation alone.

The slashed treatments gave DM increased due to nitrogen and irrigation (initially interacting): green yield and protein yield in the green were increased by irrigation with a modifying effect of nitrogen; phosphorus yield in the green was increased by irrigation alone.

The same trend of responses were evident in both sets of treatments although yields were necessarily higher in the unslashed. The most efficient use of water was in the 100 mm irrigation with nitrogen, which produced 7.5 kg $ha^{-1}mm^{-1}$.

Maximum yield response was 1300 kg ha^{-1} in the unslashed treatment. To feed the normal flock of 1000 ewes for 3 months would require 100 ha of land, 200 megalitres of water and 10 tonnes of urea (more than $2000 worth of fertilisers).

Basal area/yield relationships for rangeland grasslands (CLE-P62-WR).

Although many groups have drawn attention to deterioration in semi-arid grazing lands, there are no standards to indicate what stage a range community must reach to have deteriorated. i.e. be in poor condition. Nor, for that matter, is there a standard which indicates a productive range (i.e. excellent condition). Although there are innumerable parameters on which range condition can be assessed, the method developed must be suitable for use by graziers. The method must be simple, rapid and efficient for use in vegetation management decisions.

A similar curvilinear pattern of response was found to exist between basal area and peak standing crops of green forage, root and litter. Responses of these three components decreased as basal areas increased beyond 4.5%. Condition assessment standards are based on basal area as this parameter is an index of site production potential.

The object of grazing management of grasslands growing on infertile soils should be to maintain ground cover. By adjusting stock number to the quantity of available forage/unit area of ground (which is dependent on basal area), the manager is therefore in a position to maintain ground cover in the long term.

Publications:- Christie 1975g; Burrows 1976; Christie 1976b,d,e.

Nutritive value of preferred range grasses (CLE-P61-WR (ii)).

Although it is commonly stated that native mulga grasses, compared with buffel grass, have much higher quality to compensate for their lower production, no critical evidence exists to substantiate this statement. This project compared plant material of the same physiological stage of growth growing under field conditions. Plant material of mulga mitchell (*Thyridolepis mitchelliana*), mulga oats (*Monachather paradoxa*), kangaroo grass (*Themeda australis*) and buffel grass (*Cenchrus ciliaris*) was analysed for nitrogen, phosphorus, sulphur and *in vitro* digestibility.

Nutritive value was at a maximum immediately following rain, and then declined with time. There was little species variation in nutritive value. Phosphorus values of green shoots were low and did not exceed 0.11%; crude protein of this tissue did not exceed 15.0% and decreased to 6.0% with time. Standing dead tissue showed little variation with time, phosphorus (0.01-0.02%) was very low and crude protein varied from 4.4-5.6%.

There was little difference in nutritive value between these perennial grasses. The value at any point of time was very low in phosphorus, highlighting the importance of forbs and legumes in meeting the mineral requirements of grazing animals.

Publications:- Rowen 1975.

Diet selection by sheep (CLE-P56-WR).

The aim of this project was to examine the nutritional and botanical differences between samples clipped from a mulga (*Acacia aneura*) zone pasture and those obtained by oesophageal fistulated Merino wethers. Estimates were also made of dry matter, crude protein and energy intakes of the animals. Samples were taken 13 times from October 71 to January 74.

Above ground biomass of forage ranged from 150 to 820 kg m^2, with digestible organic matter form 52 to 27 percent and gross energy values from 4 068 to 3 386 calories per gram. Crude protein and phosphorus percentages were above 5.4 and below 0.1 respectively at all trials.

Oesophageal fistula samples had gross energy and ash levels similar to those for clipped forage samples while digestible organic matter, crude protein and phosphorus were higher. A negative relationship between *in vitro* digestibility of the diet and its mulga content was demonstrated. Estimation of digestibility from measured sheep performance suggested that the *in vitro* procedure underestimated digestible organic matter, when mulga was present in the diet.

The major grass species in both forage and fistula samples were *Monachather paradoxa* and *Thyridolepis mitchelliana*. Mulga levels in the diet samples varied from 3 to 67%, the high levels occurring during winter.

Daily faecal outputs from mature fistulated animals were generally lower than for unfistulated ones. Ash contents were higher for fistulated sheep when compared to mature intact animals, but were similar to those for young sheep. Fistulated animals had lower levels of forage intake than did intact ones.

This study showed that grazing animals selected diets of different composition to that of the pasture on which they grazed. Forbs were selected when available, as was mulga, particularly during the winter months. The animals were also capable of selecting diets of higher quality than was indicated from analysis of pasture samples.

Publications:- Beale 1975; Beale and Rowen (1985).

Low lamb marking investigations (CLE-P73-WR).

Lower than normal lamb marking percentages were reported by graziers in western Queensland between 1974 and 1977. At Blackall the hypothesis was tested that inadequate nutrition was a contributing factor to the low lambing performance. Consequently, a detailed study to assess the nutritional status of sheep grazing a mitchell grass (*Astrebla* spp.) pasture was commenced. Five sheep were fitted with oesophageal fistulae, three others with rumen and duodenal fistulae, and six intact wethers were used.

Preliminary measurements indicated that pregnant or lactating ewes were not receiving sufficient metabolizable energy for maintenance. The protein intake was adequate. Dietary intake of Na, Cu and Zn were below those considered necessary for normal growth and production. Intake of P may have been below requirements.

Low productivity of cattle in south-west Queensland (CLE-P77-WR (DAQ 37)).

The Nebine area, south-east of Charleville is regarded as being less productive, in terms of animal performance, than other areas of mulga country in south-west Queensland. One manifestation of this problem is the rapid loss of weight experienced by heifers raising their first calf.

In an attempt to define the major nutritional factors involved in this low production syndrome this study was commenced in mid-1977. Twelve Shorthorn heifers, 3-4 months pregnant were run in the study paddock from May 1977 to March 1978. Pasture measurements consisted of botanical compostion of the forage on offer and its chemical composition. Animal liveweights were recorded monthly; rumen liquor samples obtained monthly were analysed for ammonia, soluble phosphorus and sulphate concentrations and volatile fatty acid proportions; nitrogen and phosphorus contents were obtained from blood and faecal samples; the mineral status of cows was determined from rib biopsy samples.

It was concluded from this study that for the period June to December, cows were suffering from phosphorus and protein deificiences. Their sulphur status was unknown but, as sulphur and nitrogen status in plants are usually related, it is probably justified to assume that sulphur intake was also below requirements.

The investigation gave no information concerning the digestible energy intake of the animals, but this may be assumed to be below requirements.

(Funded by Australian Meat Research Council. A project associated with K/2/900 (C) and included for completeness).

Pasture intake trial (NW-P28-WR)

This study aimed to determine the diet selected and to observe the manner in which sheep grazed plants in a mitchell grass pasture. The main objective was to provide basic data which could be used in formulating general management principles. Other objectives were to observe the growth habits of some pasture species and to determine the extent and severity of seasonal nutritional deficiencies.

After break-of-season rains, sheep commenced by eating herbage and annual grasses almost exclusively. When herbage was eaten out they progressed to seed heads of curly mitchell grass and some leaf of bull mitchell grass, Flinders grass and other late germinating annuals. When these plant portions were eaten out they ate the leaves of curly mitchell grass with some leaves and pods of mimosa (*Acacia farnesiana*) and then took the stem of curly mitchell grass.

The quantity and quality of feed selected were adequate for body weight gains until the seed heads of curly mitchell grass were largely eaten out. Body weight losses which occurred after this were due to a decline in the quality of the diet eaten.

Publications:- Weston and Moir 1969.

Selection by sheep grazing mitchell grass (TRK-P2-WR).

To study the diet and grazing behaviour of sheep on mitchell grass (*Astrebla*) pastures in north west Queensland, an area was set stocked with Merino wethers at 1 sheep to 1.6 ha. Sheep with oesophageal fistulae showed a preference for annuals following rain in autumn, selecting mitchell grass only when annual species were no longer present. Vibracorders showed that sheep grazed mainly during early morning and again during early evening, with a less intense period round midnight.

Quantitative dietary selection and grazing habit studies were commenced by J.R. Peart and continued by M.S. Lorimer. Although Lorimer's work was not included in K/2/900 (C), it is summarised here for completeness.

The objective was to determine which pasture species were selected by sheep in relation to the botanical composition of the pasture available.

Mitchell grass made an important contribution to the diet throughout the year with minimum levels occurring immediately after the wet season rains when a large number of plant species, more acceptable to sheep, were available. Flinders grass made maximum contribution to the diet while in the green immature stage, immediately after the wet season rains. The quantity of Flinders grass consumed during the dry season was low. The large variety of other plant species, which form a low proportion of the total pasture dry matter available, particularly the native legumes, were, because of their higher nutritional value, of great importance in the forage selected by sheep.

Publications:- Lorimer 1978, 1981.

Nutritional evaluation of south-west Queensland pastures - mitchell grass at 'Burenda', Augathella; mulga at 'Arabella', Charleville. (HR-175-WR in association with Cle-P66-WR and Cle-P76-WR).

A study was conducted using intact and surgically modified (oesophageal fistulae, rumen, abomasal and ileal cunnulae) sheep to determine the nutritive value of diets eaten by sheep grazing on mitchell and mulga grassland assocations in western Queensland during good, average and poor seasonal conditons, The main findings were:

* On both sites forbs, when they were present in the pasture, were a large component of the diet. On the mitchell grass site, while grasses were present in the diet at all samplings, their contribution increased to almost 100% under drought conditions. The proportion of grasses in the diets of sheep on the mulga grassland site remained relatively constant (45-70%), with mulga being substituted for forbs when seasonal condition deteriorated.

* When pasture conditions were good to average there were no detectable nutritional deficiencies in the diets selected on either site. Under drought conditon however, the following were noted:

(1) On both sites, the intake of metabolisable energy was insufficient to maintain the liveweight of dry sheep.

(2) On the mitchell grass site, the fall in the pasture crude protein content led to depressed N intakes , reduced release of food N in the rumen, lowered rumen ammonia concentration, reduced efficiency of microbial N production, reduced apparent digestibility of N, reduced flow of N into the small intestine, reduced digestibility of N in the small intestine and reduced absorbed protein to energy ratio. Similar results were obtained from the mulga grassland site, the differences being that efficiency of microbial N production was not reduced nor was the ratio between absorbed protein and energy. This latter finding was due to the reduced metabolisable energy intake of the sheep on the mulga grassland site, when compared to those on the mitchell grass site. The results indicated that supplements of both non-protein nitrogen and intestinally digestible true protein would benefit sheep grazing droughted mitchell grass but not mulga grassland pastures.

(3) The phosphorus intakes on both sites were adequate for dry but not lactating sheep. Under good conditions on the mulga grassland site the P intake appeared to be below requirements for both dry and lactating sheep.

(4) Sulphur intakes were not below theoretical requirements. However, as it is known that sheep will respond to an S supplement while consuming an all mulga diet, they may also benefit from S supplementation when mulga constitutes about 50% of the diet.

(5) The sodium content of pastures was very low on both sites and if sheep do not have access to drinking water with a high Na content they may benefit from Na supplementation.

(6) Both copper and zinc intakes were marginally below requirement on the mitchell grass site, particularly for lactating ewes.

<u>Publications</u>:- Beale and McMeniman 1976, 1978; McMeniman, Beale and Murphy 1980; McMeniman and Beale 1981; McMeniman, Beale and Murphy 1985a,b; McMeniman, Kondos and Beale 1985.

(Associated project funded by K/2/1007 (A). Summary included for completeness).

<u>A Preliminary study of the effect of stocking management on regeneration of mitchell grass in a degraded pasture</u> (CLN-P36-WR).

In an unreplicated field trial at Toorak Sheep Field Research Station, Julia Creek, heavy stocking for short intervals (200 sheep for ten days) during October 1974 and October 1975, or exclosure for two years resulted in similar mitchell grass (Astrebla spp.) seedling populations to those of the normal management of continuous stocking at one sheep to two hectares. Seedling numbers were low in all treatments in both years. Basal areas of mitchell grass tended to increase in all treatments between October 1974 and April 1975.

From an examination of published reports of seedling regeneration of mitchell grass, it is concluded that a suitable rainfall pattern and lack of competition from annual grasses and old tussock material increase the chances of seedling establishment.

