Dynamics of perennial grasses with sheep grazing in *Acacia aneura* woodlands in south-west Queensland

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Abstract

The effects of grazing on the dynamics of perennial grasses in *Acacia aneura* woodland were monitored between 1978–1984. Sheep numbers were adjusted annually to utilise between 20–80% of the total forage available at the end of summer.

Increasing pasture utilisation reduced the total basal area of perennial grasses and resulted in major shifts in the occurrence of individual grass species. *Aristida* spp. were the main species under very heavy grazing. Variation in rainfall between years resulted in large changes in total basal area and in the occurrence of individual grass species.

It is concluded that long-term wool production (data not presented) commensurate with maintenance of the vegetation may be maximised by 20% rather than higher levels of utilisation.

Introduction

Acacia aneura (mulga) woodlands are an extensive vegetation resource in arid/semi-arid Australia and represent a major grazing resource for the pastoral industry. This vegetation type has been grazed by domestic livestock for about 100 years although little is known of the dynamics of the perennial grass vegetation (Harrington *et al.* 1984). Nevertheless, these authors indicate the fragile nature of perennial grasses in these woodlands. Subsequently, Mills *et al.* (1989) identified extensive pasture and soil degradation in the mulga lands.

Perennial grasses in *A. aneura* woodlands contribute a major proportion to the diet of sheep, particularly when the availability of ephemeral forbs (the preferred grazing species) is low (Beale 1975; McMeniman *et al.* 1986a). Consequently, many of the effects of grazing pressure occur as a result of the level of defoliation of perennial grasses during the dry season (Blake 1938).

Large variations in seasonal rainfall in arid/semi-arid regions result in large variations in forage production which, in turn, lead to large variations in forage utilisation by livestock. For example, utilisation of *Astrebla lappacea* (Mitchell grass) measured between 1975–1984 in a commercially grazed paddock ranged from 5–50% and was related to pasture yield (Orr and Evenson 1991).

Studies of the pattern of dry matter production in *A. aneura* woodland indicate that in excess of 90% of forage production occurs during summer (October–March) due mainly to the growth of perennial grasses (Christie 1978). Nevertheless, winter forage production can be much higher than 10% during years with above-average winter rainfall through the growth of ephemeral forbs (Silcock *et al.* 1985). This predominantly summer pattern of forage production led Ebersohn (1973) to propose that the annual adjustment of livestock numbers to forage available at the end of summer would alleviate the effects of large variation in rainfall on the forage resource. However, the level of utilisation necessary to maintain long-term productivity was not known.

This paper reports responses in basal area of the main perennial grasses in *A. aneura* woodland to widely different levels of utilisation. The data presented represent part of a larger study designed to examine both vegetation and animal responses to different levels of utilisation of the end-of-summer forage.

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Methods

Grazing experiment

A grazing experiment was established in which the treatments were the removal of constant proportions of the total forage available at the end of each summer. This experiment was unreplicated as it was designed to study a broad range of unreplicated treatments rather than a restricted range of replicated ones. The experimental site was selected on the basis of a previous history of conservative grazing. Therefore, the composition of the perennial grass vegetation at the commencement of the study was indicative of good pasture condition.

The experiment was located within the Arabella land system (Mills *et al.* 1990) on "Arabella" station, 20 km east of Charleville. Four levels of forage removal (20, 35, 50 and 80%) were established in paddocks of 110, 46, 55 and 22 ha respectively, which were fenced during 1977. Grazing commenced in April 1978 when different numbers of sheep grazed these paddocks reflecting large variation in forage availability (both browse and grass).

In April each year, i.e. at the end of summer, the total forage available in each of the 4 paddocks was determined by harvest. Visual estimates of total pasture yield in each paddock were calibrated with measured dry weight. Assuming that the annual dry matter intake of a non-lactating sheep is 400 kg (after McMeniman *et al.* 1986b), the number of Merino wethers required to achieve the desired levels of forage removal was determined thus:

$$\text{Sheep number} = \frac{\text{forage yield (kg/ha)}}{400} \times \frac{\text{utilisation (\%)}}{100} \times \text{paddock size (ha)}$$

Rainfall during autumn, winter and spring 1979 was low and stocking rates were reduced in all paddocks. Rainfall over the 1979–80 summer was low and the 80% paddock was not grazed from April 1980–April 1981 because of limited pasture yield.

