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# Managing the grass-legume balance in *Stylosanthes scabra* cv. Seca pastures in central Queensland

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## Abstract

The impacts of 4 grazing strategies (yearlong grazing, summer grazing, winter grazing and winter grazing plus spring burning) on the grass:legume balance were studied between 2000 and 2006 in a pasture oversown with *Stylosanthes scabra* cv. Seca (Seca stylo) in central Queensland. Seasonal rainfall throughout the study was generally below average. Total pasture yields in autumn were higher in the 2 winter grazing than the 2 summer grazing treatments, largely reflecting the sampling time relative to when grazing occurred. There were few differences in Seca composition in autumn, although there was a clear trend for Seca composition to be reduced by winter grazing plus burning. Both the frequency of occurrence and plant density of Seca were higher under the 2 summer grazing treatments and there was also a trend for the density of juvenile plants (<5 cm height) to be higher in the 2 summer grazing treatments. Seca soil seed banks were generally low and were reduced in the winter grazing plus burning treatment in spring 2002. The frequency of the palatable perennial grass *Pennisetum ciliaris* (Biloela buffel grass) was reduced while that of the 'increaser' species *Bothriochloa pertusa* (Indian couch grass) and *Stachytarpheta jamaicensis* (snake weed) increased in the 2 summer grazing treatments compared with the 2 winter grazing treatments. Burning in spring increased soil loss in treatments grazed in winter. Differences in Seca frequency and density but not composition were explained by the 2 summer grazing treatments promoting 'gaps' in the pasture which were then colonised by Seca plants and other 'increaser' species. It was reasoned that, with time, mature Seca plants in the 2 winter grazing treatments would die so that Seca composition would eventually become higher under summer grazing regimes than under winter grazing. It was concluded that limiting grazing to particular seasons can alter legume:grass balance and that a timeframe of 5–8 years with average to good rainfall would be necessary to achieve large shifts in composition.

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## Introduction

Oversowing the introduced legumes *Stylosanthes scabra* cv. Seca (Seca stylo) and *S. hamata* cv. Verano (Verano stylo) into native pasture can improve annual liveweight gain per head by 30–70 kg (Middleton *et al*. 1993; Coates *et al*. 1997; Burrows *et al*. 2010). However, stylos can become dominant, resulting in adverse environmental effects including the loss of perennial grasses and increased risks of soil erosion and runoff, soil acidification and fungal attack on the legume (McIvor *et al*. 1996).

Stylo composition (proportion by weight) in a pasture increases with time from sowing (Partridge *et al*. 1996; Jones *et al*. 1997). In central Queensland, Seca stylo density and composition increased from 3 plants/m$^2$ and <1% in 1988 to 75 plants/m$^2$ and 50% in 2001 (Orr *et al*. 2010a). Initially, this increase occurred more rapidly at lighter stocking rates because of greater seed availability (Orr and Paton 1993), although later increases occurred independently of stocking rates (Orr *et al*. 2010a). There is a scarcity of data on the effects of pasture management on stylo composition, although spring burning, summer spelling, fertilising and sowing a grazing-tolerant grass have been suggested to increase the proportion of grass in a pasture (Partridge *et al*. 1996;

Jones *et al*. 1997). Summer spelling between 1996 and 2000 in central Queensland substantially increased the composition of desirable, perennial grasses in a pasture and reduced those of Seca and Verano stylo (D.M. Orr, unpublished data).

Studies of cattle diets in north Queensland indicated relatively low intakes of stylo during early summer. Consumption of stylo increased subsequently to peak around 80% of the diet in the late wet season or early dry season (Coates 1996). However, dietary studies during autumn in central Queensland indicated that, despite Seca contributing up to 50% of the pasture composition, the percentage in the diets of cattle grazing the pasture was much lower (Hendricksen *et al*. 2010). The optimal proportions of grass and stylo are not clear, although a 50:50 mix has been suggested as a reasonable balance (Partridge *et al*. 1996).

These considerations indicated a need to study how the proportion of stylo in the pasture can be manipulated through grazing management. This paper reports a grazing study aimed at evaluating the impacts of 4 seasonal grazing regimes on the balance between grass and legume. These grazing regimes were based on the hypothesis that grass is the major dietary component during summer, while the proportion of stylo reaches a maximum during autumn-early winter.