The lack of information on the vegetative reproduction in mitchell grass represents a distinct gap in the understanding of the behaviour of this important native pasture genus.

Production and stability of a grazed range grassland - 'Burenda' Augathella (CLE-P66-WR (iii) - see CLE-P76-WR also).

Because of rainfall variability in semi-arid environments, it may be more appropriate to have a flexible stocking rate policy based on the total forage available at the end of summer, rather than a constant stocking rate. A constant stocking rate results in under-utilization (5-10%) of the pasture in good seasons and gross over-utilization (80%+), and eventually deterioration, in low rainfall years. For grasslands, the utilization level should be one in which the ground cover is at least maintained in the long term. In addition, management should be aimed at maintaining a proper balance between desirable (key species) and undesirable grasses.

The aims of this trial were:

(a) To determine a level of pasture utilization which gives near maximal animal production commensurate with pasture stability,

(b) Monitor reaction of perennial grasses to various stocking pressures,

(c) To examine the influence of stocking pressure on wool production per animal and wool production per hectare (biological and economic).

Treatments

Annual adjustments were made to stock numbers at the end of the summer growing season (April 1st). Stock numbers were set to consume 10%, 20%, 30%, 50% and 80% of the end of summer forage. The treatments were not replicated, but the experiment ran from 1975 to 1983.

This project has been monitoring the effects of season and utilization level on pasture production, composition and basal area, and on animal live weight and wool production.

Pasture yield, composition and basal area were assessed in each treatment paddock at the end of summer (April - June). The forage yields were assessed using a double -sampling method with 5 ranked quadrats each of 1/4 m^2. Basal area and pasture composition were assessed with a wheel point apparatus. Sheep numbers for the next year were calculated from :-

$$\text{Stock number} = \frac{\text{Forage yield (kg/ha) x Paddock size (ha) x Utilization (\%)}}{\text{Annual consumption (400 kg) x 100}}$$

The trial was stocked with wethers. Animal weights were taken bimonthly and annual wool cuts measured. Normal animal husbandry practices were used.

Estimates of the nutritive value of pastures and of dietary values and composition were obtained in project HR-175-WR.

Results.

Details of paddock sizes in the trial are given in Table 2:-

Table 2. Paddock size (ha).

Treatment	10%	20%	30%	50%	80%
Block Size (ha)	30.4	14.8	10.0	6.4	4.0

Seasons have varied in rainfall (Figure 3c), with an initial series of wet years from 1974 to 1976 and then a period which included four below average years. 1974, 1978 and 1983 all had good winter rainfalls. Forage yields in all paddocks started off at a similar level (Figure 3a). They have shown variation with seasonal conditions. The higher utilization levels (50 and 80%) depressed forage yield to the extent that at the end of summer 1983, there was insufficient pasture to restock these treatments. Pasture basal area (Figure 3b) was also higher in the lower utilization treatments and fell to very low levels in the 50% and 80% treatments by the end of summer 1983.

Herbage composition changed during the period. Some was due to climate, e.g. the fluctuations in Queensland blue grass (Dichanthium sericeum). Heavier stocking rates also induced changes. The 80% paddock changed from a perennial grassland to largely annual forbs (Table 3).

There was a trend for levels of the problem species white speargrass (Aristida leptopoda) to be higher in the 30% utilization paddock. However its contribution to pasture composition was reduced in all treatments over the duration of the trial.

(Aspects of white speargrass population dynamics and possible control measures are being investigated in A.W.C. Project K/2/1044 - Ecology and control of white speargrass in mitchell grasslands).

FIGURE 3. Forage yield (kg/ha), pasture basal area (%) and rainfall (mm) at "Burenda" Augathella (1974-83).

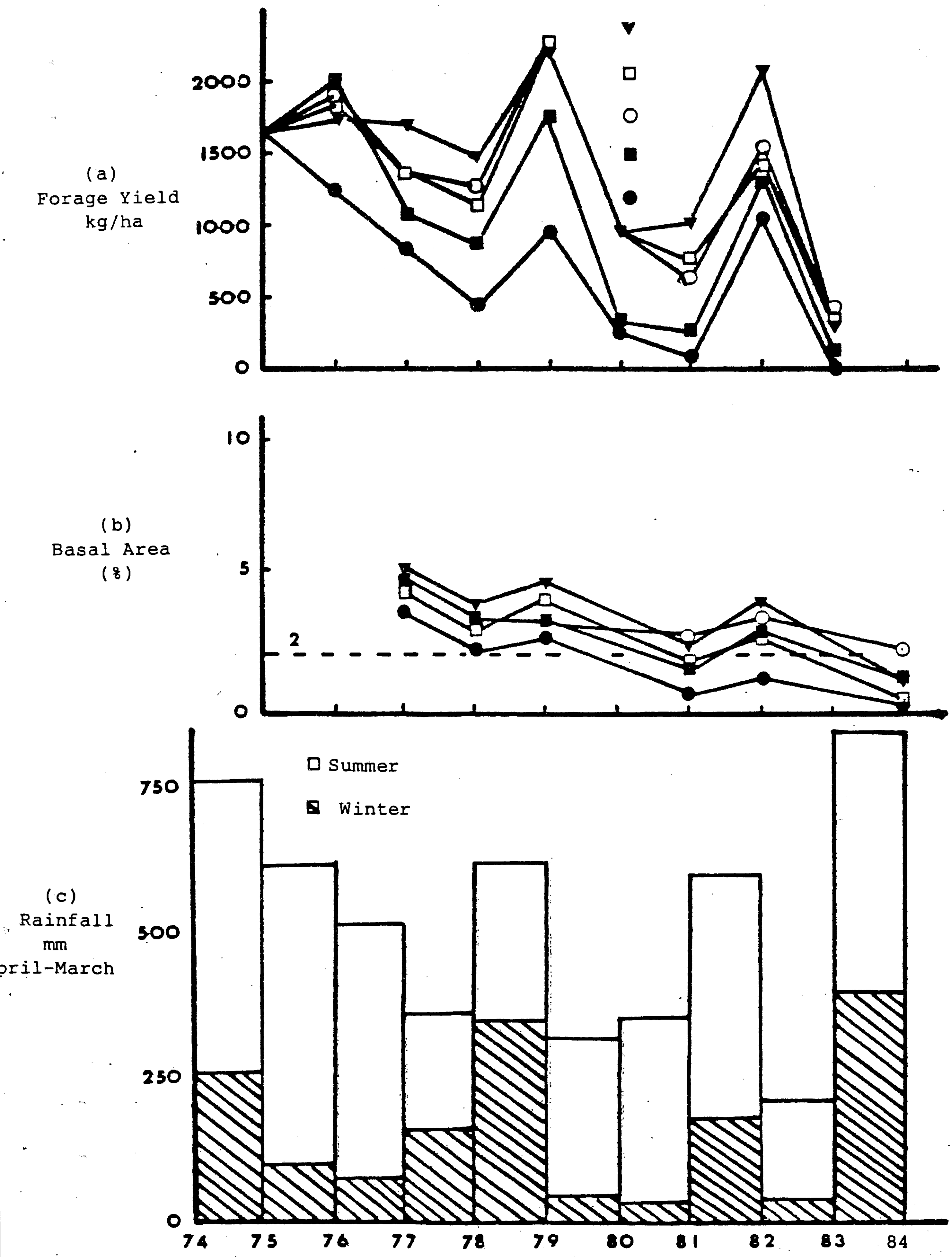


Table 5. Herbage composition in the Burenda grazing trial

(a) April 1975

Species	10%	20%	30%	50%	80%
Astrebla spp.	54.0	59.0	65.0	50.8	60.4
Aristida leptopoda	21.0	12.0	15.7	24.3	21.6
Panicum spp.	9.0	5.0	9.1	11.3	4.0
Dichanthium sericeum	4.0	12.0	5.6	8.9	5.1
Paspalidium globoideum	2.0	1.0	1.7	1.8	5.8

(b) April 1977

Species	10%	20%	30%	50%	80%
Astrebla spp.	32.0	40.0	49.0	40.0	54.0
Aristida leptopoda	12.0	5.0	10.0	11.0	8.0
Dichanthium sericeum	26.0	45.0	17.0	25.0	14.0
Digitaria spp.	1.0	1.0	1.0		
Paspalidium globoideum	1.0	1.0	1.0	1.0	1.0
Panicum decompositum	2.0	4.0	5.0	3.0	5.0
Panicum queenslandicum	26.0	4.0	17.0	16.0	15.0
Sporobolus indicus	1.0	1.0	1.0	3.0	3.0

(c) April 1978

Species	10%	20%	30%	50%	80%
Astrebla spp.	25.9	26.6	51.0	55.6	69.2
Aristida leptopoda	5.7	5.6	9.6	11.6	6.8
Dichanthium sericeum	34.3	54.1	21.3	23.2	17.4
Panicum queenslandicum	30.1	9.0	13.5	5.1	0.9
Panicum decompositum	2.7	3.6	0.4	1.0	0.8
Sporobolus spp.	1	0.4	4.1	2.8	2.8
Digitaria ammophila	1.1	0.1			
Chloris spp.	1	1			

(d) April 1979

Species	10%	20%	30%	50%	80%
Astrebla spp.	26.0	20.0	36.0	25.0	41.0
Aristida leptopoda	7.0	5	8.0	10.0	9.0
Aristida latifolia	1.0	1.0			
Dichanthium sericeum	34.0	55.0	24.0	37.0	22.0
Panicum queenslandicum	29.0	12.0	21.0	23.0	20.0
Panicum decompositum	3.0	.05	7.0	3.0	5.0
Eriochloa spp.	1.0	1.0	.01	1.0	1.0
Digitaria ammophila	1.0	1.0	1.0	1.0	1.0
Sporobolus spp.		1.0	2.0	1.0	1.0
Chloris spp.				1.0	1.0

(e) April 1981

Species	10%	20%	30%	50%	80%
Astrebla spp.	70.7	76.5	77.0	77.9	93.7
Aristida leptopoda	9.1	9.1	11.1	9.8	2.1
Dichanthium sericeum	11.5	6.5	2.4	1.4	.7
Panicum queenslandicum	2.2	1.3	1.3	.2	.7
Panicum decompositum	3.9	5.2	3.8	2.2	1.0
Sporobolus spp.	.3	1.0	3.5	8.6	1.8
Digitaria ammophila	2.3	.7	.8		
Aristida latifolia	.2				

Table 3 (continued).

(f) April 1982

Astrebla spp.	55.0	64.2	65.4	62.1	67.4
Aristida leptopoda	9.8	10.4	13.7	11.4	5.8
Dichanthium sericeum	21.3	13.9	8.6	6.7	2.4
Panicum decompositum	2.8	1.6	1.6	1.5	1.8
Panicum queenslandicum	9.0	8.6	7.3	10.4	13.3
Sporobolus spp.	.5	.6	2.8	7.4	5.4
Digitaria spp.	1.6	.8	.7	.4	.3
Paspalidium spp.					3.5

(g) April 1983

Astrebla spp.	36.1	57.1	24.2	22.1	45.3
Aristida leptopoda	6.9	2.2	4.4	1.4	1.8
Dichanthium sericeum	41.0	18.6	21.7	23.7	3.7
Panicum queenslandicum	14.0	20.4	42.4	44.8	42.3
Panicum decompositum	1.0	1.1	2.9	3.3	6.8
Sporobolus spp.	.5	.5	3.4	4.8	
Digitaria spp.	.4		.9		

Stocking rates (Figure 4a) also fluctuated with seasonal conditions. The heavier rates (50 and 80%) showed much more variation than did the three lighter treatments.

Wool production per hectare in the first years of the trial was greatest at the highest utilization levels (Figure 4b,c). As pasture yield declined in these treatments, production fell and approached that of the 30% level. The two lowest utilization treatments (20 and 10%) generally had lower production than the 30% treatment. Over the period of the trial, average wool production was highest for the 80% treatment (Table 4).

Table 4. Average greasy wool production per hectare (1975 - 83) for five utilization treatments at Burenda.

	Utilization level (%)				
	10	20	30	50	80
Wool (kg/ha)	2.02	3.07	4.39	5.74	7.15

Animal liveweights (including fleece) tended to be lower in the higher utilization treatments (Figure 5).

