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Grazing pressure and tree competition affect cattle performance and native pastures in Eucalypt woodlands of Queensland, north-eastern Australia

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Abstract

Context. Well managed grazing pressure will optimise animal and pasture production, and preserve the soil to maintain a viable beef business on native pastures in eucalypt woodlands.

Aims. A cattle grazing experiment was established to measure animal and pasture performance under management practices used in the *Aristida*/*Bothriochloa* native pastures in central Queensland.

Methods. Performance of Brahman-cross steers and pastures were measured in an experiment with three grazing pressures by two tree densities in a *Eucalyptus populnea* woodland in north-eastern Australia over 8 years in paddocks of 4–18 ha.

Key results. At low grazing pressure with trees killed by herbicide ('cleared'), stocking rate increased 35% as pasture composition and biomass improved over 8 years. At low grazing pressure where treed, stocking rate remained constant, however, at high grazing pressure where treed, it was reduced after 4 years. The annual liveweight gain increased from 0.37 to 0.45 to 0.51 kg/head.day as grazing pressure was reduced from high to medium to low grazing pressure respectively, and across grazing pressures it decreased from 0.49 where cleared to 0.39 kg/head.day where treed. Liveweight gain per hectare increased under low grazing pressure and declined at medium and high pressures. Body condition scores responded positively to lower grazing pressure and a lack of tree competition to pastures. This treatment combination also produced higher animal sale values. Pasture biomass, basal area and ground cover were all affected negatively by increasing grazing pressure.

Conclusions. Grazing 25% of autumn pasture improved dry matter production, species composition and land condition, and increased steer growth rates, body condition and their market value. This grazing pressure produced an increasing trend in stocking rates relative to the decline at higher grazing pressures. Higher liveweight gain/ha was produced initially at high grazing pressure (75% utilisation), however, after 4 years animal condition and pastures deteriorated, requiring a reduction in stocking rate to maintain the condition of both the remaining animals and the pastures. Managing tree competition to pastures is necessary to maintain the higher animal production potential.

Implications. This objective information demonstrates the benefits for cattle, pastures and long-term economic outcomes of managing for conservative grazing pressure and controlling tree competition to pasture in this woodland. Applying these findings can improve beef business outcomes and provide management groups with objective educational resources.

Additional keywords: *Aristida*/*Bothriochloa*, cattle liveweight, condition score, pasture production, poplar box.

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Introduction

Beef production is the major agricultural industry across the pastoral zone of northern Australia. Here, managing grazing pressure (GP) on pastures is a regular decision that beef cattle producers (farmers, ranchers) make to maintain their pastures and animal production, and to prepare their stock for market specifications. These management decisions affect the performance of their cattle and pastures, and have a direct effect on land condition and long-term business profitability. Rangelands are managed often by changing GP based on producers' long-term experience with their pastures and cattle body condition, and less on objective measurements of cattle growth rates or pasture production and composition. Periodic spelling or pasture rest is included in many grazing systems. However, although there are general grazing management principles for northern Australia (Ash *et al*. 2001; O'Reagain and Ash 2002; Orr 2005; Hunt *et al*. 2014), there is limited objective information to guide these management decisions in the eucalypt woodlands of central Queensland. We hypothesised that rangeland management of native pasture communities that is based on objective measurements of cattle performance, pasture production and composition, and soil surface protection, will provide definitive management guidelines for increasing the economic and long-term environmental viability of beef grazing enterprises.

There are many reports (Teague *et al*. 2011) of increased GP changing pasture structure or composition from desirable grasses to poorer grazing species both in the Australian rangelands (Landsberg *et al*. 2003; Orr *et al*. 2010*a*) and in South Africa (Van Rooyen *et al*. 1991). For example, O'Reagain and Bushell (2011) reported deteriorating pasture condition in Eucalypt woodlands in north Queensland after continuous heavy GP, and Orr *et al*. (2001) have reported composition changes in the black speargrass pastures of central Queensland due to GP. However, there are some Australian pasture communities, such as the *Astrebla* spp. (Mitchell grass) grasslands where heavy GP has not caused a dramatic shift in the dominant perennial grass composition (Orr and Phelps 2013).

In the dry tropics, animal production and breeder performance are historically variable and strongly related to animal nutrition on native perennial grass pastures (Holroyd *et al*. 1977), such as those in the *Aristida*/*Bothriochloa* (*A*/*B*) pasture community (Weston *et al*. 1981). This community is usually on infertile and poorly structured soils (Tothill and Gillies 1992), with *Eucalyptus populnea* F.Muell. (poplar or bimble box) the common overstorey tree species in southern areas and *Eucalyptus melanophloia* F.Muell. (silver-leaved ironbark) and *Eucalyptus crebra* F.Muell. (narrow-leaved ironbark) more common in the north. The detailed floristics across the varying *A*/*B* pasture soil types in central Queensland have been described by Schefe *et al*. (1993) and Silcock *et al*. (2015*a*, 2015*b*).

Tree competition can reduce pasture yields by 50% (Burrows *et al*. 1990; Café *et al*. 1999; Hall *et al*. 2016*a*). It can also affect species composition by reducing the proportion of desirable perennial grasses in eucalypt woodlands of northern Australia, including in *E. populnea* communities (Hall *et al*. 2017). This effect causes land managers to clear dense tree populations to help maintain grass and cattle production. A diverse pasture in good condition provides additional 'ecosystem service' benefits (Teague *et al*. 2011) such as diverse wildlife, surface soil stabilisation and lower soil temperatures. Species changes reported by Hall *et al*. (2017) that are indicative of heavy GP in this *A*/*B* community include a reduction of desirable species such as *Dichanthium sericeum* (R.Br.) A.Camus (Queensland bluegrass) and *Themeda triandra* Forssk. (kangaroo grass), and an increase in *Chloris* spp. (windmill grasses), *Enneapogon* spp. (bottlewasher grasses), *Tripogon loliiformis* (F.Muell.) C.E.Hubb. (five-minute grass) and of forbs, including unpalatable *Sida* spp. (flannel weeds). The botanical names in this paper are from the Australian Plant Name Index (APNI 2017).

Silcock and Hall (1996) and Hall (2000) showed that pasture composition and soil type had major influences on wool production, quality and sheep profitability in the *A*/*B* community. However, there is limited objective information about cattle performance on these pastures, especially on the effects of GP. When cattle producers better understand the degree to which their grazing management decisions affect their pastures, cattle growth rates and animal condition, they are in a more informed position to adjust GP strategically to optimise cattle performance and to minimise any detrimental environmental impacts grazing may have on the pasture.

A forage budgeting approach is promoted as the basis for good pasture management of both cattle and pasture condition in grazing land management education courses across northern Australia (Queensland Government 2018). Maintenance of desirable perennial, palatable and productive (*3P*) grasses forms the basis of native pasture-based cattle production systems across much of this region (Winter *et al*. 1991), especially where pastures are in good condition (Karfs *et al*. 2009). Exceptions are the sown exotic legume or grass pastures of central Queensland used for fattening cattle for market. These improved pastures complement the extensive C_4 grass-dominated native pastures used for breeding and steer growing in the eucalypt woodlands of the *A*/*B* pasture community.