## Methods

### *Grazing study*

A grazing study was established at Belmont Research Station (23$^0$40’S, 150$^0$50’E) in 2000. The design was a randomised block with 4 treatments replicated twice. The 4 treatments were: year-long grazing, summer grazing (October-March), winter grazing (April-September) and winter grazing with burning in spring.

A 1 m contour topographic survey of the experimental site was used to locate the 8 experimental paddocks in a large paddock that had previously been blade-ploughed and shallow disc-ploughed in September 1984. The paddock was then sown with improved pasture species at 2 kg/ha *Panicum maximum* var. *trichoglume* (Green panic), 2 kg/ha *Pennisetum ciliaris* (Biloela buffel), 2 kg/ha *Chloris gayana* cv. Callide (Callide rhodes) and 2 kg/ha *Stylosanthes scabra* cv. Seca (Seca stylo). The soil type was a gradational soil (clay loam to medium clay) (Gn3) derived from andesite parent material; the original vegetation was brigalow (*Acacia harpophylla*)/softwood scrub (B. Forster, personal communication). Single superphosphate (9.6% P) had been applied at 125 kg/ha in 1969 and 1983 and 60 kg/ha in 1975.

The experimental paddocks were fenced in February–March 2000 and grazing commenced in April 2000. Paddock sizes were 2.4 ha for the year-long treatment and 1.2 ha for the other 3 treatments. Within blocks, paddocks for the 3 seasonal grazing treatments were stratified on legume composition measured in March 2000. When possible, the winter grazing plus spring burning treatment was burnt annually following the first rainfall event of 25 mm after October 1 and, together with the winter grazing treatment, remained ungrazed until the following April. Burning occurred on November 4, 2000, October 19, 2001, October 10, 2003, November 1, 2004 and November 18, 2005. Paddocks were not burnt in 2002 because of a combination of low pasture yields and a negative Southern Oscillation Index indicating a low probability of average rainfall and hence pasture growth in the following summer (McKeon *et al*. 1990).

During the first week of April each year, after the annual pasture sampling (see below), new steers (300–450 kg) were stratified on live weight and introduced to the year-long, winter grazing and winter grazing plus burning treatments, while cattle for the summer grazing treatment grazed the surrounding, larger paddock before being introduced into the summer grazing treatment in October. One steer grazed each paddock except during 2003–2004, when 2 beasts grazed the paddocks.

### *Pasture sampling*

Pasture yield and composition were estimated annually during the last week of March using Botanal (Tothill *et al*. 1992), when 4 trained operators assessed a total of 60 quadrats, 0.5 x 0.5 m, per paddock. Legume plant density was measured by counting the number of plants in each of these 60 quadrats and plants were recorded as either mature or juvenile (plant height <5 cm).

*Stylo soil seed bank*

Stylo soil seed banks were measured annually in spring prior to burning. Ten samples were collected in each paddock and each sample comprised 5 individual cores 5 cm diameter and 5 cm deep (*i.e.*, 50 cores per paddock). Seeds were recovered by washing, sieving, floatation, aspiration and finally hand separation (Jones and Bunch 1988).

*Rainfall runoff and soil movement*

Rainfall runoff and soil movement were measured in small catchments in one replicate of the winter grazing (area 6624 $m^2$) and winter grazing plus burning (area 7907 $m^2$) treatments. Slopes ranged between 3 and 5%. Each catchment was bounded with continuous rubber belting to restrict outside runoff from entering the experimental catchment. At the bottom of the catchment, a concrete block contained a bin of 100 x 100 cm x 200 cm deep (to slow the water to allow the bed load to settle). Each soil bin was attached to a Parshall flume to measure runoff. After rainfall events which resulted in runoff, bed load settling in the collecting bin was removed, oven dried and weighed. Suspended material was not measured.

*Statistical analyses*

In evaluating the effects of treatments across time, both overall trends and seasonal effects were considered using REML. Firstly splines (Orchard *et al*. 2000) were used to assess seasonal fluctuations while fitting the full fixed (treatment x time) model. The significance of the splines was evaluated by a chi-squared test on the change in deviance. Subsequently, the fixed effects were assessed for overall trends. Within years, data were analysed using GenStat as a randomised block design using analysis of variance and using data transformation as required.