Factors influencing wool production per hectare were screened with an all-possible-combinations multivariate regression programme. The factors selected were stocking rate and wool production per head and their squared terms ($r2=0.98$). The stocking rate that produced maximum production from this relationship was not sustainable and produced pasture deterioration (Figure 3a.b). The effect of grazing treatment on future production was then investigated by lagging the X and Y variables in yearly steps. The two most significant variables selected are shown in Table 5:-

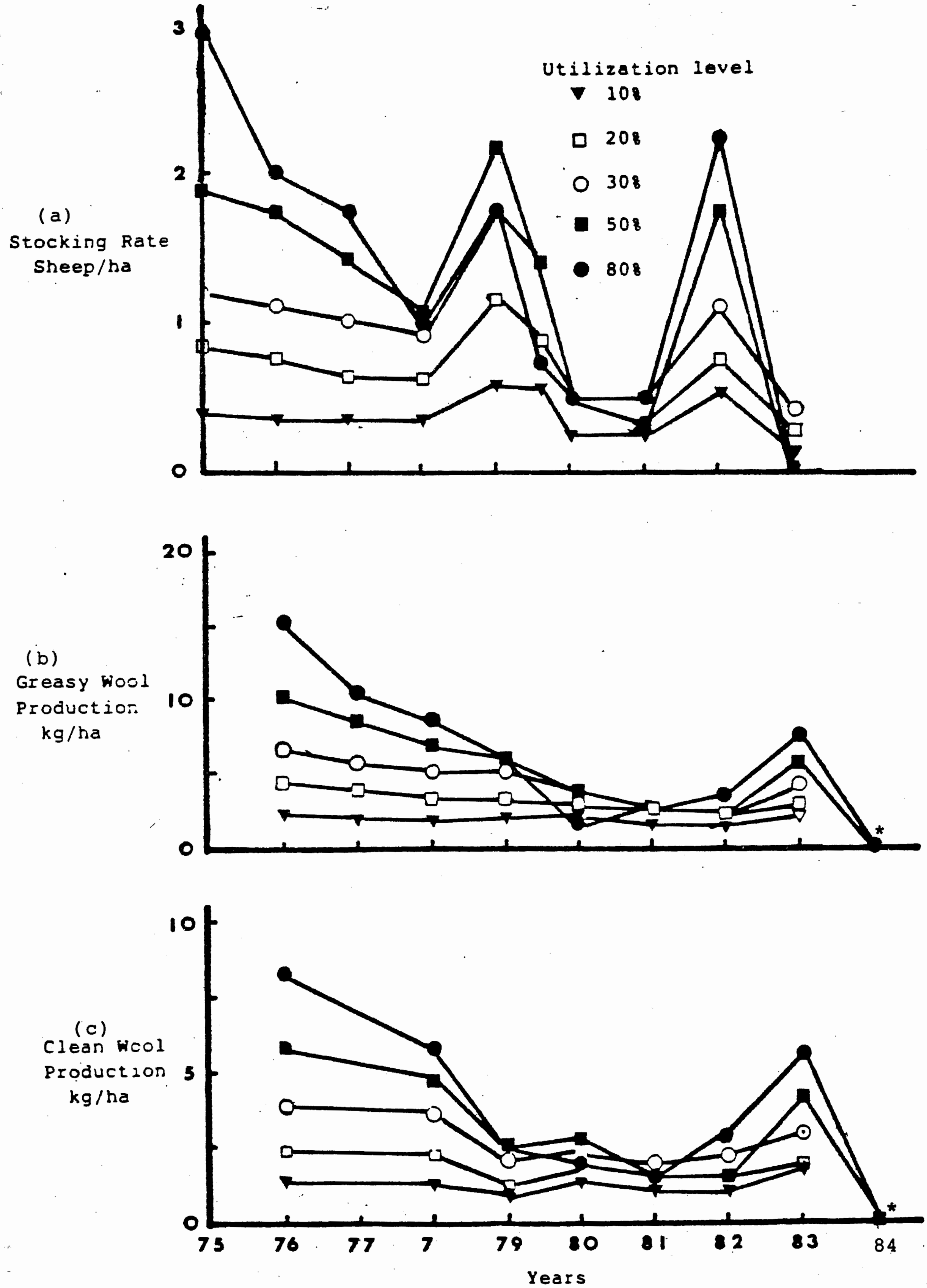
Table 5. Two best prediction variables (X's) of greasy wool production per hectare (Y) in the current year and in the next N years and their r^2 values.

	Lag in years						
X prediction variables	0	1	2	3	4	5	6
GW/HD[a]	I[b]						
$(GW/HD)^2$		I					
SR	I	I					
$(SR)^2$			I				
U			I	I			
$(U)^2$							
Y				I	I	I	I
$(Y)^2$					I	I	I
r2	0.96	0.77	0.45	0.48	0.64	0.93	0.93

[a] Variable are:- GW/HD greasy wool (kg $head^{-1}$); SR stocking rate; U utilization level; Y pasture yield (kg ha^{-1}).

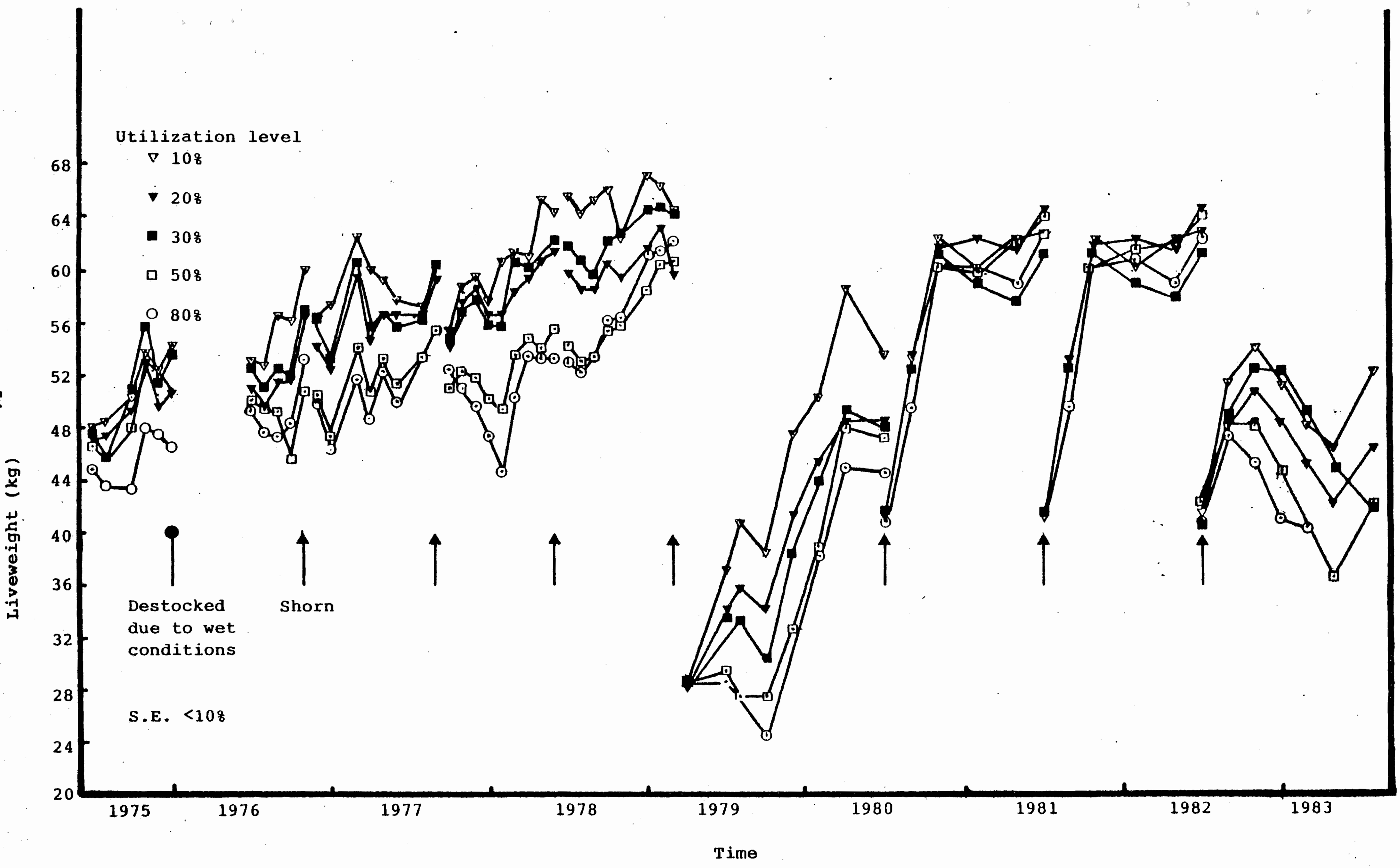
[b] I variable was included

FIGURE 4. Stocking rate (sheep/ha), and wool production (greasy and clean kg/ha) at "Burenda" Augathella (1975-83)



* Due to low pasture production, both 50% and 80% utilization treatments would not have been stocked in 1984.

Figure 5 Burenda Live Weights



The strong influence of pasture yield as a predictor of effects of different grazing treatments on wool production in 4, 5 and 6 years time should be noted. Further analysis of this relationship is required.

Discussion

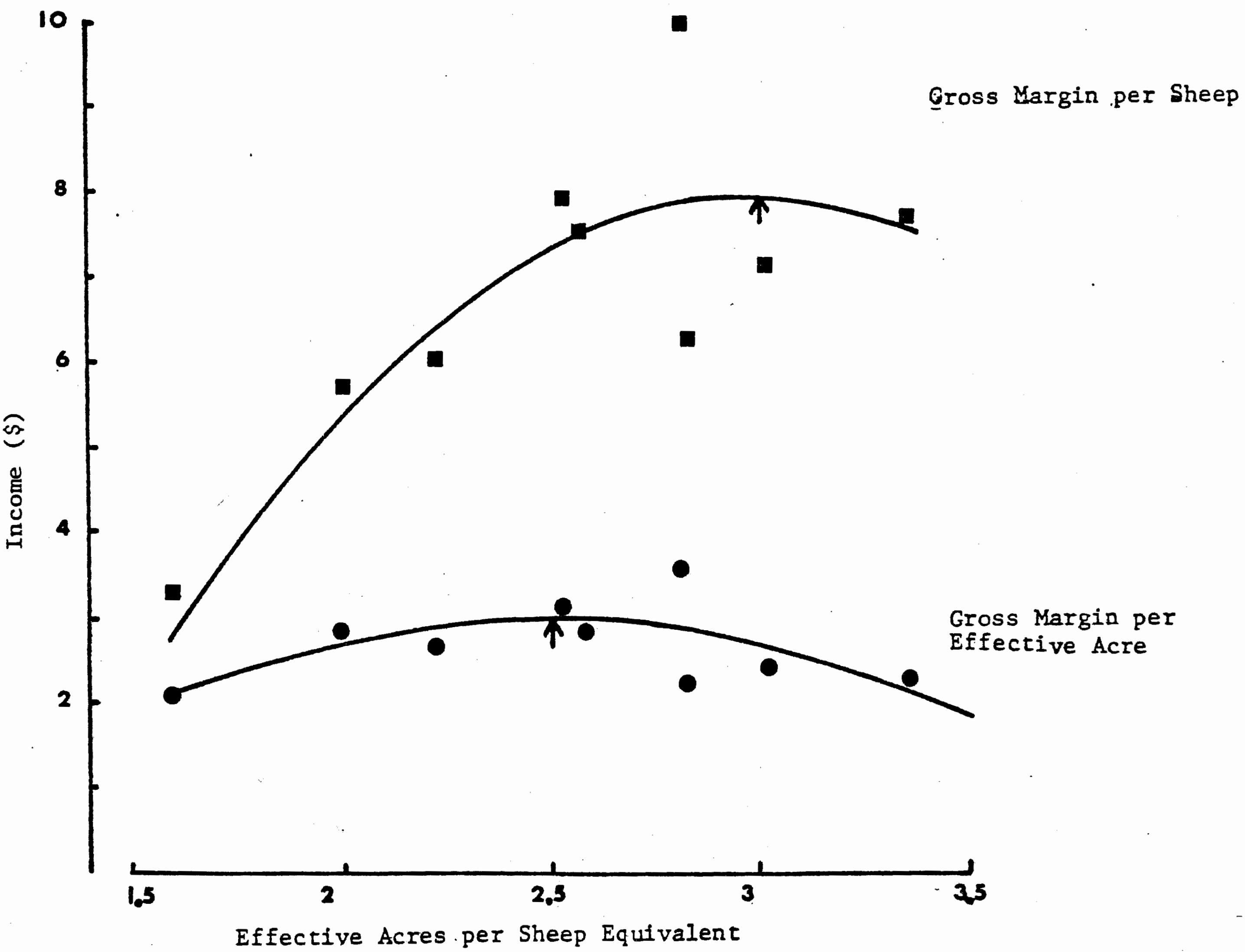
While the heavier utilization treatments have shown higher wool production on average (Table 4), this has been at the cost of detrimental changes in the pasture. The 80% level (with the highest wool production average over the trial) converted a perennial grassland to an annual forb pasture. This type of vegetation is highly nutritious when rainfall is favourable (in season and in amount), but does not stand summer heat. This paddock was destocked at the end of the summer of 1983 due to negligible pasture production.