Grazing methods or systems used around the globe are diverse to complement the local production situations (Allen *et al*. 2011). In northern Australian rangelands Hall *et al*. (2014) found that the grazing method had less effect on pastures than adjusting GP. However, the method could have an effect of producing a higher diet quality selected by cattle in the growing season under a continuous grazing system (Hall *et al*. 2016*b*). These authors reported that rotations versus continuous grazing with annual rest periods had a similar effect on pasture composition and land surface condition when GP was adjusted to match the forage on offer. Thus, this grazing management research (Silcock *et al*. 2005) in eucalypt woodlands within the *A*/*B* pasture community of central Queensland focused on GP responses under continuous grazing, with short annual rest periods in winter, and not on responses to, or altering, the grazing method or system.

This paper reports results from an 8-year GP by tree competition (trees killed/cleared vs treed woodland) experiment on cattle growth rates and body condition scores, and the concomitant pasture responses.

Materials and methods

Pasture community and location

The experiment was located in a 200 ha open woodland site dominated by *E. populnea* trees within the *A*/*B* native pasture region on a commercial beef cattle property west of Injune (25°45′23″S, 148°24′56″E), at 480 m elevation (Fig. 1). Tree basal area (BA) averaged 8.7 m^2/ha which is normal for eucalypt woodlands of Queensland (Burrows 2002). The site supported native C_4 perennial tussock grasses typical of *A*/*B* pastures in B-condition (Karfs *et al*. 2009), dominated by *Bothriochloa decipiens* (pitted bluegrass), *Aristida* spp. (wiregrasses), *Chrysopogon fallax* (ribbon grass), *D. sericeum*, *Chloris divaricata* (windmill grass), *Enneapogon* spp. and *T. triandra*. Broadleaf forbs included *Verbena tenuisecta* (Mayne's pest), *Brunoniella australis* (blue trumpet) and Chenopodiaceae

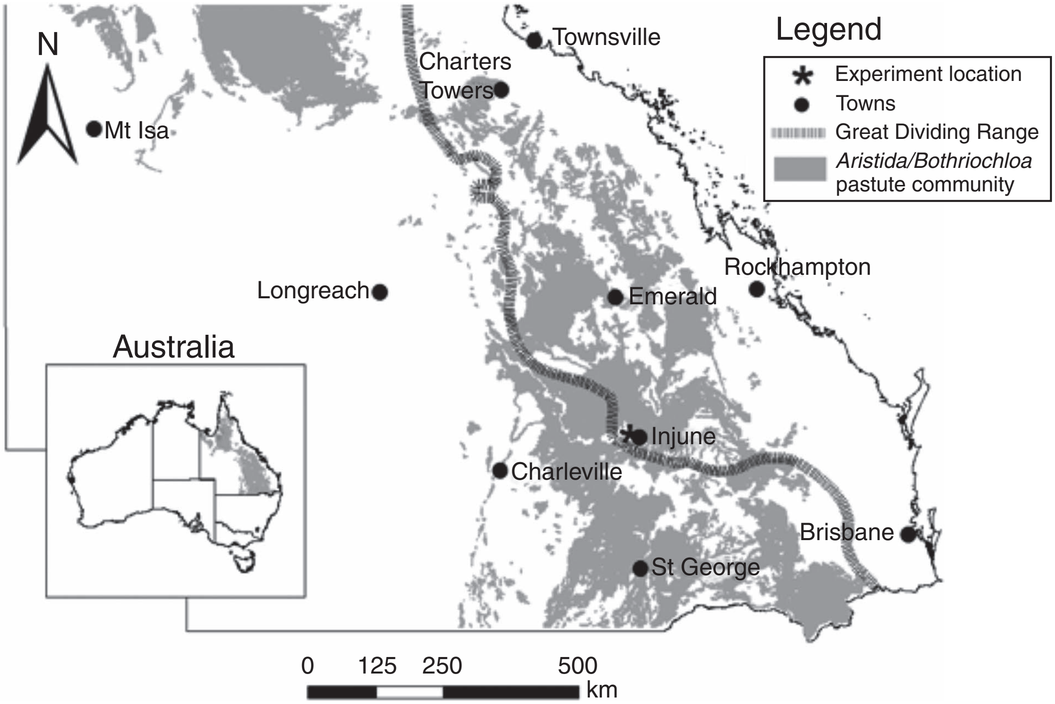

Fig. 1. Location of the *Eucalyptus populnea* woodland research site and nearest town, Injune, on the east of the Great Dividing Range, in the *Aristida/Bothriochloa* (*A/B*) native pasture community of Queensland. Insert shows the *A/B* community within north-eastern Australia.

(saltweeds), plus legumes from the *Glycine*, *Desmodium* and *Indigofera* genera (Schefe *et al*. 1993; Hall *et al*. 2016*a*). The soils were light, texture-contrast sodosols, predominantly of low nitrogen and phosphorus fertility, which are common under the *A/B* pastures of central Queensland (Silcock *et al*. 2015*b*). The mean temperature extremes are from >34°C in summer to <4°C in winter, with frosts in June–July each winter with an average of 19 days that have a minimum of <0°C (Bureau of Meteorology 2017).

Grazing pressure by tree competition treatments

The experiment was a randomised block with two replications of six treatment combinations: three GP by two tree competition levels (12 paddocks). The three GP treatments were set annually, based on a forage budgeting approach, as utilisation rates of the autumn pasture biomass. The GP were: 'low' (L) with a potential intake of ~25% of the autumn pasture biomass over the ensuing 12 months, 'medium' (M) ~50% intake and 'high' (H) ~75% intake. These GP are within an expected range in local commercial practice. The tree competition treatments were: all trees killed by Tordon herbicide, called 'cleared' (C), and trees retained untreated, called 'treed' (T). The six cleared treatment paddocks were established in July 1994, and the dead trees were left standing. Paddock areas were fixed and were determined by estimating, via the GRASP pasture model (Littleboy and McKeon 1997), the area of pasture needed with average rainfall to run three 250 kg Brahman cross steers for a year at the required GP, without and with tree competition at the measured local tree BA. The areas for the paddocks for each replication were 4, 6 and 12 ha for the high, medium and low GP-cleared, and 6, 9 and 18 ha for the same GP-treed treatments respectively. Thus, there were six steers per treatment at the start of the experiment.

For each of the 8 years of the experiment, from July 1994 to June 2002 (Years 1–8), the GP was re-adjusted for each paddock annually after the autumn pasture biomass measurements, by changing total cattle liveweight, mostly with new weaner steers (mean 192 kg). The numbers were calculated for each treatment so that over the ensuing 12 months growing animals of the initial weight would potentially consume the equivalent of the required 25, 50 or 75% of the autumn pasture biomass. For each year, the animals' expected consumption over a year was calculated at 10-day intervals from the daily intake equation of Minson and McDonald (1987). Consumption was based on estimates from local producers that young steers had the potential to gain 1 kg/head.day in mid-summer and could lose 0.3 kg/head.day in late winter. The steer growth rate was assumed to vary steadily in a sinusoidal pattern between these extremes each year. Variable steer daily growth rates occur because the dominant C_4 grasses follow the normal tropical grass pattern with growth only in the warmer summer months after rain and quality declining in the dry season (McIvor 1981). No allowance was made for winter-forb growth because the potential benefit to animal growth is small relative to that after rain in summer. Similarly, any expected pasture growth over the next wet season was not considered in the forage budget. Hence, the resultant 12-month utilisation rates could have varied from that planned, depending upon the season that followed, but the treatment relativities persisted.