## Results

*Rainfall*

Rainfall throughout the study was generally below average (Figure 1). In some months, such as February and December 2003, rainfall was above average, while summer rainfall in 2001–2002 and 2004–2005 was well below the mean. As a result of this below average 2001–2002 summer rainfall and the negative SOI (Southern Oscillation Index) in spring 2002, it was decided not to burn the winter grazing plus burning treatment during spring 2002. Following unseasonal rain of 150 mm in June 2002, an additional stylo density count was undertaken in September 2002.

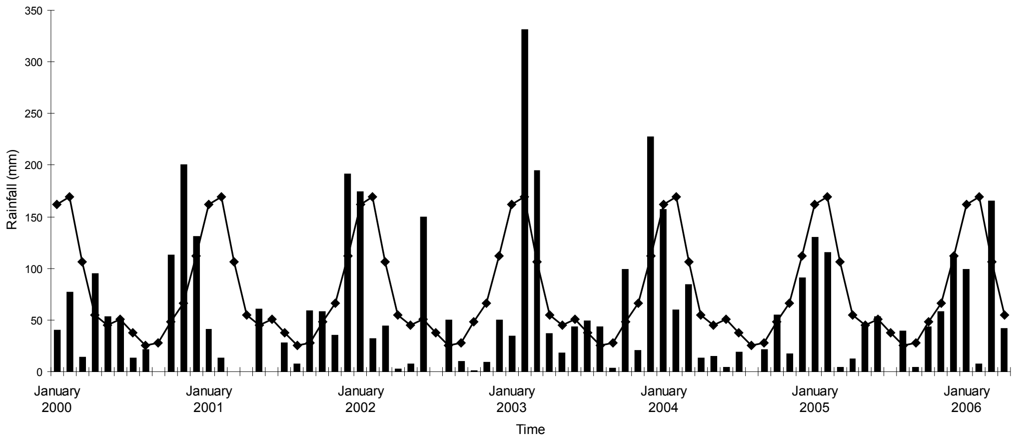


**Figure 1**. Monthly rainfall from January 2000 to March 2006 and the long-term mean rainfall (◆) at Belmont.

*Total pasture yields*

Below average rainfall throughout much of this study (Figure 1) was reflected in low pasture yields - particularly in the autumns of 2002, 2003 and 2005 (Figure 2). More favourable rainfall over the 2003–2004 summer was reflected in generally higher total pasture yields in autumn 2004, while autumn 2006 yields were boosted by 165 mm in March 2006 in an otherwise average summer rainfall. Total pasture yields in autumn were influenced by treatment (P<0.05) with yields in the 2 winter grazing treatments being highest, yields in the year-long grazing being intermediate and yields in the summer grazing treatment being lowest. (These yields reflect the timing of pasture sampling in late March in relation to the commencement of the 2 winter grazing treatments in early April).

*Occurrence of stylo*

*Composition.* The composition of Seca fell from 14% in 2000 to 3% in 2001 and then fluctuated between treatments for the remainder of the study (Figure 3). The only year in which significant differences between treatments were recorded was 2005, when composition was 16% in year-long grazing and only 1% in the winter grazing plus burning treatment (P<0.01). In 2006, Seca composition was only 2% in the winter grazing plus burning treatment and 7–11% in the remaining treatments (P>0.05).

*Frequency.* Spline analyses indicated a treatment x year interaction (P<0.05) for Seca frequency with frequency declining in all treatments from 76% in 2000 to 26% in 2002, increasing again to average 56% in 2003 and then separating according to treatment (Figure 4). By 2004, stylo