The higher utilization levels also showed larger fluctuations in stocking rate over time. In practical situations, this would mean supplementing the animals or increased livestock trading. The first alternative is costly and the second can also be, unless very astute trading is practiced. Thus, while these higher utilizations appear to produce more, pasture is degraded, seasonal risk is increased and financial returns may well be decreased. The findinge of a property financial survey from similar country in the Blackall area (Holmes 1983) showed better returns from stocking rates of about the 30% utilization level of this trial (Figure 5).

The influence of pasture yield on future wool production was indicated from the results of this trial (Table 5). This suggests that grazing treatments that cause reductions in pasture yield will reduce animal production in 3 to 5 years time. This has consequences for experimental work as well, as it suggests that the true treatment effects will become obvious only after about 3 to 5 years and that trials must be longer than this to produce realistic results.

Publications:- Ebersohn 1973; Beale and Holmes 1984; Beale *et al* 1984; Orr, Bowly and Evenson 1984.

Figure 6. Effect of stocking rate on Profitability - Blackall 1972/73 to 1980/81 (Holmes, 1983)



Production and stability in a grazed mulga grassland - Arabella, Charleville (CLE-P76-WR).

The aims and methodology of this trial were similar to those of CLE-P66-WR. The trial ran from 1978 to 1984. Estimates of the nutritive value of these pastures, of dietary values and botanical composition were obtained in project HR-175-WR.

Results.

Details of paddock size are given in Table 6.

Table 6. Paddock size (ha).

Treatment	20%	35%	50%	80%
Block Size (ha)	109.9	45.7	54.8	22.0

The total rainfall in 1978, 1980, 1981 and 1983 (Figure 7c) was above average for the area (Charleville average 451mm - Table 1), and well below average in 1979 and 1982. Both 1978 and 1983 had above average winter rainfall (Charleville average 154mm).

Pasture yields at the end of summer generally followed the rainfall pattern (Figure 7a). They were initially lower for the 20 and 35% treatments, but after the first year these two levels (and particularly the 20% one) had higher forage yields than the more heavily utilized treatments.

Pasture basal area (Figure 7b) was highest for the 20% level over the trial. This was the only treatment to remain close to the value of 2%, below which pastures tend to be unstable. The 35% treatment recovered to about this level in 1984, whereas both of the higher utilization levels were well below 2% after the second year.

Botanical composition of woody plants at the start of the trial is given in Table 7. There was less mulga in the 20% paddock, which highlights the problem of obtaining uniform areas of the large sizes needed for grazing experiments in semi-arid conditions.

FIGURE 7. Forage yield (kg/ha), pasture basal area and rainfall at "Arabella" 1978-84.

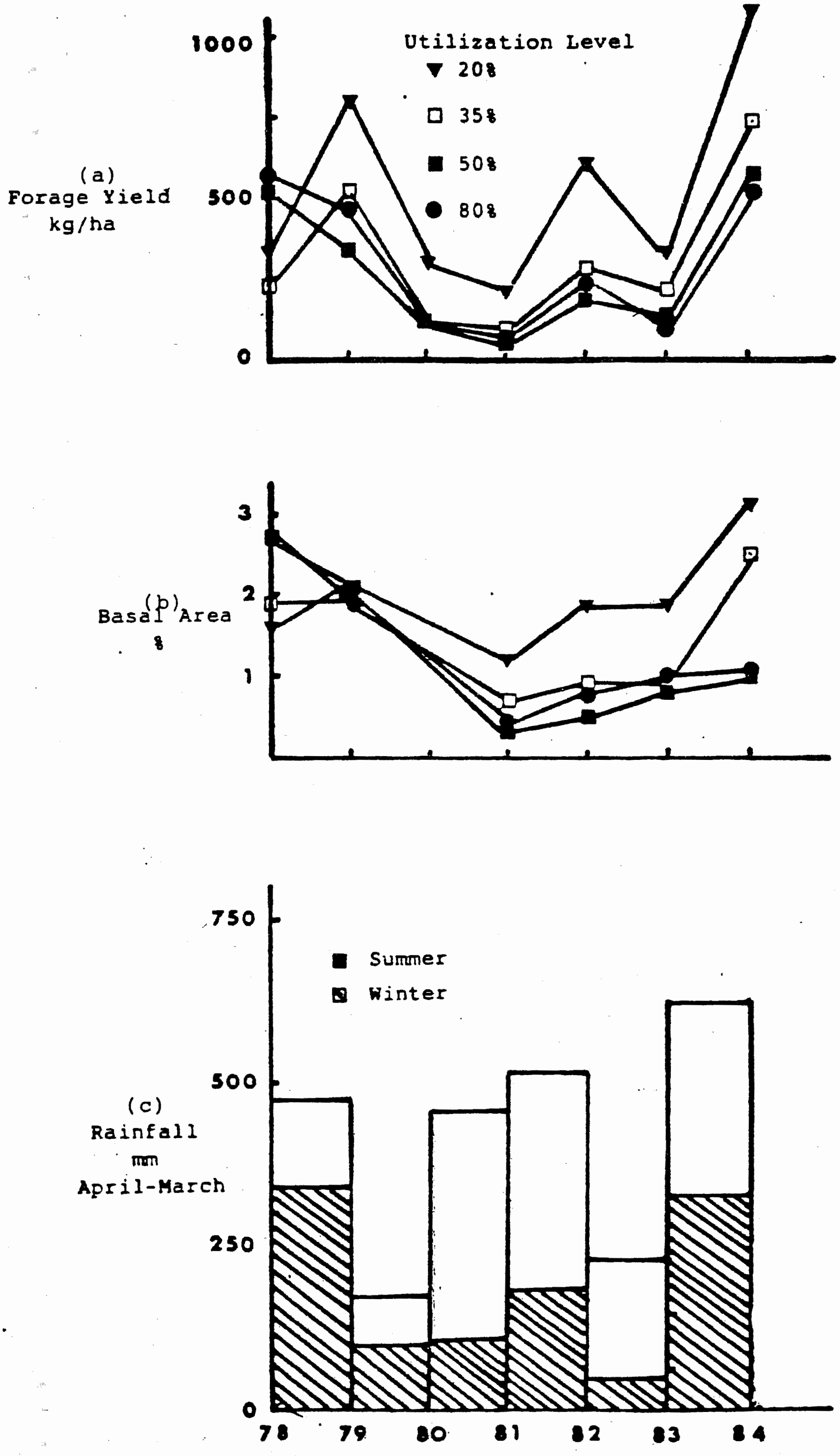


Table 7. Woody plant composition in March 1978 (stems/ha).

(a) Mulga	Treatment			
	No. of stems per ha.			
Size class (cm)	20%	35%	50%	80%
30	38	430	1430	1573
31 - 100	75	394	2026	1479
101 - 150	40	222	454	346
> 150	170	340	817	577
Mature	95	283	100	77
Totals	418	1669	4877	4052

(b) Other species

Species	20%	35%	50%	80%
Prostanthera suborbicularis	168	217	107	218
Eucalyptus populnea	23	01	10	14
Eucalyptus melanophloia	33	7	20	27
Cassia artemisioides	0	0	337	36
Cassia nemophila	2	0	10	5
Cassia spp.	0	0	3	0
Eremophila bowmanii	125	0	40	0
Brachychiton populneum	3	0	0	0
Alstonia constricta	0	0	80	27
Totals (plants/ha)	354	234	607	327

The desirable species (*Thyridolepis mitchelliana*, *Monachather paradoxa* and *Amphipogon caricinus*) increased under the lighter stocking rates, but were replaced by less desirable species (particularly *Aristida* spp.) under heavier utilization (Table 8).

Table [illegible]. Herbage composition (% of dry matter yield).

(a) March 1978

Species	20%	35%	50%	80%
Aristida spp.	13.2	11.3	32.2	37.9
Thyridolepis mitchelliana	34.5	58.1	51.6	55.8
Monachather paradoxa	35.5	21.2	7.4	0.8
Digitaria spp.	8.9	9.1	7.5	5.3
Eragrostis spp.	0.2	0.1	0.4	1.2
Themeda australia	5.0	0.3	0.8	0.2
Panicum spp.	0.4	0.1		
Amphiposon carcinus	1.5	0.1		
Eriachne spp.	0.9			
Tripogon loliiformis	0.5		0.1	

(b) June 1979

Species	20%	35%	50%	80%
Aristida spp.	15.0	15.0	31.3	37.2
Monachather paradoxa	29.8	25.2	4.2	1.1
Thyridolepis mitchelliana	29.6	42.5	52.3	53.0
Amphipogon caricinus	11.4	2.8	1.0	0.3
Panicum spp.	1.3	1.5		
Digitaria ammophila	5.4	6.7	4.6	3.1
D. Brownii	1.2	4.0	2.7	1.1
Eriachne spp.	1.0	0.8	0.5	
Themeda australis	3.8	0.9	0.5	
Tripogon loliiformis	0.4	0.5	2.0	2.5
Eulalia fulva	1.1			
Eragrostis spp.			0.7	1.8

(c) June 1981

Species	20%	35%	50%	80%
Aristida spp.	7.1	17.0	30.8	36.8
Thyridolepis mitchelliana	35.8	33.6	28.9	18.8
Monachather paradoxa	29.7	27.1	4.9	7.4
Digitaria spp.	2.5	5.6	6.3	7.8
Eragrostis spp.	0.3	0.3	0.6	2.0
Themeda australis	0.3	0.4		0.8
Tripogon loliiformis	4.1	7.5	25.5	25.0
Panicum spp.	0.7	2.5	0.3	0.5
Amphipogon caricinus'	17.6	5.9	2.1	0.3
Eriachne spp.	1.4			
Eulalia fulva	0.4			
Traghus australis			0.3	0.4

Thyridolepis mitchelliana	34.3	30.3	26.2	32
Monochather paradoxa	29.2	29.9	8.2	8
Amphipogon caricinus	22.0	5.5	1.5	8
Aristida spp.	7.8	19.4	29.2	25
Eriachne sp.	1.6	2.2	1.4	0
Themeda australis	1.2	1.1	0.4	0
Panicum sp.	1.1	1.1	0.7	0
Tripogon loliiformis	0.9	3.0	21.6	24
Digitaria spp.	1.3	7.0	8.9	5
Eragrostis spp.	0.3	0.4	1.1	1
Enneapogon spp.	0.2	0.2		

(d) April 1984

Aristida spp.	9.2	36.0	43.7	45.5
Thyridolepis mitchelliana	28.7	25.1	18.0	13.8
Monachather paradoxa	25.2	17.1	7.0	4.8
Digitaria spp.	5.5	8.1	11.2	7.2
Eragrostis spp.	0.6	0.5	6.5	11.0
Themeda australis	0.9	0.4	0.3	0.5
Tripogon loliiformis	1.7	2.7	9.5	15.9
Panicum spp.	4.3	4.3	3.2	0.9
Amphipogon caricinus	23.6	5.6	0.4	0.3
Eriachne spp.	0.5	0.2	0.2	

Stocking rates(Figure 8a) were initially high in the 80% utilization paddock. However , this treatment had to be destocked in 1980 and was not restocked until April 1981. The higher utilization treatments also tended to have more variation in stocking rates than did the lighter treatments.