Grazing occurred between November 1994 and June 2002 with no stock adjustments made during a year if seasonal conditions were exceptionally good. Operational constraints required older and heavier animals, mean 275 kg/head, be grazed in Years 5 and 7, compared with a mean of 161 kg/head for steers in all other years. Hence, comparisons of actual GP can be made based on numbers per hectare and on animal equivalents (AE) per hectare where 1 AE equals 450 kg liveweight steer at maintenance (McLean and Blakeley 2014). The welfare of the animals was considered at all times, so steers could be removed from paddocks temporarily if their condition deteriorated due to inadequate pasture supply.

Liveweight and body condition score measures of cattle performance

All animals were weighed 4–8 times per year after a 1–2 h fasting period. The average daily liveweight gain (ADG) for each herd and paddock was calculated on an annual basis, defined as the grazing period for each herd. The ADG during the three main seasons of summer, autumn/winter and spring was also calculated. Body condition scores (CS) on a scale of 1 (very poor, emaciated) to 5 (overfat), using a photographic standards method (FutureBeef 2018) for consistency, were recorded for the final 6 years at all weighing times. The CS range for the 'store' steers during this experiment was between 1.5 and 3.7.

Pasture measurements

In all paddocks, pasture attributes were measured annually between 1994 and 2002. Each autumn standing herbage mass (dry matter yield, DMY), its species composition, species frequency, a greenness estimate and ground cover were recorded by the *Botanal* procedure (Tothill *et al*. 1992). In each winter, pasture BA was recorded by strikes from a five-point frame 75 cm long (Rangelands West 2014). Details of the pasture measurements and their results are reported by Hall *et al*. (2016*a*). To establish the potential quality of the diet available, wet chemistry analysis for the concentrations of crude protein and phosphorus (P), *in vitro* dry matter digestibility and metabolisable energy, was conducted on the green leaf of some common tussock grasses and *V. tenuisecta*, a widespread forb, between March and August of Year 1. A similar analysis of plant tops of major grasses was conducted also in late autumn of Year 7.

Pasture species were grouped into management categories for clarity of presentation of some data. Grasses were deemed 'decreaser', 'intermediate' or 'increaser' types (Dyksterhuis 1948) according to their known reaction to GP, as used in grazing land management courses (Queensland Government 2018). Non-grasses other than legumes were classed as forbs when comparing responses to those of perennial grasses.

Economic assessment after sale of animals

An economic analysis of the three GP was based on the first three herds (Years 1 to 3) which were sold directly off the experiment at public auction at Roma, Queensland, whereas subsequent herds were sent to improved pastures to fatten before marketing. The herd from Year 1 was sold in three condition classes representing the low (heaviest and highest CS animals), medium and high (lightest and lowest CS animals) GP, respectively. Only the animals from low and medium GP for Years 2 and 3 were sold directly off their paddocks, whereas the poorer-condition, high GP treatment animals were grazed on better quality *Astrebla* (Mitchell grass) downs country until reaching a marketable condition. For the economic analysis of the high GP treatment, the estimated sale values for animals in Years 2 and 3 were calculated from the percentage difference between the three GP treatments for the sale of all animals from Year 1.

Statistical analyses

General linear mixed models were used to analyse the cattle and pasture data statistically, using restricted maximum likelihood (REML) in GENSTAT (2016). For all variables, the residual patterns justified the underlying statistical assumptions, so no transformations were required. 'Paddock', the experimental unit to which the GP by tree competition treatments were applied, was a fitted random effect, as was 'years' within these, and both were restricted to prevent negative estimated variance components. The fixed effects treatments were the three GP, the two tree competition levels, the 8 years and their interactions. For CS analyses over 6 years (3–8), the initial CS on entry to the experiment was used as a covariate. The significance level $P < 0.05$ was used for acceptance of a statistically meaningful difference for all analyses. A correlation analysis was conducted between the annual means of the animal (ADG, CS end of year, CS annual change) and pasture (DMY, BA, cover) parameters.

Results

Rainfall and seasonal conditions

The experiment commenced after a below average rainfall period with a low biomass averaging 500 kg/ha. The experiment received widely variable rainfall, from decile 1 to 9. In three of the years, an average of 500 mm was received in the October to March summer pasture-growing period compared with the local long-term mean of 425 mm, and there were three drier years receiving over 100 mm below the mean (Table 1). Two of these years fell within decile 1 or 2,

Table 1. Annual (July to June), summer (October to March), winter (May–August) and grazing period rainfall (mm) for 8 years from July 1994 to June 2002

Year	Annual July–June	Summer October–March	Winter May–August	Grazing period rainfall
1 1994–1995	392	314	47	375
2 1995–1996	571	439	144	758
3 1996–1997	654	475	39	611
4 1997–1998	707	506	148	691
5 1998–1999	844	527	89	802
6 1999–2000	391	288	96	391
7 2000–2001	569	501	78	569
8 2001–2002	456	270	61	347
Long–term[A]	634	425	122	

[A]Long-term average rainfall (mm) from nearby 'Westgrove' Station, 110 years recording.

Table 2. Annual stocking rates (ha/head) trends for six grazing pressure (GP) × tree competition treatments for Years 1 to 8, the mean no. steers per treatment and the 8-year stocking rate trend

Treatment GP × trees	Stocking rate (ha/head) for 8 years 1	2	3	4	5	6	7	8	Mean	Trend
Low GP – cleared	4.0	4.0	4.0	4.1	3.0	2.7	2.8	2.4	3.4	Increase
Medium GP – cleared	2.0	2.0	2.0	2.0	2.0	1.8	2.4	2.3	2.1	No change
High GP – cleared	1.4	1.3	1.3	1.3	1.3	2.0	2.0	2.0	1.6	Decrease
Low GP – treed	6.0	6.0	6.0	6.0	5.9	5.3	6.8	7.5	6.2	No change
Medium GP – treed	3.0	3.0	3.0	3.0	3.8	4.5	4.5	4.5	3.7	Decrease
High GP – treed	2.3	2.0	2.0	2.1	3.1	2.9	2.9	2.9	2.5	Decrease
Mean	3.0	3.0	3.0	3.0	3.1	3.1	3.5	3.6	3.1	No change

whereas Years 2 and 4 received above average winter rainfall, which followed summers of average to above average rainfall. There were summer rainfall events each year that produced effective pasture growth of the perennial grasses. The unusually wet (402 mm) April to September period in 1998 maintained green leaf in the winter pastures for longer than is usual and this season grew appreciable amounts of winter-active forbs, such as *Calotis* spp. (daisy burrs).