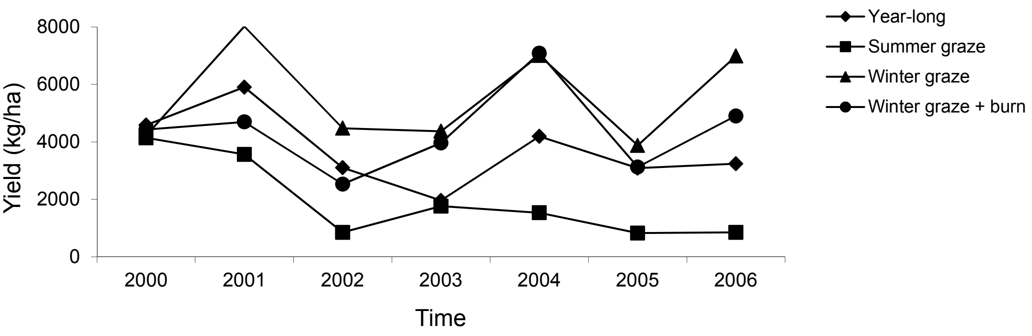


**Figure 2**. Total pasture yields (kg/ha) in autumn in 4 grazing treatments between 2000 and 2006.

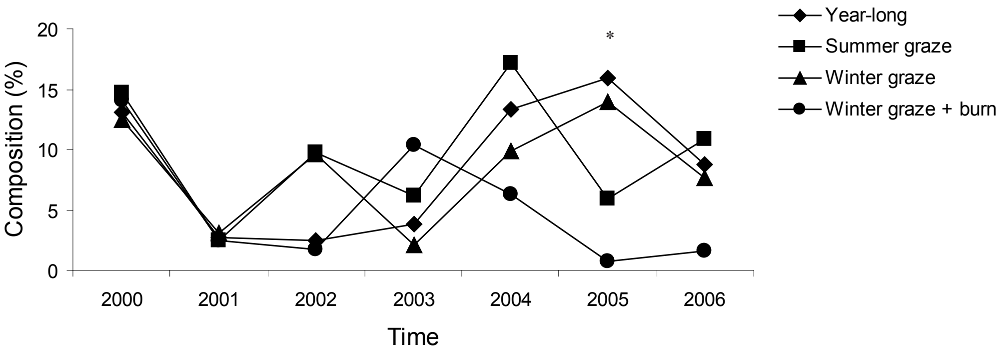


**Figure 3**. Changes in the composition of *S. scabra* cv. Seca in autumn in 4 grazing treatments between 2000 and 2006. [Asterisks indicate significant (P<0.05) differences within years].

frequency was highest with summer and year-long grazing, intermediate with winter grazing and lowest with winter grazing plus burning. This pattern persisted until 2006, when the highest frequency was 76% with summer grazing and lowest at 18% with winter grazing plus burning.

*Total density.* Total Seca density followed a similar pattern to frequency. Spline analyses indicated a treatment x year interaction ($P<0.05$), with density declining in all treatments from 10 plants/m$^2$ in 2000 to 2 plants/m$^2$ in 2002, increasing again to average 12 plants/m$^2$ in 2003 and then separating according to treatment (Figure 5). By 2004, stylo density was highest for summer grazing and year-long grazing, intermediate for winter grazing and lowest for winter grazing plus burning and this pattern persisted until 2006, when the highest density was 12 plants/m$^2$ for summer grazing and 1 plant/m$^2$ for winter grazing plus burning.

*Juvenile Seca density.* The density of juvenile Seca plants varied from <1 plant/m$^2$ in 2000 up to 7 plants/m$^2$ in 2003 (Figure 6). Density of juveniles tended to be higher in the 2 treatments grazed in summer, although these differences were significant ($P<0.05$) in 2006 only.

*Seed banks.* The soil seed bank of Seca fell from 650 seeds/m$^2$ in 2000 to 170 seeds/m$^2$ in 2004 (Figure 7), reflecting the low rainfall during the March-May period in the intervening years, when Seca plants usually flower and seed. From 2001 to 2004, the winter grazing plus burning treatment had a lower soil seed bank than the other 3 treatments; however, this difference was significant ($P<0.05$) only in 2002.