Wool production per hectare was initially lowest from the 20% treatment and highest from the 80% one (Figure 8b,c) until destocked. After restocking, it again had the highest production in 1982 and 1983, but was showing signs of collapse again in 1984 when the trial ended. In contrast, the 20% treatment, after the first year, had the next best production and was more even from year to year.

(greasy and clean kg/ha) at "Arabella" 1978-84.

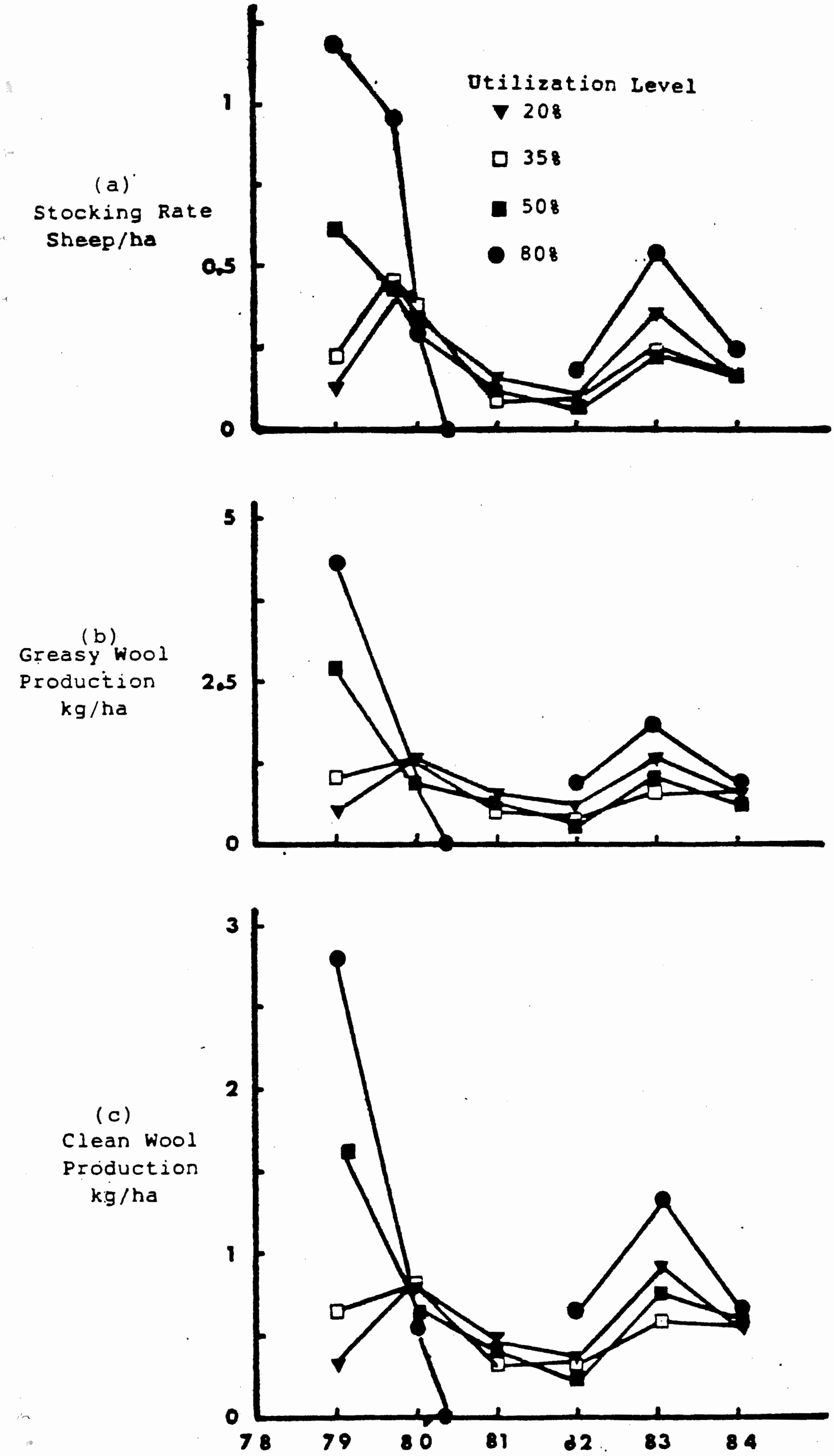
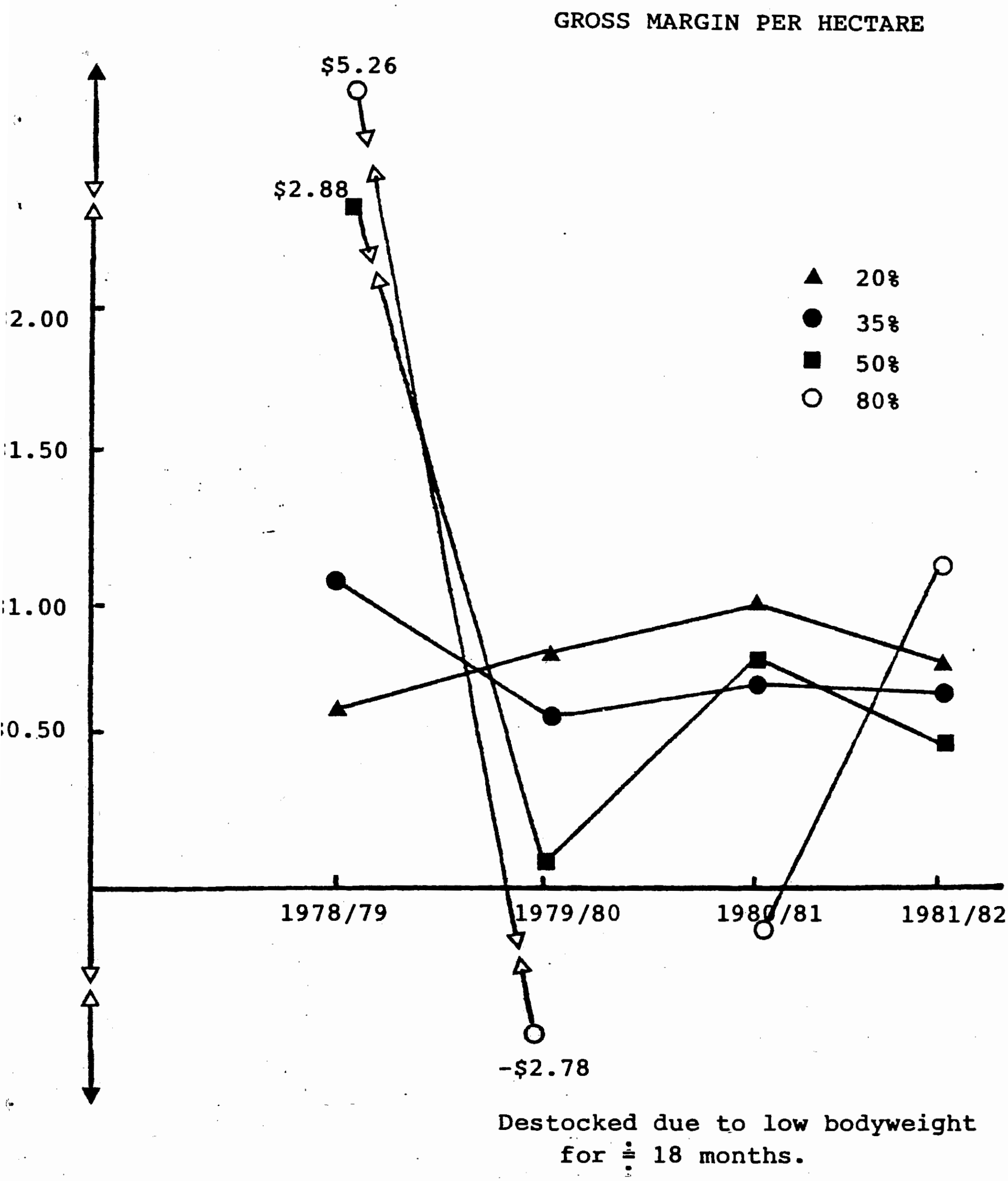
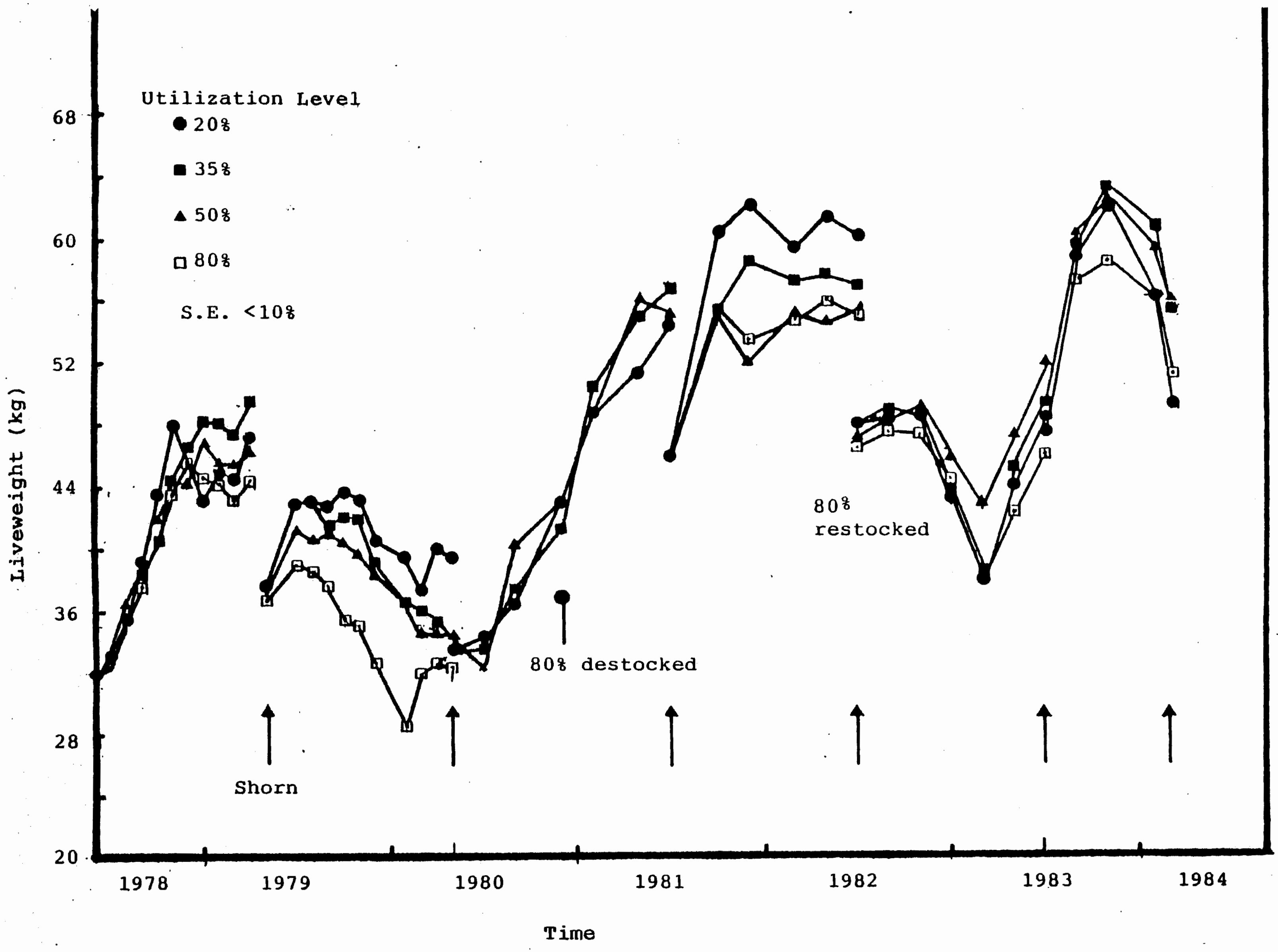


FIGURE 9. Gross margins for different utilisation levels at "Arabella".