Animal numbers and stocking rate

The annual grazing periods for Years 1–8 were 264, 365, 342, 280, 315, 349, 316 and 218 days respectively. The mean grazing days for Years 2–7 was 328 days per year. Grazing was not always for the full year due to the logistics of selling one herd and acquiring new Brahman-cross steers from commercial herds in north Queensland as their replacements. These delay periods were unrelated to the pastures and always occurred in the dormant phase for these pasture grasses.

The initial stocking rate (SR) of three head per paddock in Year 1 was maintained until the winter of Year 4 when steers lost weigh due to declining pasture quality and availability, which caused a reduction of one steer in one replication of the high GP-treed treatment. This temporary removal until after summer rain commenced was for animal welfare reasons. Thereafter, numbers varied slightly each year in response to the forage available in autumn, which reflected the accumulated effects of prior grazing and seasonal conditions. By Year 8, steer numbers had increased to 10 total (2.4 ha/head) in the two replications of the low GP-cleared treatments with an increasing trend, compared with a reduction to four animals in the high GP-treed (2.9 ha/head) and medium GP-treed (3.7 ha/head) treatments with a decreasing trend as drier years occurred (Table 2). Over the 8 years of the experiment, there was no sizeable change needed in steer numbers to meet GP goals in the medium GP-cleared and the low GP-treed treatments. However, a decrease in animal numbers from six to four was required in the high GP-cleared treatment (2.0 ha/head) in later years of the experiment due to low pasture biomass. This was despite receiving higher rainfall in years 4 (707 mm), 5 (844 mm) and 7 (569 mm).

When SR trends are compared on an AE basis a similar pattern existed but with a general increase for Years 5 and 7 when the larger-framed and heavier animals were grazed

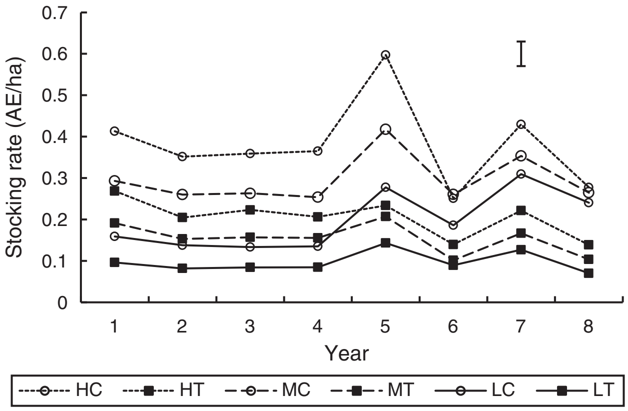

Fig. 2. Mean annual stocking rate in animal equivalents (AE/ha) for three grazing pressures (GP) × two tree competition levels over 8 years. Least significant difference bar ($P = 0.05$) is shown. One AE calculated on a 450 kg steer at maintenance. HC, high GP cleared; HT, high GP treed; MC, medium GP cleared; MT, medium GP treed; LC, low GP cleared; LT, low GP treed.

(Fig. 2). Only the low GP-cleared treatment showed a sustained improvement in carrying capacity over time, while treed treatments at medium and heavy GP exhibited a declining trend, irrespective of the general trend induced by lower rainfall years towards the experiment's conclusion. There were signs in later years of an emerging change in AE carrying capacity of heavy GP-cleared (declining SR) and medium GP-cleared (increasing SR) treatments (Fig. 2).

When the SR for the initial Years, 1–4, were compared with the latter Years, 6–8, it increased markedly only in the low GP-cleared treatment (Table 2). Year 5 was not included in this comparison as it was a transition period with above average rainfall over the previous 2 years (mean 776 mm), which affected pasture growth and ground cover, the latter increasing to a site mean of 57%. In addition, heavier animals were grazed in this year than during the first 4 years. The greatest SR reductions after Year 5 (38–54%) occurred in the high GP treatments, both cleared and treed, and in the medium GP-treed treatment.

Animal liveweight

Liveweight change per head

The treatment differences tended to be consistent over the years and there was no significant treatment by year interaction. Notably, there was no evidence that ADG among the six treatments diverged over the 8 years as the GP were adjusted to pasture supply annually. However, the individual 'GP' and 'trees' main-effects were significant ($P < 0.01$) in all yearly analyses. These six treatment combinations are of specific interest, and their interaction was significant or near so in most analyses. The mean annual ADG for the six treatments were: LC 0.56, MC 0.49, HC 0.43, LT 0.46, MT 0.40, and HT was 0.31 kg/head.day. The low GP-cleared treatment consistently had the highest ADG and the high GP-treed the least. Over the experiment, the ADG in the medium GP-cleared treatment was marginally higher than in the low GP-treed treatment.

Overall, ADG response to GP from the 8 years showed a consistent downward trend from 0.51 kg/head.day for the low GP, to 0.45 kg/head.day for medium to 0.37 kg/head.day for the high GP treatment. This trend occurred throughout the experiment except for Years 5 and 7 (Fig. 3*a*), where there were mixed responses related to the above average summer rainfall of over 500 mm during both growing seasons, and in Year 5 there was also well above average winter rainfall the previous year (148 mm). Those 2 years also carried the steers of greater initial age and liveweight.

Tree competition to pastures was associated with a reduction in the liveweight gain per head (LWG/head) in most years. The ADG in the cleared treatments (mean 0.49 kg/head.day) was consistently higher ($P < 0.05$) than in the treed treatments (0.39 kg/head.day), at the same nominal GP, for all herds except in Year 5 (Fig. 3*b*). There were no consistent tree competition differences between treatments in Year 5, possibly related to the pasture responses from the abnormally wet seasonal conditions. The greatest difference in LWG due to tree competition was for the low-rainfall final year (Year 8) where cleared treatments produced 0.21 kg/head.day higher LWG than did the treed treatments. These differences occurred despite the greater reduction in SR in the two higher GP-treed treatments as the experiment progressed. Liveweight losses of 0.12 kg/head.day occurred in the comparatively dry winter of Year 7 (78 mm rainfall) in the high GP-treed treatment, even with the reduced SR.

There was a positive liveweight response by the remaining steers within a year when there was above average rainfall and the SR had been reduced for animal welfare reasons. For example in Year 5, after the poorest animal was removed from both replications of the high GP-treed treatment after average losses of 20.5 kg/head, the remaining steers then gained over 30 kg/head during the following spring when pastures responded to the winter rainfall of 89 mm. These steers had gained only 0.03 kg/head.day between March and July and were losing weight between July and August at a rate of 0.59 kg/head.day before the SR was reduced. This improved weight gain in spring (Table 3) also followed an abnormally high summer and winter rainfall period over the previous year.