Basal area of perennial grasses

The percent basal area of perennial grasses was measured along permanent transects using a wheel point apparatus (Tidmarsh and Havenga 1955) with points spaced 1 m apart. Percent basal area was calculated from the number of "hits" on the base of live perennial grass plants and all recordings were made by the senior author to eliminate differences in the definition of a "hit".

There were 4 transects each of 300 points at 80% utilisation, 6 transects of 500 points at both 35 and 50% utilisation and 8 transects of 500 points at 20% utilisation. Recordings were made annually during May–June from 1978–1984 except in 1980 and 1983 when summer drought precluded accurate species identification.

Field data were summarised as individual species basal area and total basal area and results are presented for each year. The major species were *Aristida* spp. and *Thyridolepis mitchelliana* while other species, e.g. *Monochather paradoxus* and *Digitaria* spp. were of minor importance and contributed unevenly to total basal area.

Statistical analyses

Species and total basal areas within each year were analysed using GENSTAT (Anon. 1987) using a generalised linear model of proportions, with a binomial error structure. If the treatments were shown to be significantly different ($P<0.05$), pair-wise testing between individual treatments was conducted.

No attempt was made to analyse across years.

Results

Seasonal rainfall

Summer (October–March) rainfall was below the long-term mean for Charleville of 364 mm throughout this study (Figure 1). Despite this, rainfall of 163 mm in March 1982, 144 mm in November 1983 and 131 mm in January 1984 was very much above the long-term mean for these months. Winter (April–September) rainfall was very much above the long-term mean during 1978 and 1983.

Stocking rates

Stocking rates imposed to achieve the different levels of utilisation varied widely and ranged from 0.07 sheep/ha for the 50% utilisation during 1981–82 to 1.18 sheep/ha for the 80% utilisation during 1978–79. Mean stocking rates were 0.21 sheep/ha at 20, 35 and 50% utilisation and 0.51 sheep/ha at 80% utilisation.

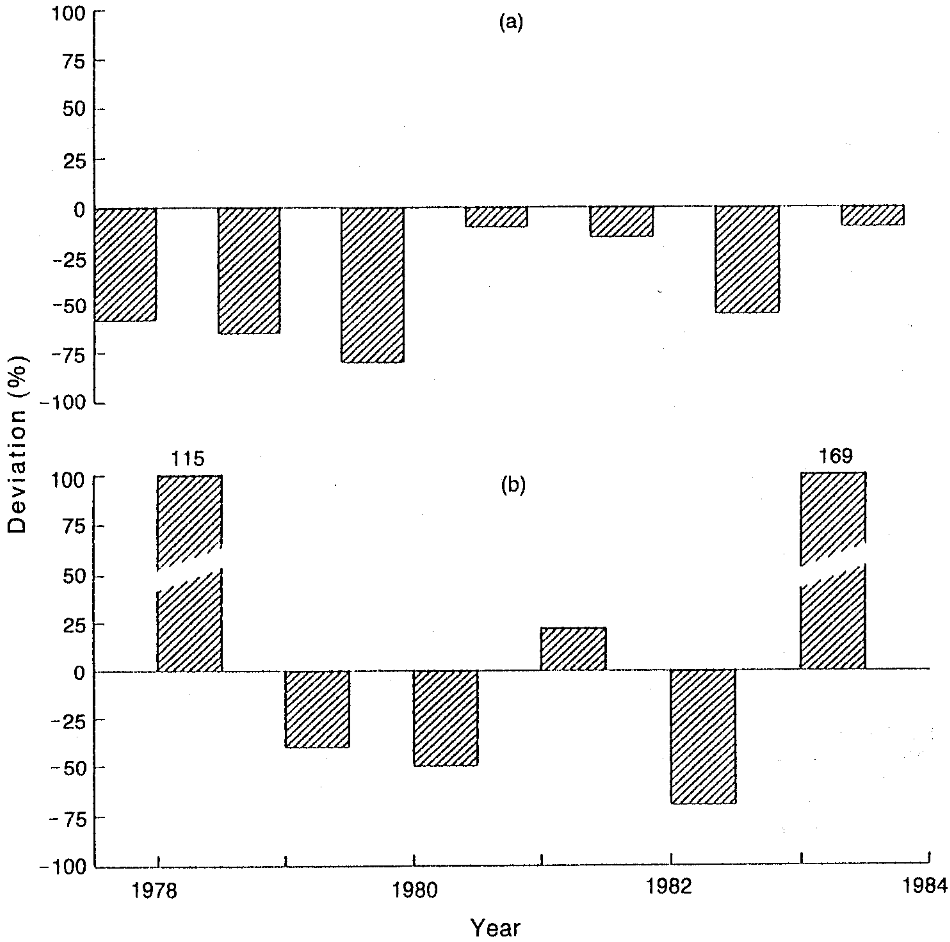

Figure 1. Deviation (%) from long-term mean (a) summer and (b) winter rainfall in *A. aneura* woodland near Charleville between 1977–1984.