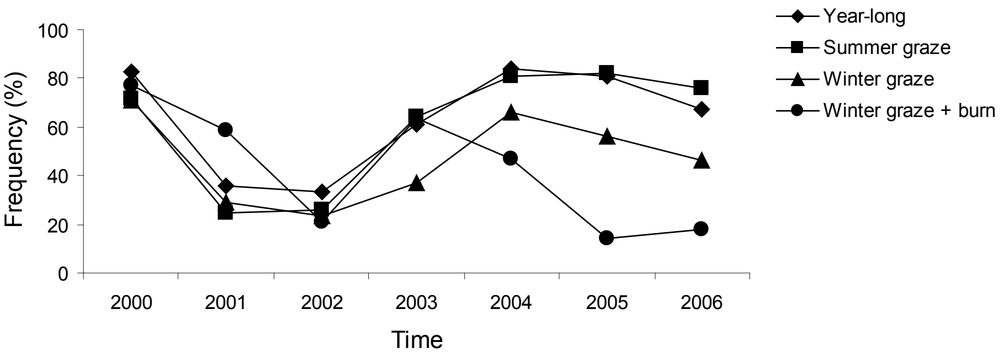


**Figure 4**. Changes in the frequency of *S. scabra* cv. Seca in autumn in 4 grazing treatments between 2000 and 2006.

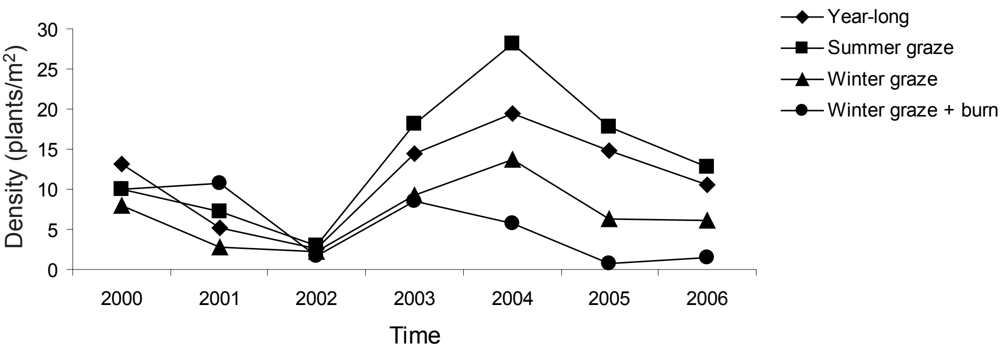


**Figure 5**. Changes in the density of *S. scabra* cv. Seca in autumn in 4 grazing treatments between 2000 and 2006.

### *Occurrence of other species*

Changes in the frequency of other plant species due to grazing became apparent with significant year x treatment interactions ($P<0.05$) for *Pennisetum ciliaris*, *Bothriochloa pertusa* and *Stachytarpheta jamaicensis* (Figures 8a, 8b and 8c). The frequency of *P. ciliaris* declined throughout this study with both year-long and summer grazing, was maintained with winter grazing plus burning and improved slightly with winter grazing. *B. pertusa* was uncommon in 2000 but increased throughout the study, with greater increases in both the year-long and summer grazing treatments than in the 2 winter grazing treatments. While the initial frequency of *S. jamaicensis* was 25%, it increased during 2001 and then declined to around 10% in 2002. After 2002, *S. jamaicensis* increased in the summer grazing treatments.

### *Soil erosion and runoff*

Cumulative soil loss between October 2001 and January 2005 was 10 kg/ha in winter grazing plus burning compared with 2 kg/ha in the winter grazing treatment (Figure 9). Soil loss was accentuated following burning in spring 2001 and 2003, when burning exposed the soil surface. Rainfall of 330 mm in February 2003 also increased soil loss.

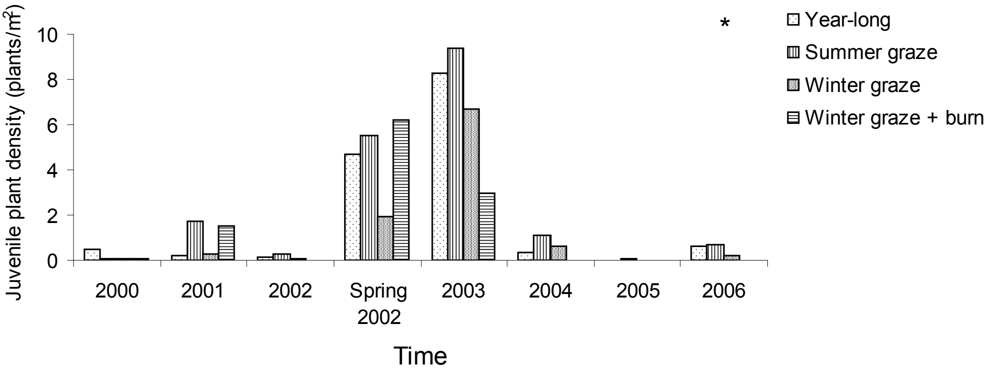


**Figure 6**. Changes in the density of juvenile plants of *S. scabra* cv. Seca in autumn in 4 grazing treatments between 2000 and 2006. [Asterisks indicate significant ($P<0.05$) differences within years].