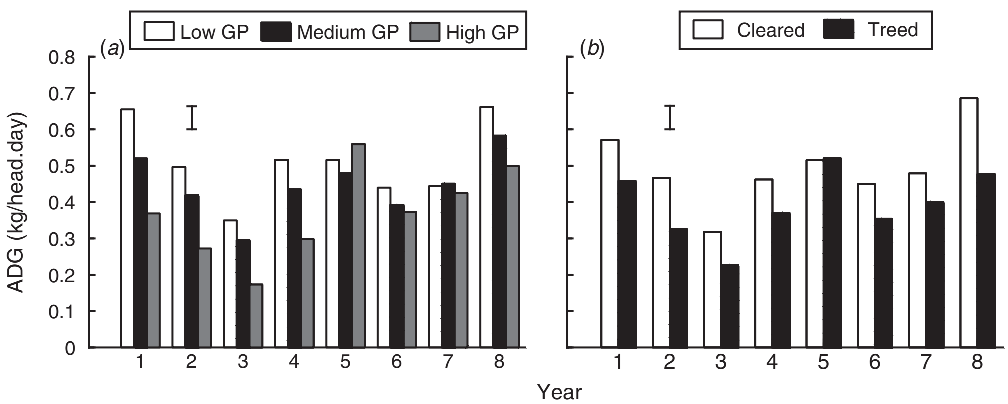

Fig. 3. (*a*) Grazing pressure (GP) and (*b*) tree competition effects on mean annual liveweight change per day (kg/head.day) for Years 1 to 8. Least significant difference bars ($P = 0.05$) are shown. Stocking rates were reduced after Year 4 in high and medium GP treatments. ADG, average daily liveweight gain.

Table 3. Effect of reducing stocking rates and above average rainfall over the previous year on steer liveweight (LW) and growth rates measured as average daily gain (ADG) between January 1998 and March 1999 in the high grazing pressure-treed treatment

Grazing period	Steers (no.)	LW change (kg/head)	Days (no.)	ADG (kg/head.day)	Season
January–March 1998	6	41	63	0.65	Summer
March–July 1998	6	3	107	0.03	Autumn-winter
July–August 1998	6	–27	46	–0.59	Winter
August–November 1998[A]	4	38	77	0.49	Spring
November–December 1998	4	30	43	0.69	Spring-summer
December 1998–February 1999	4	63	62	1.02	Summer
February–March 1999	4	42	43	0.98	Summer

[A]Stocking rate was reduced in both replications as animal condition deteriorated.

Table 4. Mean liveweight gain (kg/ha) trends for six grazing pressure (GP) × tree competition treatments over 8 years, the per cent change and trend in liveweight gain between Years 1 and 8

Treatment GP × trees	Total annual liveweight gain (kg/ha) 1	2	3	4	5[B]	6	7[B]	8	Change Years 1–8 (%)[A]	Trend
Low GP – cleared	50	52	33	49	54	71	56	68	37	Increase
Medium GP – cleared	73	90	62	69	77	82	75	63	–12	Decrease
High GP – cleared	81	94	54	77	113	79	77	65	–20	Decrease
Low GP – treed	25	26	18	24	26	27	25	17	–30	Decrease
Medium GP – treed	43	42	26	35	31	29	31	24	–43	Decrease
High GP – treed	43	37	23	32	53	34	38	27	–33	Decrease

[A]The grazing period for Year 1 was 264 days compared with 218 days for Year 8.
[B]Years 5 and 7 herds initial mean liveweight of 275 kg/head.

The interacting effects of the improved seasonal conditions and a reduced SR that caused this growth rate increase could not be separated.

There were consistent and significant differences ($P < 0.05$) in daily liveweight changes (ADG in kg/head) due to GP (low GP highest) and tree competition (cleared highest) between years and seasons. In periods of dry pastures between late autumn and spring, the steers at high GP had a greater rate of liveweight decline than those in the medium and low GP treatments. At the same time in the cleared treatments, steer liveweight was marginally better than those in the treed treatments. For example, in the winter of Year 7, steers in the cleared treatments had a growth rate of 0.04 kg/head.day compared with a loss of 0.13 kg/head.day in the treed treatments.

Growth rates were highly variable in spring and varied from gains of 0.64 kg/head.day (Year 2, low GP-cleared) to losses of 0.25 kg/head.day (Year 7, high GP-treed). The highest seasonal growth rate of 1.3 kg/head.day occurred in the low GP-cleared treatment over the summer of Year 1, and the lowest summer growth rate was 0.24 kg/head.day in the high GP-treed treatment in Year 3.

Liveweight changes per hectare

There was significant annual variation between treatments in LWG/ha. For example, the prolonged growing season of Year 5 produced 113 kg/ha LWG from the high GP-cleared treatment compared with 53 kg/ha gain from high GP-treed treatment. In contrast, in the following year with low decile 2 summer rain, an average LWG of 71–82 kg/ha was produced in the three cleared treatments compared with 27–34 kg/ha in the treed treatments. The mean LWG/ha of the last 3 years of the low GP treatments (cleared and treed) (mean 44 kg/ha) showed a positive gain (27%) and an improving trend, compared with the first 4 years (mean 35 kg/ha). In contrast, the medium and high GP treatments exhibited a slight decline (6%) in LWG/ha relative to the initial years, declining from 55 to 52 kg/ha. The only treatment to show an improving trend (36%) from Year 1 to 8 was the low GP-cleared treatment (to 68 kg/ha) (Table 4). Over 8 years of the experiment the cleared treatments produced a higher LWG/ha than did the treed treatments, with means of 69 and 31 kg/ha, respectively, when stocked at the same theoretical GP.

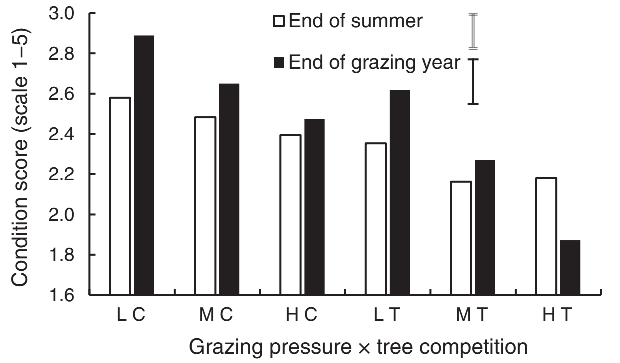

Fig. 4. Mean animal body condition scores (1 = very poor, emaciated to 5 = overfat) for six grazing pressures (GP) × tree competition treatments at the end of summer and at the end of the annual grazing period, for Years 3 to 8. Least significant difference bars (P = 0.05) are shown. LC, low GP cleared; MC, medium GP cleared; HC, high GP cleared; LT, low GP treed; MT, medium GP treed; HT, high GP treed.

Animal condition scores

Steer body CS were significantly and positively correlated with ADG (r = 0.99), and were highest at low GP-cleared and lowest in the high GP-treed treatments. The main effects of GP, tree competition and years were all highly significant, some at $P < 0.001$ level, for CS. Notably, the steers in the high GP-treed treatment lost condition between the end of summer and the end of the herds' annual grazing period in autumn-winter, while steers in the other treatments gained or maintained condition (Fig. 4). Over the 6 years, the mean final CS were 2.7, 2.4 and 2.1 for the low, medium and high GP respectively. Low GP-cleared resulted in the greatest improvement in CS. The mean annual grazing period CS change averaged +0.67 units for animals at low GP, +0.49 at medium GP, and +0.27 at high GP ($P < 0.001$). The cleared treatments had a higher ($P < 0.05$) final grazing period CS of 2.62 compared with 2.10 where treed, and they also produced a higher ($P < 0.01$) annual CS change of +0.63 compared with +0.32 where treed.