Changes in the basal area of perennial grasses

Both grazing and season had a major effect on total basal area and the basal areas of *Aristida* spp. and *T. mitchelliana*. Total basal area declined in all paddocks between 1978–1981 (Figure 2a) during a series of seasons with below-average summer rainfall and increased between 1981–1984 following seasons with good rainfall during 1981–82 and 1983–84 (see Figure 1). The increase in total basal area after 1981 was greater under 20 and 35% than under 50 and 80% utilisation. Between 1978–1984, total basal area increased at 20 and 35% but was reduced at 50 and 80% utilisation. *Amphipogon caricinus* was a major contributor to the increase in total basal area at 20% utilisation.

Basal area of *T. mitchelliana* at the beginning of the study in 1978 varied between paddocks and was highest at 80% and lowest at 20% utilisation. However, by 1981 basal area of *T. mitchelliana* was higher at 20 and 35% than at 50 and 80% utilisation (Figure 2b). Between 1982–1984, basal area of *T. mitchelliana* increased under 20 and 35% but not under 50 and 80% utilisation. Between 1978–1984, basal area of *T. mitchelliana* increased only at 20%, was maintained at 35%

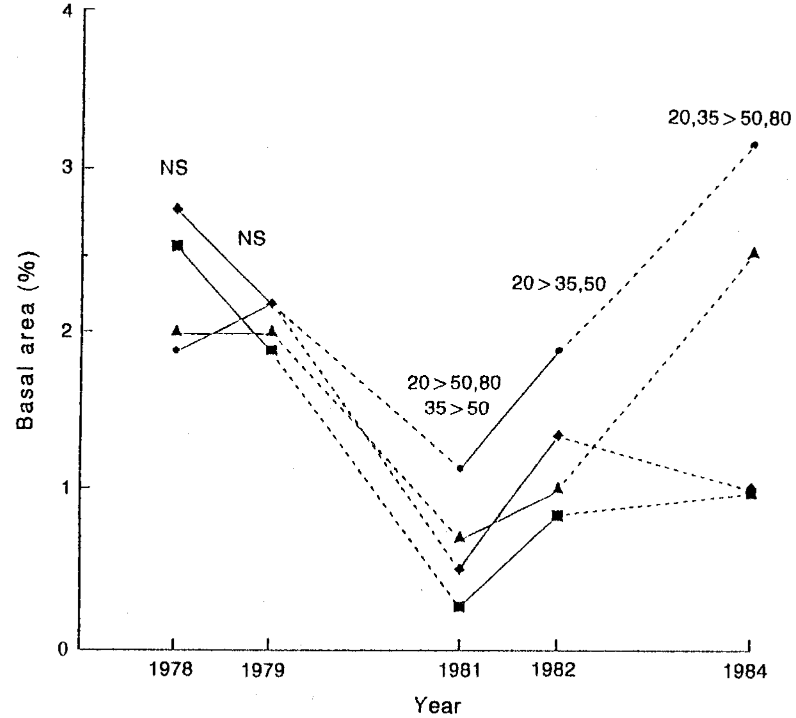

Figure 2a. Total basal area (%) under 4 levels of utilisation of end-of-summer forage in *Acacia aneura* woodland between 1978–1984: 20% (●), 35% (▲), 50% (■) and 80% (◆). (Significant differences ($P<0.05$) are indicated).