The gross margin is calculated as net wool proceeds less variable costs of $5/hd. Assumes wool at 250 c/kg greasy ($2.19 net of selling and transport).

Figure 10 Arabella Live Weights



that, after the first year, the 20% treatment had among the best returns of the four levels. Animal bodyweights (Figure 10) were, in general, lowest in the 50 and 80% treatments.

Factors influencing wool production per hectare were screened with an all possible combinations multivariate regression programme. The factors selected were stocking rate and wool production per head and their squared terms ($r2=0.63$). The effect of grazing treatment on future production was then investigated by lagging the X and Y variables in yearly steps. The two most significant variables selected are shown in Table 9:-

Table 9. Two best prediction variables (X's) of greasy wool production per hectare (Y) in the current year and in the next N years and their r^2 values.

	Lag in years				
X prediction variables	0	1	2	3	4
GW/HD[a]	I[b]				
$(GW/HD)^2$		I			
SR	I	I			
$(SR)^2$			I		
U				I	I
$(U)^2$		I	I	I	I
Y					
$(Y)^2$					
r^2	0.56	0.23	0.64	0.49	0.95

[a] Variable are:- GW/HD greasy wool (kg $head^{-1}$); SR stocking U rate; U utilization level; Y pasture yield (kg ha^{-1}).

[b] I variable was included

This type of analysis at Burenda selected pasture yield rather than utilization. As utilization is a combination of stocking rate and pasture yield, further analysis of the data is indicated.

Discussion.

This trial has shown that a level of 20% utilization of end-of-summer pasture yield can increase pasture yield, encourage desirable pasture species, reduce undesirable species and maintain basal area while giving similar wool production per hectare to heavier utilization treatments.

The higher utilization treatments have shown larger fluctuations in stocking rates and in gross margins. In a commercial situation, these fluctuations would mean either supplementation or an increase in stock trading. Both of these would most likely lower the gross margins for that treatment. Utilization level has also been indicated as the factor of current management which most influences wool production in 3 to 4 years time.

<u>The effect of cattle grazing on mitchell grass</u> (TRK-P5-WR).

In the decade 1967-77, cattle grazing increased in importance on the northern mitchell grass pastures. In two shires (Richmond and McKinlay), sheep numbers declined from 1.7 million to 0.8 million, while cattle numbers increased from [illegible] million to [illegible] million during this period. This project investigated some of the effects of severe defoliation by cattle of mitchell grass during the late dormant season.

Thirty steers grazed a 32.4 ha paddock over six consecutive years (1971-1976) from mid to late dry season until the break-of-season rains. By the end of each grazing period, vegetation had been grazed to approximately 5 cm of ground level.

Heavy grazing resulted in:- breaking-up of the old mitchell grass tussocks into a large number of smaller plants; a reduction in the basal area of mitchell grass; reduced forage yields; reduced root yields; a greater contribution of annual (mainly Flinders) grasses and short-lived perennial grasses and forbs; reduction in feathertop (<u>Aristida latifolia</u>) population; and an increased number of forbs.

Strategic heavy grazing by cattle in winter/spring is an effective means of removing dead material from previous seasons. This can improve the quality of forage subsequently available, by permitting growth of forbs and ephemeral grasses, which play an important role in animal production.

Heavy grazing by cattle, for two or three seasons also appears to offer a management strategy to reduce the feathertop population, and could help to reduce the grass seed problems in wool growing enterprises.

This project was conducted during a series of average to above average rainfall seasons. Results could well have been different if favourable growing season rains were not received.

<u>Publications</u>:- Hall and Lee 1980.

4. FORAGE CROPPING

Historical Background (From Pressland 1980)

A surge of interest in forage cropping was shown in western Queensland in the middle 1950's to the early 1960's due to seasons with good rainfall and to the innovating influence of Dr P.J. Skerman of the University of Queensland. Crops were grown on a small scale by many graziers from the north-west of Queensland to the New South Wales border districts around Cunnamulla. The drought conditions of the middle to late 1960's resulted in a decrease in cropping ventures. However, interest was renewed with the better rainfall years of the late 1970's.

Current situation of forage crops (From Pressland 1980)

The areas in the south and central west of Queensland on which forage cropping is undertaken lie south of Blackall to Charleville and east from Charleville. Some small areas are also used around Cunnamulla and Quilpie. Individual areas under cultivation range up to 800 ha, with a total cultivated area for the region of about 3500 ha.

Both winter and summer crops are grown, but the former predominate because of the greater effectiveness of winter rains due to decreased evaporation. This is particularly the case south of Tambo. Some summer crops such as Sugardrip (*Sorghum bicolor*) are used as a stand-over crop in the late summer-autumn until winter crops are ready for grazing.

Forage cropping is undertaken to stabilize production and reduce stock losses. Fodder is grown for both sheep (particularly at lambing and weaning, and more particularly on stud properties) and cattle, with the greater use for cattle.

Major losses in animal production occur during the winter months due to frosting and blackening of native pastures from the rain/frost combination. Unlike frost free areas where hayed-off pastures are available, together with high protein green herbage, only small quantities of winter forb species and blackened dry material, which may be utilized by cattle with access to urea-molasses licks, are present.

In order to offset the poor ration available from native pastures during the winter, some graziers have turned to forage crops of oats (*Avena sativa*) and barley (*Hordeum vulgare*). Summer forage cropping is a more opportunistic venture, and may be considered a bonus rather than a necessary feature of a cropping programme. Nevertheless, summer crops have been ensiled for later use, as was recommended by Dr P.J. Skerman over twenty years ago.

Small areas of irrigated crops (both spray and flood irrigation have been utilized) are in existence. Lucerne (*Medicago sativa*) hay has been produced on one or two properties, but most of the forage produced has been strategically grazed.

Waterspreading (Cull 1964a,b; Burrows, Cull and Ebersohn 1966; Pressland 1977) has been used in areas west of Charleville and in the Cunnamulla-Eulo area to boost production from native pastures and to grow crops. These schemes have been successful for the former purpose, but have limited potential for the latter because of the lack of follow-up rain.

Projects in this section include :-

Originally the objective was to derive a possible relationship between frequency, duration and volume of water flow and and the resultant soil water situation on the one hand, and efficiency of herbage production from different plant communities on the other. This was not possible in practise, but a comparison of herbage yields from areas receiving differing quantities of flood water was achieved.

Three blocks, one fully flooded, one partly flooded and one receiving only rainfall were established. Dry matter yields from the three plots were compared over a number of seasons, together with the effect of fertilizer on the yield of native pasture in the fully flooded plot.

Yields of native pasture were up to six time as high on the flooded plot as the unflooded, and the addition of 40 kg N ha^{-1} trebled the yield on the flooded plot. Yields from the partially flooded plots were intermediate.

Yields of native pastures can be increased greatly by the use of cheap forms of water diversion. Waterspreader schemes can have their place in overall property management, though the areas can be succeptible to woody weed invasion.

(Funded by Water Research Foundation, site used for other trials)

Forage crops cutting trial (CLE-P44-WR).

The aim of this trial was to study the effect of plant density on dry matter production of summer and winter crops on a water spreader.

A series of small plot trials were sown from 1970 to 1973. Either summer or winter crops were sown depending on the time of a flood across the waterspreader.

Emergence of summer crops (sudax, sudan grass, pearl millets) was low from all sowings. Possible causes were: depth of sowing, seed floatation and soil crusting. The period of inundation should not have been a major factor contributing to the poor emergence as shown by laboratory studies.

Cereal crops (oats and barley) were more successful than tap rooted crops (safflower and rape), in that germination and emergence of the former were higher, resulting in more even crop stands. Row spacings were a significant factor affecting dry matter yields of oats and barley, 36cm rows resulting in higher yields than 18cm rows at the same rate of sowing.

Winter cropping on water spreaders may be a successful way of producing high protein fodder for special purposes at a time when the quality of the native pasture is low.

Publications:- Wilson 1961,1962; Burrows, Cull and Ebersohn 1966; Cull, Burrows and Ebersohn 1966; Cull and Ebersohn 1965; Pressland 1980.

Effect of wet and dry planting and use of press wheels on emergence of pearl millet and sudax (CLE-P51-WR).

The aim of this trial was to determine whether sowing into moist soil was advantageous to the ensuing crop compared with sowing into dry soil and waiting for germination rains, and whether soil compaction aids emergence in the marginal cropping area.

The treatments used were two species, two planting conditions (wet and dry) and two soil compactions (nil and compaction).

Germination of pearl millet was higher than that for sudax. Press wheels increased emergence of both species. Dry matter yields tended to be lower on compacted plots than uncompacted.

The use of press wheels ensures better emergence of seedlings, but the ensuing yields on compacted plots may be lower if rain following emergence is minimal.

Publications:- Pressland 1980.

Effect of nitrogen and plant densities on the forage yield of barley and oats (CLE-P53-WR).

The aims of this trial were :-

(1) to show the effect of four seeding rates on yield and water use of barley and oats.

(2) to show the effect of 56 kg N ha-1 on forage yield and protein content of oats and barley.

A 16 x 3 split plot randomized block design was used, incorporating two row spacings, four sowing rates and two species, with each plot split so one half received the equivalent of 56 kg N ha-1.

Barley outyielded oats, but yields of both species were suppressed by the addition of nitrogen at sowing. Water stress minimised the plant density effects, though dry weights from plots sown at 36 cm row spacings were lower than those sown at 18 cm spacings.

Poor seasonal conditions for the duration of the trial masked potential treatment effects. The trial has shown up the marginal environment for cropping, and the opportunistic nature of such a venture in this area.

Publications:- Pressland 1980.

Varietal trials of barley and oats (CLE-P30-WR).

(i) 1968.

A barley/oats varietal trial was sown on a grey brown soil of heavy texture. Barley grew quicker than oats, and its regrowth after the first harvest was as good as, and in some instances, better than that of oats. Hermitage cross 2094/8 gave the highest cut of 1040 kgDM ha^{-1} on first sampling, and Cape gave the best regrowth of 2,120 kgDM ha^{-1}. The bulk yields harvested for hay from the "ungrazed" plots were similar for barley and oats. Regrowth grew up to 30-40 cm high, but that from barley was inferior to oats in both bulk and quality.

(ii) 1969.

A comparison of the yields of five oat and five barley varieties under two fertility levels was made on a mitchell grass downs soil in the Tambo district.

Dry weather after sowing produced little growth. A comparison of the survival ability of the 10 varieties showed that all but one of the barley varieties were able to utilize the available moisture more efficiently than the oat varieties.

A pot trial was carried out at the laboratory to show the effect of three soil nitrogen levels on the dry matter yield of Bentland oats and Prior barley. Preliminary results indicated that the barley slightly outyielded the oats at maturity and that the highest dry matter yields were obtained when nitrogen was applied to barley and oats at a rate of 56 kg ha^{-1}. Nitrogen levels of 112 kg ha^{-1} produced lower yields. Oats tended to recover more quickly and outyielded barley when harvested at intervals before maturity.

(iii) 1970

a. "Westquarter", Tambo.

A 12 x 3 randomised block with split plots was used to evaluate five oats, four barley varieties, safflower, Sordan and rape with and without 112 Kg N/ha on a grey brown soil of heavy texture. Planting on 26/27th March 1970 followed 38mm of rain, however, only 25mm additional rain was received during the trial. Rape failed to germinate.

Safflower and Sordan outyielded all the oats and barley varieties under both nitrogen regimes. Barley outyielded oats, and Saia was the best oats variety. The effect of nitrogen at sowing was variable, though a tendency to suppress dry matter yields was common.

Pot trials to compare the effect of water stress on five oats and four barley varieties showed that the barley varieties were more efficient, but variability was high within both the oats and the barley varieties. In pot trials, nitrogen was the major soil nutrient limiting plant growth. Phosphorus response was negligible and there was no N/P interaction.

b. "Beechal", Cheepie.

Black barley, Bentland oats, Horowitz safflower and rape were compared on a lateritic red earth soil subject to periodic flooding by water spreading.

They were sown on 5th May 1970, four weeks after a flood. Two weeks after sowing 15 mm of rain fell, but no further rain was recorded for the duration of the trial.

Low D.M. yields resulted. However, Bentland oats outyielded barley, safflower and rape. Poor germination of oats and rape resulted in low plant densities.