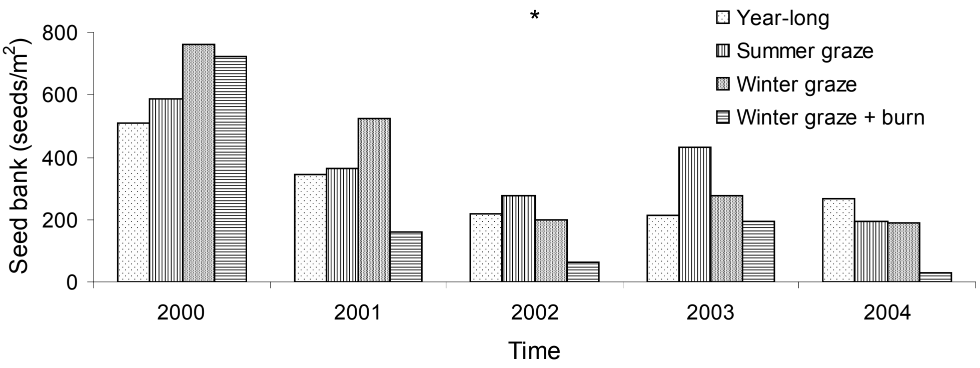


**Figure 7**. Changes in the soil seed bank of *S. scabra* cv. Seca in spring in 4 grazing treatments between 2000 and 2004. [Asterisks indicate significant ($P<0.05$) differences within years].

## Discussion

This study indicated that summer and year-long grazing can increase both the frequency and density, but not the composition, of Seca in a pasture above that under winter grazing and winter grazing plus burning. This finding supports and provides further evidence for the suggestion (McIvor *et al*. 1996; Partridge *et al*. 1996) that grazing management can be used to alter botanical composition in grass-legume pastures by spelling or reducing grazing pressure in summer to favour growth and seed production of perennial grasses. However, the results obtained in this study are limited by the duration of the study (6