Economic analysis

The mean relative sale price for herds one, two and three was 100, 85.8 and 67.3% for the animals from low, medium and high GP treatments respectively. These commercial values reflect both the liveweight and condition score of the steers. The dollar values per kg and per head varied between the 3 years with market conditions, but the value relativities between the low and medium GP animals remained largely the same in this store cattle market.

Pasture species responses to grazing pressure

Standing herbage mass, ground cover, basal area and species frequency

Pasture herbage mass responded positively to higher summer rainfall, lower GP and tree clearing (Hall *et al*. 2016*a*, 2017). It varied from 500 kg/ha at the start of Year 1, reflecting low rainfall and grazing over the previous two summers, to a mean of over 3400 kg/ha by Year 5 in the low GP treatments. The GP effect on standing herbage mass remained consistent over years, but affected species composition differently and thus their contribution to the total biomass. For example, the desirable *3P* grass *D. sericeum* declined under high GP to 4.2% compared with 9.4% (210 kg/ha) at low GP, and in contrast *Sida* spp., an unpalatable forb, increased from 4.8 to 14.5% at high GP. The 8-year mean autumn pasture biomass of the cleared treatments was 2150 kg/ha, double the 1000 kg/ha herbage mass of the treed treatments (Table 5).

There was consistent pasture condition improvement from Year 1 to Year 8 in the low and medium GP-cleared treatments relative to the other four treatments. The autumn pasture ground cover was greater than the benchmark level of 40% in most years at the low (experiment mean 52%, to a maximum of 64%) and medium GP treatments (mean 46%), but it fell below this level in the high GP treatments in 5 of the 8 years, although the mean was 41% (Table 5). The cleared treatments had higher ($P < 0.05$) ground cover (mean 54%) than the treed treatments (39%) every year. Pasture BA was significantly higher ($P < 0.05$) under low GP (mean 3.9%) than at high GP (2.9%), with medium GP between these levels at 3.4%. The cleared treatments (8-year mean 4.1%) consistently had higher ($P < 0.05$) pasture BA than the treed treatments (mean 2.8%) (Table 5). The frequency of *3P* grasses declined with increasing GP. For example, by Year 8, the frequency of *D. sericeum* declined from 25 to 7% and *B. bladhii* was almost eliminated, declining from 6 to 0.2%, between low and high GP respectively. The frequency of *C. fallax* was unrelated to GP. Although some weedy species, including *Sida* spp., increased their frequency at high GP, they did not dominate pastures in any treatment. Hall *et al*. (2017) have reported details of pasture species responses to GP at this site.

Nutrient concentrations of pasture

Nutrient concentrations from a selected sub-sample of species shows a wide variation between species and seasons, from nutritional deficiency to high quality for grazing (Table 6). The decline in quality of *D. sericeum* between March and May reflects a rapid maturity and the low or negligible rainfall that can be experienced over autumn in this environment. The crude protein and phosphorus concentrations of the tops of the main grasses in late autumn of Year 7 ranged

Table 5. Pasture herbage mass (kg/ha), ground cover (%), and basal area (%) responses between the autumn of Year 1 and the autumn mean of Years 7 and 8 for six grazing pressure (GP) by tree competition treatments

Treatment	Herbage mass (kg/ha)			Ground cover (%)			Basal area (%)		
GP × trees	Year 1	Years 7, 8	Change (%)	Year 1	Years 7, 8	Change (%)	Year 1	Years 7, 8	Change (%)
Low GP – cleared	1190	2520	111	45	61	38	2.8	6.3	124
Medium GP – cleared	1060	1720	63	30	53	73	2.9	6.1	108
High GP – cleared	920	610	–34	34	45	30	1.7	4.8	190
Low GP – treed	1150	870	–24	41	44	7	2.6	4.8	83
Medium GP – treed	690	560	–19	22	40	81	1.7	4.5	162
High GP – treed	550	500	–8	36	41	15	1.0	3.8	285
Least significant difference ($P = 0.05$)	935	661	–	15	11	–	1.1	0.7	–

Table 6. Nutrient concentrations, in vitro dry matter digestibility and metabolisable energy of green leaf of the common grasses and a forb species in the experiment in autumn and winter of Year 1

IVDMD, *in vitro* dry matter digestibility

Pasture species	Month	Crude protein (%)	Phosphorus (%)	IVDMD (%)	Metabolisable energy[B] (MJ/kg DM)
Bothriochloa bladhii	March	8.9	0.07	57	7.8
Dichanthium sericeum	March	11.5	0.08	61	8.5
Aristida ramosa	May	8.2	0.14	45	6.2
Cenchrus ciliaris	May	9.6	0.07	65	8.2
Dichanthium sericeum	May	4.7	0.08	45	6.2
Verbena tenuisecta[A]	August	17.5	0.14	75	10.7

[A]Forb species.

[B]Metabolisable energy calculated from IVDMD.

from 2.6% for *B. decipiens* (0.07% P) to 5.4% in *C. divaricata* (0.15% P). Such nutrient levels combined with contrasting digestibility levels interact to produce the metabolisable energy levels (Table 6) that underpin the LWG results presented. Mean autumn pasture greenness for the low, medium and high GP treatments was similar at 42, 41 and 39% respectively, and 43 and 38% for cleared and treed treatments respectively.

Correlations between animal and pasture parameters

There were strong correlations between the 8-year means of some of the main animal and pasture parameters. The ADG, CS for the end of the grazing year, and the CS change within each year, were all strongly and positively correlated (r >0.85) with the pasture mean autumn herbage mass, ground cover and pasture BA. In contrast, the proportion of forb species (non-grasses) in the autumn pastures had a strong but negative correlation (r > –0.94) with animal growth rates and CS.

Discussion

Animal liveweight response

Steer liveweight changes clearly responded to the GP, but were strongly influenced also by rainfall within seasons. For example, mean summer gains were 0.93 and 0.73 kg/head.day in low GP-cleared and the high GP-treed treatments compared with 0.18 and 0.05 kg/head.day in the dry winter periods respectively. Substantial liveweight loss rates at high GP of greater than 0.12 kg/head.day occurred in one dry winter despite the recent SR adjustments for available forage, shows that GP management is critical during this winter period. Frosts occur each winter causing a rapid decline in quality of these pastures. The nutrient analysis of leaves of some main grasses showed that crude protein deficiency (<6.3%) was a contributing factor, so temporary weight losses could be expected in most winters (Bray *et al*. 2015). Poor cattle growth rates in winter have been reported on other native pasture types, such as *Heteropogon contortus* (black speargrass) grasslands, in a similar environment (McLennan *et al*. 1988). In this experiment, liveweight changes in spring were most variable, ranging from gains of over 0.6 kg/head.day to losses of 0.2 kg/head.day. This strongly reflects the variable rainfall and minimum temperatures commonly experienced at this time of the year. If good spring rains occur, frosts cease relatively early, and there is a growth response from most perennial grasses in these pastures. However, until useful rain falls after a normal low-rainfall winter, little new growth occurs as temperatures rise and pasture quality continues to deteriorate (GRASP pasture growth modelling data, not presented), along with reduced steer growth rates.