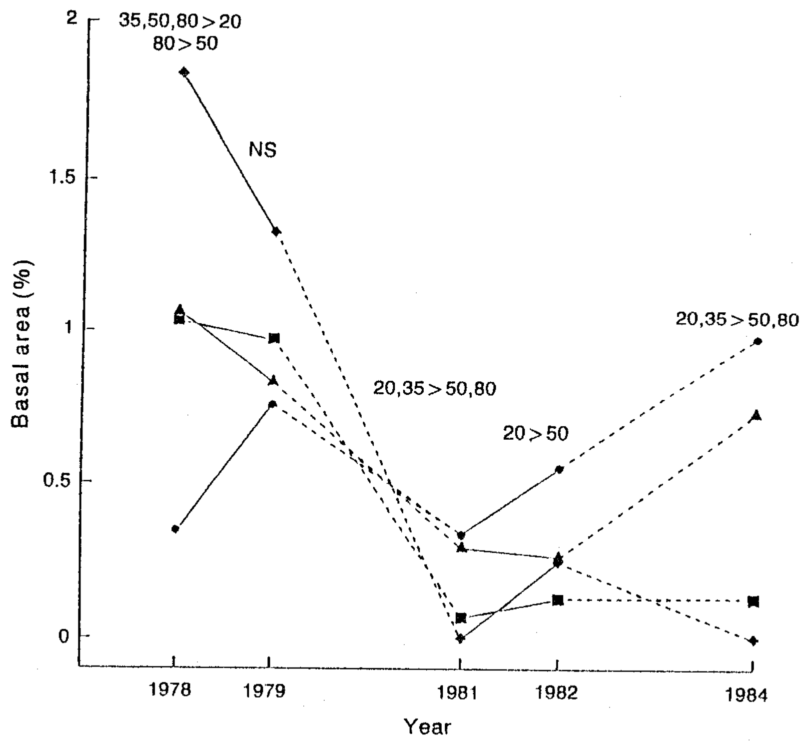

Figure 2b. Basal area (%) of *Thyridolepis mitchelliana* under 4 levels of utilisation of end-of-summer forage in *Acacia aneura* woodland between 1978–1984: 20% (●), 35% (▲), 50% (■) and 80% (◆). (Significant differences ($P<0.05$) are indicated).

and was reduced by both 50 and 80% utilisation. *T. mitchelliana* was a major contributor to total basal area at 20% utilisation in 1984.

Basal area of *Aristida* spp. in 1978 varied between paddocks and was highest at 50% and lowest at 20% utilisation although these differences between treatments had been eliminated by 1981 (Figure 2c). Between 1982–1984, basal area of *Aristida* spp. increased particularly under 35, 50 and 80% utilisation. *Aristida* spp. contributed approximately half of the total basal area at 50 and 80% utilisation in 1984. Between 1978–1984, the basal area of *Aristida* spp. increased at 35%, remained relatively unchanged at 20 and 80% and was reduced at 50% utilisation.

Discussion

Effects of utilisation on the pasture

These results must be regarded as tentative because of the short time span of this study relative to the longevity of perennial grasses. Furthermore, these treatments were unreplicated so that it is possible that the results reflect inherent differences in the population of grasses in the paddocks. However, our results are consistent with other studies in *A. aneura* woodland (e.g. Mills *et al.* 1989). Therefore, it is possible to draw some conclusions regarding the influence of grazing on perennial grasses in this vegetation type.

Differences in grazing and rainfall have caused marked changes in the perennial grass vegetation. The major effects of increased utilisation have been a reduction in total basal area and major shifts in basal area of individual species. The major effects of rainfall have been large variations in total basal area between years and large changes in the contribution of individual species to total basal area.

Large initial differences in species present were apparent at this site which highlights the heterogeneous nature of perennial grass vegetation. These differences are accentuated in semi-arid/arid areas where carrying capacities are low and the area required for grazing studies is large. A similar heterogeneity in *A. aneura* shrublands in Western Australia has been reported by Wilcox (1973).