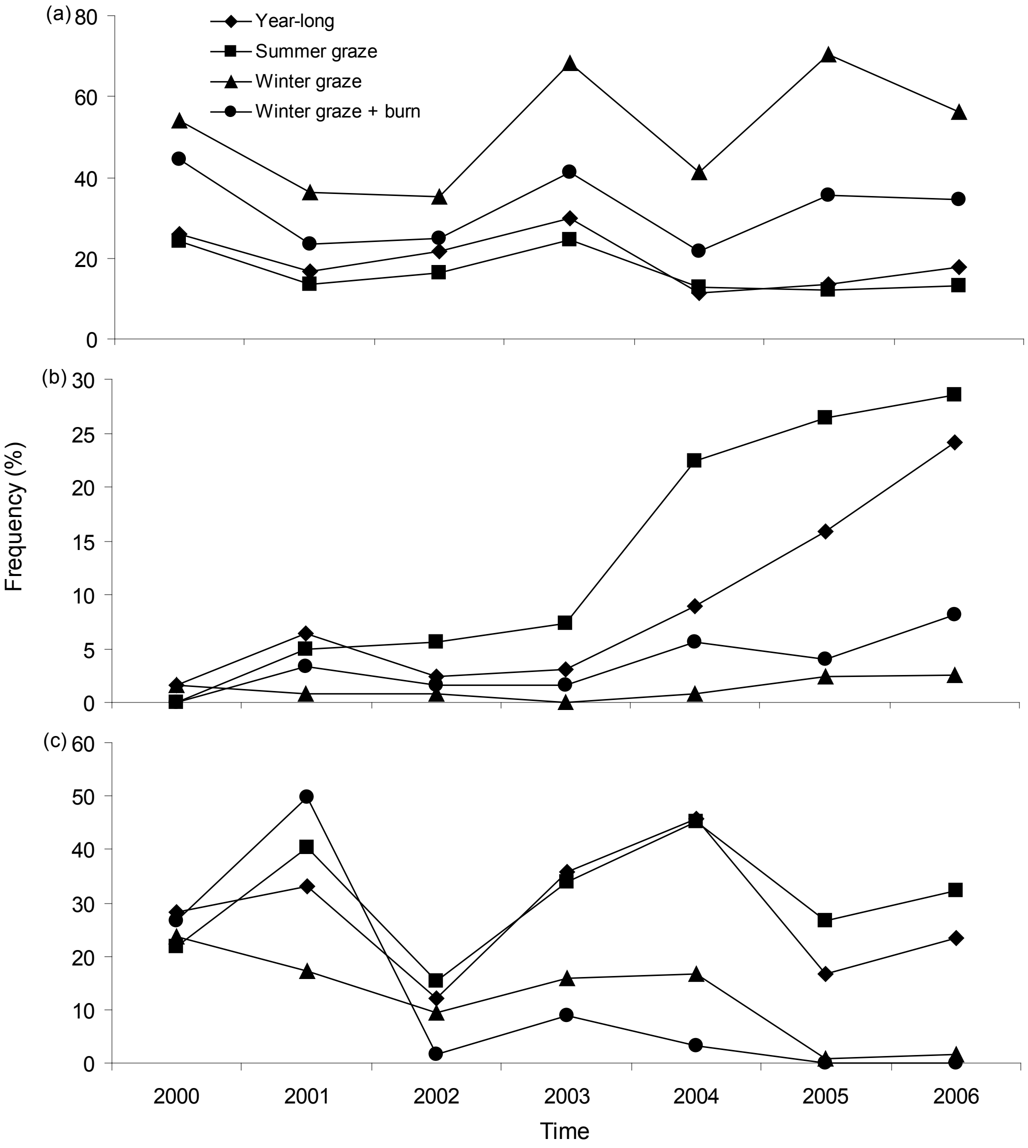


**Figure 8**. Changes in the frequency of: (a) *Pennisetum ciliaris*, (b) *Bothriochloa pertusa* and (c) *Stachytarpheta jamaicensis* in autumn in 4 grazing treatments between 2000 and 2006.

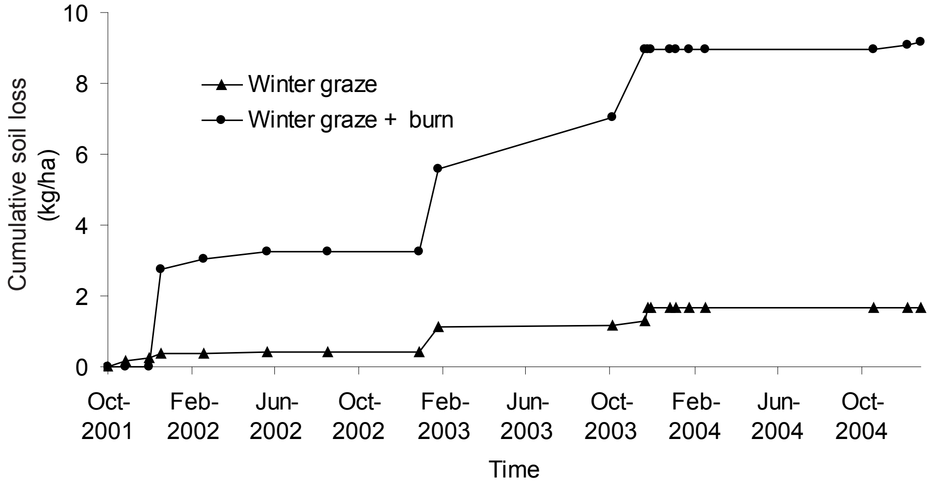


**Figure 9**. Cumulative soil loss from winter grazing and winter grazing plus burning treatments between October 2001 and January 2005.

years) in comparison with the life-span of the Seca plants.