The range of liveweight responses between seasons and years makes animal management for these pastures more difficult than in the more productive environments of Queensland where seasonal liveweight responses, pasture growth rates and grass quality are more favourable (Bray *et al*. 2015). This suggests that the poplar box woodlands are more reliably suited to breeding and selling weaners through to forward steers, than to producing young cattle finished for slaughter. Burrows *et al*. (2010) and O'Reagain *et al*. (2011) have also reported a wide annual variation in animal production and poorer pasture condition at high SR. Such high GP resulted in negative financial gross margins in 6 of 12 years in a north Queensland eucalypt woodland (O'Reagain *et al*. 2011). Their economic analysis, similar to ours, did not include any long-term environmental costs of high GP, such as the associated decline in pasture and land condition, which also occurred at high GP in this experiment. Persistent high GP produced a poorer economic return in both environments.

Annual steer growth rates on Queensland native pastures vary widely between years (Orr 2005; Burrows *et al*. 2010). In this experiment on *A*/*B* pastures, annual LWG went as high as 208 kg/head (Year 2, low GP-cleared), while the overall eight-herd average for the six treatments was 132 kg/head.year. Annual LWG for Queensland bluegrass pastures (*Dichanthium* spp.) of 150 kg/head.year, equivalent to 0.41 kg/head.day (Miller and Stockwell 1991) are somewhat higher, but those results are from more fertile heavy clay soils. Such figures can be compared with 160 kg/head.year for sown exotic grass (*Cenchrus ciliaris*) pastures on brigalow country, and 120 kg/head.year in the southern speargrass (*H. contortus*) native pasture zone (Quirk *et al*. 1990). Some pasture types can be augmented with tropical legumes, such as *Stylosanthes* species or leucaena, which can increase annual LWG by 37 kg/head (Orr 2005) or to over 200 kg/head (Quirk *et al*. 1990) respectively. However, the currently available tropical legume cultivars are not well adapted to this *A*/*B* eucalypt environment so are not a management option to increase animal production from these pastures at this time.

Forage budgeting via pasture yield assessment was the approach adopted in this experiment for adjusting GP to maintain the desired treatment levels. Thus animal numbers and/or liveweight per paddock were re-adjusted annually based on the pasture response to the last summer growing season under the existing GP. Producers can incorporate this approach in their grazing management of these *A*/*B* pastures. Turn-off of forward store cattle, CS >3.0, may be achieved in years of above average summer and winter rainfall, as occurred between 1997 and 1999. However, if this marketing approach is practised, then in low rainfall years an assessment must be made to remove or sell unfinished animals, preferably by late summer or autumn. Such poor rainfall years occurred in three of the 8 years of the experiment. The change in pasture quality between seasons in these pastures is similar to that reported for two eucalypt communities of north Queensland (McIvor 2007). Although nutritional supplements such as protein or urea were not used to stimulate animal intake in winter or spring in this experiment, it is an option available to beef producers in this environment to help maintain animal condition, although it can put greater pressure on pasture and land condition.

Steer growth rates responded positively after rain in winter to a 33% reduction in SR when one animal was removed from each replication of the high GP-treed treatment. This awareness may encourage producers to reduce their SR in autumn as pastures deteriorate, particularly in low rainfall periods.

Condition score

The CS were closely related to liveweight changes, and the rate of condition increase over summer was consistently lower at high GP than at the other two GP levels. A declining animal condition can be a longer-term indicator for managers to reduce GP, to improve the performance of both their animals and pastures. However, losing condition is a lagging indicator, as the pasture and land condition may have begun to deteriorate before observing a loss in animal condition. For example, overgrazing of short pasture after rain could maintain body condition while the land condition was deteriorating. Managers need to monitor pastures as well as animal condition to assess any early indication of land condition deterioration and make GP adjustments accordingly.

The pasture-growing period over summer produced the major animal condition gains, as expected. There were only small gains in body CS in some treatments between autumn and spring. However, this period spans over half of the year. The exception was from the animals in the high GP-treed paddocks, which consistently declined in CS during this period, on average to 1.82, a 'poor' body condition category. At this CS, the steers were not in an acceptable market state. In comparison, the steers in the low GP treatments, and in some years in the medium GP-cleared paddocks, were marketable as 18-month-old forward stores (CS $\geq$2.5). The animal production value of tree killing, or clearing, and maintaining an open woodland was well demonstrated during this experiment by the consistently higher animal growth rates and CS compared with those in the treed woodland with the same pasture biomass available per animal.

Gross economic returns

GP management by cattle owners influences the liveweights and CS of animals they present to market. However, cattle sale returns are affected within and between years by many interacting factors, irrespective of the animals presented to market (ACCC 2017). Some of these are beyond the influence of the producer, such as overseas demand and foreign currency exchange rates. The additional sale value per head for animals grazed at low (+74%) and medium (+40%) pressure above that of animals grazed at high GP in the initial years of this experiment, will help compensate for potentially higher short-term per hectare gains from grazing at high pressure. These sale values were before the pasture condition deteriorated markedly causing a reduction in the SR. Unless high GP ceases, the animal's sale value will decline along with a reduction in pasture productivity, poorer species composition, and the potential of soil loss from erosion. In addition, it is possible that there will not be a viable market for low CS animals from high GP pastures in this region. This contrasts with the north Australian live export trade where liveweight and age, not condition score, are more important sale selection criteria.

Grazing pressure

The variable rainfall affected new pasture production, composition and greenness regularly, which then affected pasture nutrient concentrations, and presumably diet quality. Our research protocol envisaged only potentially short-term reductions in animal numbers. In commercial practice, there is scope to adjust GP in response to pasture changes. After excellent summer rainfall, GP could be increased by purchasing additional cattle, such as weaners, or holding steers longer to target a higher-weight market, or conversely numbers be reduced by earlier sales if summer rains fail and pastures deteriorate rapidly. There are regular cattle sales within this region offering opportunities to make these stocking adjustments to suit feed availability. Altering a breeding herd structure takes more time and is a less flexible option than the purchase or sale of growing cattle. Liveweight, CS and growth rates can be converted to adult equivalents using appropriate tables (McLean and Blakeley 2014), as we have illustrated (Fig. 2), for comparison with studies of cattle performance in other areas.

The GP in this experiment represent the range of SR implemented tactically by commercial cattle producers over time in this variable climatic zone. The growth rates and CS from the steers in our low GP treatments (25% pasture utilisation), reflect utilisation towards the upper end of the recommended range of 10–30% of annual pasture growth. This level of GP is suggested as sustainable for environments in northern Australia by Hunt (2008), Orr *et al*. (2010*b*), Orr and Phelps (2013) and Stone *et al*. (2016).