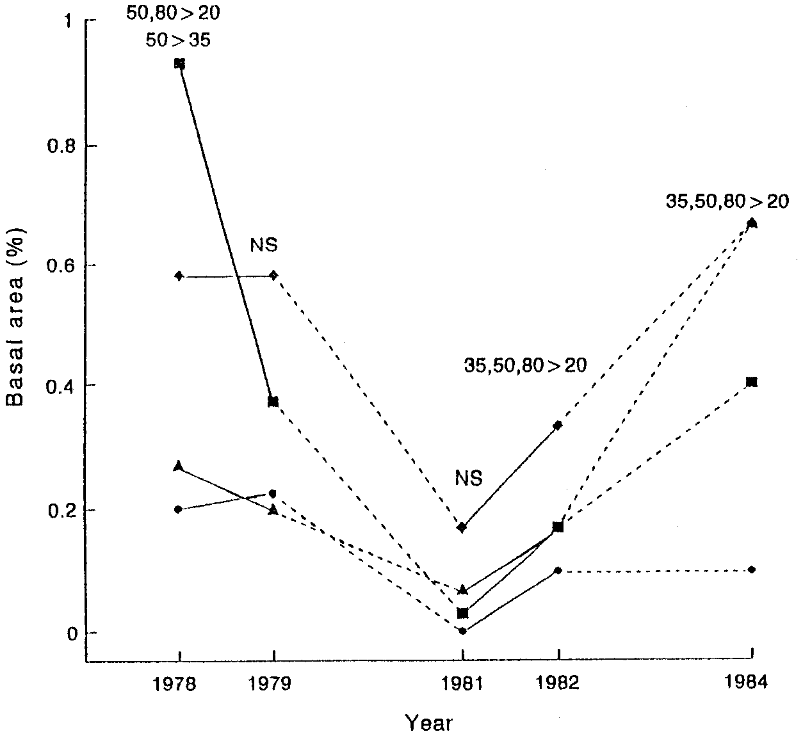

Figure 2c. Basal area (%) of *Aristida* spp. under 4 levels of utilisation of end-of-summer forage in *Acacia aneura* woodland between 1978–1984: 20% (●), 35% (▲), 50% (■) and 80% (◆). (Significant differences (P< 0.05) are indicated).

Changes in species composition

The change in basal area from *T. mitchelliana* dominance under light grazing to *Aristida* spp. dominance under heavy grazing reflects the inability of *T. mitchelliana* to withstand heavy grazing. In addition, *T. mitchelliana* is further disadvantaged relative to *Aristida* spp. with increased grazing pressure because *T. mitchelliana* is selectively grazed while *Aristida* spp. remain only lightly grazed (Beale 1975; McMeniman *et al.* 1986a).

Both species rely heavily on seed production to ensure continued survival because both species are short-lived and vulnerable to seasonal drought (Brown 1981). Ecophysiological studies of seed production in *T. mitchelliana* and *Aristida armata* indicate that *T. mitchelliana* is susceptible to increased grazing pressure through a reduction in reproductive capacity. Heavy defoliation of *T. mitchelliana* and *A. armata* during glasshouse studies caused *A. armata* to recommence seed production 3 weeks earlier than *T. mitchelliana* (Brown 1985; 1987). In those studies, *A. armata* also had a much higher proportion of assimilates allocated to inflorescence than did *T. mitchelliana*. In the field, *T. mitchelliana* is further disadvantaged over *A. armata* because emerging inflorescences of *T. mitchelliana* are more susceptible to defoliation than those of *A. armata* since the position of the tiller meristem at the time of transition to the reproductive state is more accessible to grazing animals (Brown 1982).

Reduced total basal area under heavy grazing, particularly during drought, was associated with an increase in the incidence of *Tripogon loliiformis*. Roberts and Silcock (1982) indicated that this species is common where the soil surface is bare. Furthermore, the reduction of perennial grass cover in *A. aneura* woodlands predisposes the vegetation to invasion by woody weeds, e.g. *Eremophila gilesii*. Both Booth (1985) and Harrington and Hodgkinson (1986) reported woody weed seedlings were less able to survive where a vigorous perennial grass cover was maintained.

Implications for grazing management

Perennial grasses were favoured by light grazing (20% utilisation). Moderate grazing (35% utilisation) maintained a similar total basal area to that under light grazing but by 1984 the contribution of *Aristida* spp. to this total basal area was greater than that of *T. mitchelliana*. Heavy grazing (50% utilisation and greater) was detrimental to perennial grasses and resulted in a major difference in composition such that *Aristida* spp. were the predominant species.

The composition of perennial grasses resulting from heavy grazing has important implications for the recovery of the vegetation following release from heavy grazing. *Aristida* spp. dominate the perennial grass vegetation with heavy grazing and experimental evidence (Brown 1986; 1987) indicates that any recovery of desirable species may be difficult to achieve. In addition, woody weeds are more likely to invade under heavy than under light grazing.

The data presented in this paper represent the perennial grass responses in a grazing study designed to examine the vegetation and animal responses to different levels of utilisation of end-of-summer forage. By combining the results presented here with animal production data from this study (Charleville Pastoral Laboratory, unpublished data), it is concluded that, of the utilisations monitored, maintenance of the vegetation may be maximised by 20% utilisation. This corresponds to a stocking rate of 0.20 sheep/ha for the duration of this study.

The adjustment of animal numbers to the forage available at the end of summer was practical as an experimental manipulation of grazing pressure. However, such adjustments in an overall property management situation may be less practical because of economic penalties associated with the sale or purchase of large numbers of animals. Large adjustments of animal numbers are required less frequently at light utilisation; graziers could retain a conservative nucleus of breeding animals and sell or purchase additional animals depending on rainfall.

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