Because of the effect of dry winds and warm days on evaporation during winter, slow growing winter crops may not be as successful as faster growing summer crops in this environment.

Publications:- Pressland 1980.

Soil moisture accretion and cultivation methods (CLE-P18-WR).

Three field experiments to study the effect of time and method of cultivation during fallow, on soil moisture accretion and crop growth were established at a site near Charleville. The soil was a grey-brown cracking clay (46 percent clay) typical of the mitchell grass (*Astrebla* spp.) downs.

In the first experiment, soil moisture accretion was followed on plots cultivated in November 1966 with either a disc plough or scarifier or not cultivated. Soil moisture was increased in the 90 cm deep profile by cultivation, but remained almost constant for the duration of the summer fallow. There was no difference in soil moisture under the disced and scarified plots.

The remaining experiments were designed to study the effect of cultivations during fallow on soil moisture at the time of sowing. One early summer cultivation resulted in soil moisture levels similar to that gained from two or more ploughings. However, crop yields were highest following three cultivation.

It was concluded that two or three cultivations during fallow decrease the loss of soil water through transpiration by weeds and should increase the number of years in which forage crops can be successfully grown in south western Queensland.

The effect of time and number of presowing cultivations on soil moisture at sowing (CLE-P49-WR).

The aim of this trial was to define the effect of time of cultivation during fallowing on soil moisture at sowing and subsequent crop performance.

No cultivation and cultivation following the first, second and third summer rains, and combinations of these were replicated three times in a randomized block design.

One early summer cultivation (December-January) during a fallow resulted in soil moisture conservation similar to that from two or more ploughings. However, crop yields were highest following three cultivations.

The importance of weed control during fallowing is highlighted by this trial. Farmers should be encouraged to cultivate their arable land as soon as possible after the first summer rains, and maintain as weed free a fallow as possible.

Publications:- Pressland and Batianoff 1976; Pressland 1980.

Moisture use efficiency of oats, barley and rape at two nitrogen levels, "Westquater", Tambo (CLE-P42-WR).

This trial aimed at showing the effect of high nutrition status on bulk dry matter yields and moisture use efficiency of the crops, and also to provide a comparison between the crops.

Unfortunately, no beneficial rain fell on the trial site after sowing, so results were limited. Indications were that the barley utilized the available moisture more readily than the oats and rape. Germination of barley was higher than the oats, which could account for its high moisture requirement.

In conjunction with the forage cropping programme, soil moisture and bulk density studies were made with a neutron moisture meter.

Legumes for pasture hay (TRK-P6-WR).

Over two growing seasons, ten legume species were oversown into Flinders

The first experiment (1976/77 season) examined the dry matter production of nine species:- Macroptilium uniflorum cv. Leichhardt, M. axillare cv. Archer, Macroptilium atropurpureum cv.Siratro, M. lathyroides (phasey bean), Glycine wightii cv. Cooper, Sorghum sp. ST26 (forage sorghum), Lablab purpureus cv. Highworth, Vigna radiata (mung bean) and Vigna sinensis (cowpea). The design was the treaments (including a nil) with four replicate plots (10 m x 10 m) in a completely randomised design. The second experiment (1977/78) was designed to examine the effects of seeding rate on four species (Lablab purpureus cv. Highworth, Vigna radiata, Vigna sinensis and Glycine max (soybeans), with 2 replicates in randomised blocks. Nitrogen and phosphorus levels were determined in both experiments.

Rainfall for 1976/77 was 604 mm (160% of normal, probability $< 10\%$) and for 1977/78 was 288 mm (77% of normal, probability of 65%).

L. purpureus, V. radiata, V. sinensis, Sorghum spp. and M. uniflorum yielded 1900, 3260, 2370,800 and 700 kg ha-1 respectively, while other species failed. G. max also failed to establish in the second experiment. V. radiata and V. sinensis re-established from seed produced in 1976/77. All yields in 1977/78 were low, only 70 kg ha^{-1} at a "normal" seeding rate. Yield of Flinders grass in 1977/78 was 50% of that for 1976/77, which indicated that this native species was more capable of growth under low rainfall conditions than the legumes tested.

Publications:- Wilson, Edwards and Scanlan 1980.

Chloride levels in lucerne soils (BKL-P17-WR).

Attempts to grow lucerne under irrigation were unsuccessful on a number of properties in western Queensland. Few good stands have been established. There are very few sites where suitable soils and assured water supplies are adjacent, and the heavy clay soils mostly used have low infiltration rates. These often have high levels of chloride in the 0-60 cm soil depths - often in excess of 1000 p.p.m. Poor lucerne growth occurrs with chloride levels of this magnitude.

Trials were established to attempt to reduce these levels. At "Whynot", Quilpie, an area which was ponded for two months reduced chloride levels in the 0-60 cm profile to where they would not have affected lucerne growth. Ponding for 6 weeks, draining for a week and ponding for a further six weeks caused an even larger reduction. At "Wakefield", Isisford, deep ripping to improve moisture penetration also reduced chloride levels.

Publications: Cull 1965, 1968a,b.

Research often consists of the sub-division of problems into smaller components which are studied in detail. To manage the problem we must be capable of putting this new knowledge together in a manner that enables the problem to be tackled with an understanding of the long-term effects of the changes made in handling it. One approach to this is by simulation.

Simulation (CLE-P61-WR and CLE-P66-WR).

Many workers have suggested that the key to maintaining productivity of semi-arid rangelands is to maintain, more or less, a continuous supply of herbage, of reasonable nutritive value to the animal, by relating animal numbers to the end of summer forage each year. Management of vegetation and animals in extensively grazed situations has to be interlocked with, and is dependent on, climate fluctuation especially precipitation. Computer simulation can therefore play an important role in vegetation management decision making in rangelands. A simple mathematical model which estimates the herbage production per unit area of ground in relation to precipitation and condition for native grasslands has been developed and was used to derive animal number (wethers) for a soft mulga paddock over the period 1969-74.

Where grassland was in excellent condition, at no stage would energy have been limiting for the district average stocking rate to be maintained. For grassland in medium condition, mulga would have been fed in only two of the five years. However, where grassland was in poor condition, at no stage could the district average stocking rate have been maintained without continuous feeding of mulga. Such a policy would have resulted in the complete utilization of the ground storey in one year and over 80% utilization in two other years, so that the preferred species would have eventually disappeared.

Sound management of mulga shrublands should be aimed, at least, at maintaining the ground cover. This exercise suggests that stocking rates in south-west Queensland should be derived as grazing pressure i.e. the number of animals per unit of available forage. Constant stocking rate estimations, based on the area of land, are inappropriate because of the wide variation in precipitation and grassland condition. The overall aim of resource management in semi-arid ranglelands, to maintain the biological system in the long-term, may be best met by a flexible stocking policy. However, its application to the grazing industry of south-west Queensland may be impractical, in many instances, because existing property areas are too small to maintain a varying, but economic flock size.

Publications:- Christie and Hughes 1983; Hughes and Christie 1983.

Further examples of the integration of research findings from this project are in the number of publications that use its findings to address the problems of management in the mitchell grass and mulga regions and in the extension of this management advice.

Pressland (1976) addressed the effects of removal of mulga on rangeland stability. Even ten years after thinning, ground storey vegetation was still in a state of flux. Management can markedly influence pasture composition and mulga regeneration. Poor rangeland management may lead to reductions in basal area sufficient to reduce productivity and accelerate degeneration through soil and nutrient losses in run-off water. Mills (1981) discussed land degradation in the mulga lands of far south-west Queensland in relation to the extended drought periods which occur in the area. Pressland (1981, 1984)found that stocking rates in mulga country were similar to those in mitchell grass and Mills (1981) developed the theme that maintenance of stock numbers on mulga country during extended dry periods, and restocking too rapidly at the end of a drought, is biologically unsound. An alternative approach outlines the need for financial incentives to encourage sound biological practices and for government assistance in the search for, and finance of, additional areas for small land-holders.

Burrows (1979) concluded that the central requirements for sound vegetation management in Queensland's semi-arid sheeplands are firstly, a realistic appraisal of the environment, and secondly, sufficiently large enterprises to favour conservative stocking policies (legislatively enforced if necessary). Inherent in this concept is the ability to lighten grazing pressures (at times of nutritional stress) and to increase them by adjusting paddock size (for shrub control). In the latter case the choice between winter and summer grazing may also be important. Present knowledge of the autecology and reaction to grazing of the vast majority of plants in these ecosystems is abysmal, and until this is overcome, under- rather than over-utilization should be encouraged.

Management requirements were summarized by Burrows (1980), and these are listed below:-

(i) Environmental determinants of animal production.

* Rainfall variability in amount and effectiveness is the primary factor limiting pasture growth and hence animal production.

* Ninety percent of potential grass production in mulga pastures occurs in the October-March period (Christie 1978a).

* Mitchell grass soils are inherently fertile while mulga soils are quite infertile, being characterized by a strongly acid profile, low nutrient availability (notably phosphorus) and surface sealing which contributes to significant rainfall run-off.

* Woody plants tend to dominate rangelands, especially on infertile soils. As the environment becomes harsher,shrubs will tend to dominate rather than trees, where the physiologically more efficient life form of the shrub is needed for persistence.

* In induced grasslands or savannah there is an inverse curvilinear relationship between woody plant density and pasture yield. But unlike higher rainfall regions many of the trees and shrubs of the inland are important sources of browse for domestic animals.

* Surface water is generally not a problem in mitchell grass and mulga systems and the underlying artesian basin ensures relatively even use of these rangelands.

(ii) Managerial determinants of animal production.

* Pasture stability and animal productivity on semi-arid rangelands are affected by many factors such as soils, vegetation type, rainfall, stocking pressures, industry economics etc. Of these factors the most readily manipulated by the grazier are concerned with his stock e.g. types of animals being grazed, stocking pressures and time of shearing.

* Stock numbers should be adjusted to the feed available. In practice this means that carrying capacity is largely determined by the numbers that can be safely carried in poor seasons.

* Animal production as opposed to liveweight maintenance is largely influenced by the availability and accessibility of broad leaf plants ('nutrient accumulators') in the pasture.

* The need to improve animal productivity has to be balanced against the need to promote stability through the maintenance of a high proportion of perennial grass in the pasture. There is clear evidence that interseasonal variation is markedly greater where the vegetation is comprised of mostly annual species. For this reason, along with the difficulty of establishing grass species on infertile soils, basal area will generally override composition as the principal determinant of grassland condition (Christie 1978b).

* Utilization levels should be adjusted so that consumption does not exceed 20 percent of end-of -summer production in mulga grasslands and 30 percent of this in mitchell grasslands. In practice stocking levels should be such that 12 months after grass growing rain has fallen there is still a good coverage of stubble on the pasture. There is little evidence that rotational or other grazing systems in Australian rangelands improve vegetative cover or animal production over continuous grazing systems (Wilson 1977). By corollary, as far as it is practical, animals should be segregated within herd or flock structures but allowed freedom of movement within uniform land units.

* The minimum requirement of animal management is disease and parasite control. Mineral supplementation is beneficial in certain situations but it is not a panacea to nutritional stress in mulga and mitchell grass systems.