Tree competition

Irrespective of the GP, trees in this environment provide strong competition to pasture production and they affect the desirable grass composition (Hall *et al*. 2017). A similar tree-pasture competition result has been reported in the dry tropics of northern Australia (Café *et al*. 1999). In our experiment, the treed treatments consistently produced lower animal growth rates and body CS than occurred in the cleared treatments. These animal performance results reinforce industry practice where managing tree populations is an issue for maintaining higher pasture productivity and an economically viable beef business in these *A*/*B* woodlands. Control of woody plant competition must be integrated with managing GP. In most years in the present experiment, running steers at high GP in treed woodlands produced animals with a reduced growth rate, in lower condition, and of a reduced market value, as demonstrated when such animals were sold at auction.

Pasture composition, cover and basal area

The desirable *3P* grasses in this B condition pasture, such as *D. sericeum*, *B. bladhii* and *T. triandra*, responded positively to the low GP treatment, especially after tree clearing. These grasses also persisted at medium GP for 8 years with variable annual responses (Hall *et al*. 2017). Land managers can use the presence of these species and their per cent contribution to the pasture to indicate the success of their grazing management strategies. Promoting the *3P* grass component is an aim of grazing management approaches in perennial, tropical, native pasture communities (Queensland Government 2017). Another useful indicator grass was *C. divaricata*, which increased in the more heavily grazed patches of this pasture. This species was also an ‘increaser’ in a subcoastal environment in central Queensland at high GP (Orr *et al*. 2001). Most grasses and forbs at this site are common throughout the eucalypt land types of the region (Schefe *et al*. 1993; Silcock *et al*. 2015*a*) and are expected to respond everywhere to GP like they did in this experiment. The increase in unpalatable weed species at high GP, e.g. *Sida* spp., should be a concern to managers, but there were no major weed invasions during the eight variable-rainfall years of this experiment. However, an increase in forb composition under high GP has been reported in other Queensland native pastures, including *Astrebla* grasslands (Hall and Lee 1980). The steady increase in tree and shrub density reported for similar eucalypt woodlands (Burrows *et al*. 1998, 2002; FutureBeef 2017), and in other woodland communities (Archer 1995) was apparent in some treatments at this site (Jones *et al*. 2018), but woody regrowth did not become a significant issue during the experiment.

The broad floristics in these treatments was not changed dramatically over 8 years by the GP imposed. This indicates the length of the experimental period or the below average rainfall in some years were insufficient to produce the broad pasture composition, woody weed and land condition changes that can be expected from high GP of eucalypt woodlands over the long-term (Hall *et al*. 1994). Their State and Transition model suggests that as pasture condition deteriorates, less desirable ‘increaser’ grasses including *Aristida*, *Chloris*, *Eragrostis*, *Enneapogon* and *Sporobolus* species will dominate and woody regrowth, mostly from the eucalypts, may occur. Such intermediate and undesirable grasses were common at this site (Hall *et al*. 2016*a*) and contributed to the B-condition rating given to these pastures when the experiment began.

Heavy and continuous GP can also reduce soil aggregate stability and soil organic matter, as well as increase bare areas and sediment loss in some pastures (Teague *et al*. 2011), increase hillside erosion (McIvor *et al*. 1995) and reduce rainfall infiltration that will lower pasture production (Snyman 2003). After 8 years, the low GP-cleared treatment paddocks were approaching A-condition, while the high GP-treed treatments were in C-condition. The other treatments were between these scales from C- to B+ in condition. No paddocks had deteriorated to D condition. Any surface deterioration or loss of ground cover is undesirable as the sodosol soils of these eucalypt land types are prone to gully erosion (Silburn *et al*. 2011). A reduction in ground cover, for example to <40%, as GP increases could also be used by land managers to identify that their GP is too high for the seasonal conditions. The declining pasture BA with increasing GP is difficult for cattle producers to monitor accurately, so is not a useful indicator to include in their management.

In this poplar box woodland, Hall *et al*. (2017) reported that at low GP, a productive pasture composition, including the desirable grasses *T. triandra* and *D. sericeum*, could be maintained and that it was a sustainable management system. However, this GP probably underutilised the resource in financial terms, except in low rainfall years. In above-average rainfall years, pasture composition also remained stable at moderate GP where trees were cleared. An unusual response to low GP was a small increase in the undesirable *Aristida* spp. This result is usually associated with long-term high GP in this environment. Burning *A. ramosa* in spring is recommended to encourage grazing of the new growth (Lodge *et al*. 1999), but was not practised in this experiment.

Management implications

Flexibility to alter GP in response to rainfall in different seasons will provide land managers of *A*/*B* pastures with good production per head and usually per hectare, and will reliably produce saleable animals. Where dynamic management is less feasible for adjusting SR within a season, a low GP will always produce the best pasture and per animal performance in the longer-term. However, the economics of different management approaches will vary with the changing seasonal and market conditions and needs to be monitored. In this woodland, 1 year of heavy GP reduced the sale value per animal, and after 4 years damaged the pastures and caused a reduction in the potential SR, thereby magnifying the financial penalty of persisting with this high GP management strategy. Medium GP in cleared pastures was a productive compromise in the higher rainfall years and may be more financially viable. Infrastructure development and purchase and sale options for changing stock numbers to adjust GP, while achieving a desired animal production level and pasture condition, is achievable in this region of Queensland. The above average rainfall years, including wet winters, provide the most flexible management options and best animal production potential because GP can be temporarily increased without detrimental effects to the pastures. Declining animal condition in this environment is a useful, although probably a late indicator for managers to reduce GP with the knowledge that the remaining animals will maintain or improve in body condition in some winter and spring seasons. However, the potential pasture condition decline needs to be addressed without waiting for a visible loss in animal condition.

The strong correlations between mean steer LWG and their CS changes, as well as with pasture herbage mass at the end of summer, pasture BA and ground cover, support their use as broad indicators for management decisions regarding SR, and hence GP. Parameters such as CS and ground cover are readily measurable and could be a guide to expected animal performance over the coming year, with a reservation that some within-year correlations were not high when rainfall was low and variable. The negative correlation between animal growth rate and the proportion of forbs in the pasture was because most were unpalatable and ungrazed such as *Sida* and *Sclerolaena* species.

This data support our hypothesis that objective measurements of animals and pastures can provide definitive management guidelines for increasing the environmental and economic viability of beef grazing enterprises in these woodlands. Also, the data can be used to produce models of animal performance, pasture and seasonal interactions to guide management to improve beef production systems in similar eucalypt and pasture communities.

Conclusions

In the *A*/*B* pasture type of central Queensland, using a conservative GP of 25% pasture utilisation improved pasture dry matter production and pasture species composition. This contributed to better land condition, as well as increasing steer growth rates, their body condition and market value. This GP also produced an increasing trend in SR relative to the higher GP, on land that was initially in fair condition. Although higher LWG/ha was produced initially at high GP (75% pasture utilisation), after 4 years the condition of the animals and pastures deteriorated to such an extent it required a significant and sustained reduction in SR to maintain the condition of both the remaining animals and the pastures. Managing tree competition to pastures is essential to maintain the higher potential animal production from this community. Applying these findings can improve beef business outcomes for beef producers and also provide administrators, resource management groups and beef extension officers with better educational resources.

Conflicts of interest

The authors declare no conflicts of interest.

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