The maximum life-span of Seca plants is 8–10 years (Gardener 1984; Orr *et al*. 2010b). The differences in frequency and density of Seca plants, but not in composition, may be explained by differences in the range of age classes of Seca plants present in the 4 treatments. The high yields (to achieve similar pasture composition) from fewer plants was probably achieved through larger, older plants in the winter grazing treatment. As these older plants die and recruitment is lower than with summer grazing, the composition of Seca in the winter grazing treatments will eventually fall. Therefore, grazing management needs to consider the life-span of Seca plants when aiming to achieve large shifts in the grass:Seca balance.

Higher frequency and density of Seca under summer grazing, particularly after 2002, resulted from greater establishment of Seca plants in 'gaps' between grass plants created when cattle selectively grazed grasses. This suggestion was supported by the increased number of juvenile plants under summer grazing. Similarly, both *B. pertusa* (Jones 1997; Cooksley 2003) and *S. jamaicensis* (Anderson 1993) are indicators of disturbance and their increase under summer grazing is further evidence of these 'gaps' created by summer grazing. The higher frequency and density of Seca under summer grazing will, in the longer term, lead to an increased composition of Seca. Conversely, the reduced frequency of the palatable perennial grass *P. ciliaris* under summer grazing indicates the detrimental impacts of summer grazing on such palatable grasses. This finding supports the suggestion (Orr and Paton 1997; Ash *et al*. 2002) that summer spelling is useful in maintaining the integrity of palatable, perennial grass in these pastures.

Repeated (burnt 5 times in 6 years) spring burning with relatively high fuel loads had a deleterious impact on Seca density and frequency in this study. This finding conflicts with data of Gardener (1980) indicating that Seca is resistant to burning - even with high fuel loads - because it possesses underground growth buds which sprout again following fire. The deleterious impact of frequent burning on Seca in the current study supports the suggestion (Noble *et al*. 2000) that fire may be more successful in killing individual Seca plants where perennial grasses are available to 'carry' the fire. Perennial grass fuel loads at the time of burning in this study were around 2000 kg/ha. Radford *et al*. (2001) reported that fuel loads below this are sufficient to control seedlings of the invasive shrub *Acacia nilotica* (prickly acacia), while fuel loads of 2000 kg/ha are sufficient to control the invasive weed *Cryp-*

*tostegia grandiflora* (rubber vine) in native pastures (Radford *et al.* 2008). Furthermore, field inspection in the winter grazing plus burn treatment suggests that burning may also be reducing the occurrence of individual forb species (D.M. Orr, unpublished data).

While any loss of topsoil is of concern, the 2–10 kg/ha soil loss between 2001 and 2005 for this clay loam was very small compared with that on other soil types elsewhere in central Queensland. For a texture contrast soil with 3–5% slope near Emerald, Waters (2004) reported soil losses of 2–24 t/ha between 1994 and 2000, while for a duplex soil with 5–6% slope near Calliope, Sallaway and Waters (1996) reported losses of 50–1100 kg/ha between 1991 and 1996 with the highest figures in both studies being recorded at the heaviest stocking rates. Although not reported here, runoff was also low compared with these other studies.

In north Queensland, Cooksley and Quirk (1999) reported that heavily stylo-dominant pastures (>90% legume composition) were unable to be restored to high perennial grass composition in the short term with management options such as spelling, fire and variable stocking rate, although a combination of fire and spelling could recover a 'significant native grass component' given 'sufficient time'. However, results from my study suggest that, provided there is a reasonable yield of perennial grasses, summer spelling should be more effective in restoring high perennial grass composition than burning and that burning should be used as a strategic management tool. An important difference between north and central Queensland is that native grasses, especially *Heteropogon contortus*, are less persistent in north than in central Queensland (Orr *et al*. 2004). Cooksley and Quirk (1999) emphasise the importance of managing the grass:legume balance before the perennial grass composition falls below 30–40% and the results from my study support this suggestion.

### *Practical implications*

The low initial Seca composition in this study combined with generally low rainfall limited the opportunities to achieve large differences in Seca composition in the pastures with the management strategies imposed, and this situation was compounded by the relatively high fertility of the soil together with the presence of introduced grasses. Nevertheless, this study has indicated that grazing only in certain seasons can alter the grass:legume balance in a pasture but periods of 5–8 years with average to good rainfall may be necessary to achieve large shifts in composition.

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