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APPENDIX

List of Projects associated with K/2/900(C)

FILE NO.	OLD PROJECT NO.	FUND	PROJECT NAME	OFFICERS INVOLVED	ESTAB. DATE	STATUS
	TBA-44-AG		Pasture growth rates, L.C. Burville Stonehenge	RW		Concluded
CLE-P14-WR		K/2/900C	Winter forage yield-Hillgrove, Morven	JC		Not estab.
CLE-P17-WR		K/2/900C	Production from summer legumes Hillgrove, Morven	JC		Not estab.
CLE-P18-WR		K/2/900C	Production from summer legumes, Westquarter	JC	1966	Not estab.
			Soil moisture accretion and cultivation methods	GNB		Published
CLE-P19-WR		K/2/900C	Plant population variation with different methods of ploughing Depth of moisture penetration with ripping treatments (Listowel Valley).	JC	1965	Concluded
CLE-P25-WR		WTRRES	Efficiency of water use on a water redistribution scheme-Beechal	WHB,IFB	1968	Published
CLE-P27-WR		K/2/900C	Water use efficiency of dryland oats-Tambo	TET	1967	See CLE-P42
CLE-P28-WR		K/2/900C	The effect of depth of planting on emergence of buffel grass seedlings at high density			Abandoned
CLE-P29-WR		K/2/900C	Herbage establishment on a water-spreader at Eulo	GNB	1967	Abandoned
CLE-P30-WR		K/2/900C	Varietal trial of oats and barley Westquarter	AJP,GNB	1968	Published
CLE-P33-WR		K/2/900C	Determinants of drought tolerance in pasture plants Seedling germination studies of native and introduced species	WHB	1969	Published
CLE-P34-WR		K/2/900C	Organic matter productivity under buffel. Root productivity and turnover of natives and introduced species	EKC		Published
CLE-P35-WR		K/2/900C	Eco-morphological aspects of native and introduced species	EKC		Published
CLE-P38-WR	55.14	K/2/900C	Moisture use of grain sorghum-densities and rows	AJP		Published
CLE-P39-WR		K/2/900C	Forage crop cutting-Cheepie and Eulo (Failed to establish-abandoned)	AJP	1968	Abandoned

FILE NO.	OLD PROJECT NO.	FUND	PROJECT NAME	OFFICERS INVOLVED	ESTAB. DATE	STATUS
CLE-P40-WR		K/2/900C	Summer forage screening (Failed to establish-abanonded)	AJP	1968	Abandoned
CLE-P41-WR		K/2/900A	Longevity and dormancy of giant button and mulga seed buried in the soil	GNB	1969	Abandoned
CLE-P42-WR		K/2/900C	Water use efficiency of oats, barley and rape at two nitrogen levels-Westquarter (H.O. Beechal)	AJP	1969	
CLE-P43-WR		K/2/900C	(i) Factors affecting the establishment of native species on mulga soils (ii) Establishment of native species on densely timbered and well grassed mulga soils (Part transferred to CLE-P70-WR)	RGS	1969	Published
CLE-P44-WR		K/2/900C	Forage crop trial-Beechal 3 row spacings, 2 sowing rates of Sudax and bullrush millet. Oats and barley plus other spp.	AJP	1971	Published
CLE-P46-WR		K/2/900C	Sodseeding oats and barley into uncultivated mitchell grass	AJP	1970	Published
CLE-P48-WR		K/2/900C	Spatial distribution of pearl millet and sudax-Westquarter	AJP	1971	Published
CLE-P49-WR		K/2/900C	The effect of time and number of plowings on soil moisture at sowing	AJP	1970	Published
CLE-P50-WR		K/2/900C	(iii) Production and water use of mulga species	AJP	1970	Published
CLE-P51-WR		K/2/900C	Effect of wet and dry planting and use of press wheels on emergence of pearl millet	AJP	1971	Published
CLE-P530WR		K/2/900C	Effect of nitrogen and plant densities on the forage yield of barley and oats	AJP	1971	Published
CLE-P54-WR		K/2/900C	Special distribution of safflower	AJP	1971	Published
CLE-P56-WR		K/2/900C	Diet selection by sheep-Halton	IFB PJR	1972	Published
CLE-P60-WR		K/2/900C	Seed viability changes of native pasture plants in laboratory storage, Laboratory studies on seed germination and dormancy. Optimum constant temperature for germination of pasture species,	RGS	1973	Published

FILE NO.	OLD PROJECT NO.	FUND	PROJECT NAME	OFFICERS INVOLVED	ESTAB. DATE	STATUS
CLE-P61-WR		K/2/900	Productivity and biomass transfer in range grasses	EKC,BJC	1973	Published
			(i) Productivity and biomass transfer in mulga <u>Acacia</u> <u>aneura</u> rangelands	EKC,BJC	1973	
			(ii) Seasonal changes in nutritive value of preferred grasses	EKC,PJR	1973	
			(iii) nutrient circulation in a grazed buffel grassland	EKC,BJC		
			(iv) plant water relation of semi-arid grasses	EKC		
			(v) nett primary production and soil water balance in mitchell (<u>Astrebla</u>) grasslands	EKC		
			(vi) a simulation model for estimating animal stocking rates in the mulga shrubland of south west Queensland	EKC		
CLE-P62-WR		K/2/900C	Condition assessment in rangelands. Basal area/yield relationships for rangeland grasses.	EKC,BJC	1974	Published
CLE-P66-WR		K/2/900C	Production and stability of a grazed range grassland	EKC	1975	Published
			(i) Defoliation studies of the grasses of south west Queensland	EKC	1975	Published
			(ii) A comparison of primary production and water use of a C3 and C4 semi arid grassland community	EKC	1975	Published
			(iii) Productivity and stability of mitchell grass downs, Burenda grazing trial (SEE HR-175-WR ALSO)	EKC,DN Others	1975	
CLE-P69-WR		K/2/900C	Water stress in 4 grasses in pots	AJP	1975	Published
CLE-P69-WR		K/2/900C	Nutritive value of native plants (This project became incorporated in CLE-P73-WR, CLE-P77-WR and Burenda and Arabella nutrition trials)	IFB,PJR	1975	Superceded
CLE-P70-WR		K/2/900C K/2/900A	Herbage production as influenced by cutting frequency (Modified CLE-P43-WR) Herbage production on densely timbered and well grassed mulga soils as influenced by frequency of defoliation	RGS,LW KJL	1970	Partly published
CLE-P71-WR		K/2/900C	Survey of effects of mulga clearing	AJP		Abandoned
CLE-P73-WR		K/2/900C	Low lambmarking investigations - botanical and diet (D.A.I. No)	IFB,NPMcM	1976	Prelim. report

FILE NO.	OLD PROJECT NO.	FUND	PROJECT NAME	OFFICERS INVOLVED	ESTAB. DATE	STATUS
CLE-P74-WR		K/2/900C	Ecophysiological studies of native grass	EKC		Published
CLE-P75-WR		K/2/900C	Defoliation studies of the grasses of south western Queensland	RFB	1977	Published
			Part 1. Growth study of selected arid zone grasses	RFB		
			Part 2. Field observations of defoliation			
			Part 3. Observations of developmental morphology			
			Part 4. Glass house defoliation studies		1978	
			Part 5. Field observations of clipping, burning and fertilizing			
			Part 6. Mulga survival under different levels of pasture utilization			
			Part 7. Factors affecting *Aristida* germination (seed dormancy)			
			Part 8. Allelopathic effects of *Aristida* (Not established)			Not established
			Part 9. Defoliation studies-grasses			
CLE-P76-WR		K/2/900C	Production and stability in grazed mulga rangelands-Arabella grazing trial See HR-175-WR ALSO	WHB,IFB Others PSB,CJE, DC	1978	Concluded
CLE-P77-WR		AMRC DAQ37	Low productivity of cattle in south west Queensland-Dingwall and Wallal. (A.K.A. HR-DQ-37)	IFB,NPMcM	1977	Report
CLE-P79-WR		K/2/900C	Temporal change in the germinability of pasture seeds exposed to field conditions	RGS,FTS	1978	Concluded
HR-175-WR		K/2/1007A K/2/900C	Nutritional evaluation of south west Queensland pastures (i) Mitchell grass downs-Burenda (ii) Mulga pastures-Arabella	NMcM,IFB	1976	Published
BLACKALL PROJECTS						
BKL-P10-WR		K/2/900C	Composition of mitchell grass A. Walker, "Northampton Downs"	DLP		Published
BKL-P11-WR		K/2/900C	Feathertop in mitchell grass J. Legge, Malverton Siding	DLP		Published
BKL-P14-WR		K/2/900C	Blackspear control R. Woolcock, "Forest Park"	DLP		Concluded
BKL-P17-W		K/2/900C	Chloride levels in lucerne soils	JC	1962	Published
BKL-P18-WR		K/2/900C	Burning and stocking trial on feathertop C. Lloyd, "Lorne"	DLP	1963	Published

FILE NO.	OLD PROJECT NO	FUND	PROJECT NAME	OFFICERS INVOLVED	ESTAB. DATE	STATUS
BKL-P19-WR		K/2/900C	A fodder crop comparison trial-Tambo	JC	1964	Abandoned
BKL-P20-WR		K/2/900C	Oats planting rate trial-Minnie Downs, Tambo	JC	1964	Abandoned
BKL-P21-WR		K/2/900C	Lucerne row spacing-Minnie Downs, Tambo	JC	1964	Abandoned
BKL-P22-WR		K/2/900C	Grass sward trial-Minnie Downs, Tambo	JC	1964	Abandoned
BKL-P23-WR		K/2/900C	Buffel and speargrass counts "Duniera" and Tambo	JC		Published
BKL-P32-WR		K/2/900C	Moisture penetration into clay-pans G. Patterson, "Listowel Valley"	JC	1964	Published
BLK-P34-WR		K/2/900C	Summer legume trial P. Nicholson, "Burenda"	JC	1964	Abandoned
BKL-P40-WR		K/2/900C	Waterspreading - summer grazed crops, Cheepie	JC	1964	Abandoned
BKL-P41-WR		K/2/900C	Waterspreading - annual summer legumes, Beechal	JC	1964	Abandoned
BKL-P45-WR		K/2/900C	Yabil grass trial J. Walker, "Northampton Downs"	DLP	1964	Abandoned
BKL-P46-AG		K/2/900C	Lambing ewes on winter forage crop, "Lansdowne"	JC GLG	1965	Abandoned
BKL-P53-AG		K/2/900C	Dynamics of grazed <u>Astrebla</u> spp. pastures	DMO	1972	Published
BKL-P54-WR		K/2/900C	Utilization zones in three grazed paddocks	DMO	1972	Published
BKL-P55-WR		K/2/900C	Dynamics of grazed <u>Astrebla</u> pastures	DMO, PSB	1975	Published
TOORAK PROJECTS						
	NWP5	K/2/900C	Pasture cutting trial, Toorak	DIS	1958	Concluded
	NWP11	K/2/900C	Length of fallow, row spacing and N, Toorak	DIS	1959	Abandoned
	NWP28	K/2/900C	Pasture intake trial	EJW	1969	Published
TRK-P2-WR		K/2/900C	Selection by sheep grazing mitchell grass	JP	1968?	Published
TRK-P5-WR		K/2/900C	Cattle grazing mitchell grass	TJH, GL JCS	1971	Published

FILE NO.	OLD PROJECT NO	FUND	PROJECT NAME	OFFICERS INVOLVED	ESTAB. DATE	STATUS
TRK-P6-WR		K/2/900C	Legumes for pasture hay	JCS	1976	Concluded
RICHMOND PROJECTS						
	NWP29	K/2/900C	Survey of selenium occurrence	EJW		Abandoned
RMD-P5-WR	NWP30	K/2/900C	Mitchell grass defoliation-Toorak	EJW	1962	Abandoned
RMD-P7-WR	NWP32	K/2/900C	Grazing trial-Toorak	EJW	1962	Abandoned
CLONCURRY PROJECTS						
CLN-P36-WR		K/2/900C	Stocking a degraded mitchell grass pasture	JDC	1974	Concluded
CLN-P37-WR		K/2/900C	Irrigation of mitchell grass	JCS	1976	Concluded
CLN-P39-WR		K/2/900C	Fire in the mitchell grass of n.w. Qld	JCS	1976	Concluded

OFFICER ABBREVIATION CODE

RW	R. Wilson	GNB	G. Batianoff	DP	D. Purcell
JE	J. Ebersohn	TET	T. Telford	GL	G. Lee
WHB	W. Burrows	AJP	A. Pressland	GP	G. Payne (S&W, Blackall)
IFB	I. Beale	JP	J. Peart	PJR	P. Rowen
RGS	R. Silcock	DMO	DL Orr	BJC	B. Caffery
FTS	Flora Smith	TJH	T. Hall	NMcM	N. McMeniman (S&W, Charleville)
LW	Lynn (Corbett)Williams	JCS	J. Scanlan	GLG	G. le Gross (S&W, Blackall)
EKC	E. Christie	DN	D. Niven (S&W, Charleville)	RFB	R.F. Brown
JC	J. Cull	EJW	E. Weston		
PSB	P. Bowly	DIS	D.I. Sillar		
KJL	K. Lehane	JCS	J. Scanlan		