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Long term effects of different stocking strategies on land condition and profitabilty in a highly variable climate

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Abstract

Rainfall variability is a major challenge to sustainable grazing land management in northern Australia. We present data from a long-term grazing trial comparing the performance of different cattle stocking strategies over 27 years of highly variable rainfall. Strategies involved combinations of different stocking rates, fixed versus flexible stocking and wet season pasture spelling.

Individual live weight gain (LWG) and product price were highest at moderate stocking rates applied with or without wet season spelling. Total LWG/ha was highest at heavy stocking rates, but gross margins lowest due to reduced product value and drought feeding costs. Flexible stocking was as profitable as fixed moderate stocking but also avoided the need to destock in drought years.

Land condition as indexed by the proportion of 3P (palatable, perennial and productive) grasses declined rapidly under heavy stocking, reducing resilience and long-term carrying capacity (LTCC). Although fixed moderate stocking at LTCC initially maintained land condition, condition ultimately declined due to the failure to reduce stocking rates in droughts. Land condition also declined with drought under flexible stocking, but recovery appears greater with recent good seasons. Wet season spelling was essential to buffer drought effects and is accelerating recovery post drought.

These results show that over the long term, heavy stocking is a high risk, and ultimately an unprofitable and unsustainable strategy. Although fixed, moderate stocking strategies are lower risk, they will still lead to degradation if stocking rates are not reduced in dry years to match forage availability. We recommend that climate variability be managed using flexible stocking rates in a pro-active, risk averse manner coupled with regular wet season spelling. These should be applied adaptively based on seasonal conditions and observed responses to management actions.

Introduction

Rainfall in northern Australia is highly variable at seasonal, annual and decadal scales making sustainable and profitable livestock management extremely challenging. Failure to manage for this variability has led to a number of degradation events with large shifts in land condition to other, less productive states (McKeon *et al.* 2009). Many graziers have learnt to manage for this variability by, for example, stocking around long-term carrying capacity (Purvis 1986; Landsberg et al. 1998), spelling pastures to accumulate forage for use in drier times and varying stocking rates to match available forage.

Unfortunately, wider adoption of these strategies within industry has been disappointing (Anon. 2017) resulting in ongoing cycles of degradation and economic loss in drought periods. The reasons for non-adoption are complex, but one key factor is that while these strategies are clearly beneficial for land condition, there is little or no data on their relative productivity and profitability.

To address this issue a large grazing trial was established in 1997 in a semi-arid, tropical savanna in northern Australia. The key objective was to quantify the performance of different stocking strategies in a highly variable rainfall environment in terms of their effects on animal production, land condition and profitability. This empirical data would support development of recommendations and adoption products to assist managers to make evidence-based decisions on managing for rainfall variability and help improve adoption of more sustainable and profitable grazing strategies.

Methods

The trial was established in 1997 on the property 'Wambiana' (20° 34' S, 146° 07' E), 70 km south of Charters Towers, Queensland. Long term (114-year) mean annual rainfall is 643 mm (C.V.= 40%), with 70% falling in the hot summer months. The vegetation is an open Eucalyptus-Acacia savanna overlying C4 tropical grasses. The native shrub Carissa ovata is also becoming increasingly dominant.

The trial has five grazing strategies, replicated twice. Paddocks are approximately 100 ha in size and contain a similar mix of the three main soil types. Strategies were: heavy stocking (HSR: 4 to 5 ha/AE [animal equivalent: 1 AE=450 kg steer]), moderate stocking (MSR: 8 to 10 ha/AE), rotational wet season spelling (R/Spell: 8 to 10 ha/AE), flexible (Flex) stocking (4 to 20 ha/AE) and flexible stocking with wet season spelling (Flex+S). Stocking rates in the flexible strategies were set based on end of wet season (May) pasture availability with further check points through the grazing year. In the R/Spell and Flex+S paddocks, spelling was implemented by resting different subsections within paddocks during the wet season. Importantly, strategies are managed adaptively as 'management philosophies' in consultation with a grazier advisory committee.

The trial was stocked with Brahman steers 1.5 and 2.5 years old and managed according to industry best-practice guidelines. Cattle are weighed at the start and end of the grazing year with older steers going to commercial slaughter (O'Reagain et al. 2009). Gross margins (GM) were calculated as product value less supplementation, vaccination, drought feeding and interest on livestock capital costs (O'Reagain *et al.* 2011). Pasture yield and species composition were monitored annually in May using the BOTANAL procedure (Tothill *et al.* 1992). Here we present the % contribution of 3P (palatable, perennial and productive) species to yield as an index of land condition. The key 3P species at the site are *Bothriochloa ewartiana, Dichanthium sericeum* and *Heteropogon contortus*.

Results

Rainfall and management

Rainfall varied widely (246 to1223 mm) over the trial period, with the initial four good years leading into an extended six-year drought (Fig. 1). This was followed by a further wetter phase and then a run of dry years, with

rainfall (246 mm) in 2014/15 being the fourth lowest on record. The 2021/22 season was also extremely dry (348 mm) but conditions changed abruptly thereafter with 2022/23 exceptionally wet (1064 mm).

With the early good years and abundant forage, the Flexible strategies were initially very heavily stocked, leading to overgrazing with the onset of the first drought phase. Stocking rates were subsequently sharply reduced and a more risk-averse approach adopted, involving setting upper limits to stocking rates and increasing the number of stocking rate adjustment decision points.

The HSR initially performed well but stocking rates had to be cut sharply in both the first and second drought periods due to the extreme scarcity (<200 kg DM/ha) of grazeable forage. Drought feeding had to be provided to the HSR steers in seven years of the trial compared to only once in the other strategies (Table 1). In contrast to the HSR, stocking rates in the MSR and R/Spell treatments were maintained throughout almost the entire trial period. One exception was in 2017/18 when, in line with a 'moderate stockers/rotational spellers' management philosophy, both were destocked for the wet season to prevent overgrazing.

In May 2022, due to ongoing drought and the almost complete lack of forage, the MSR, HSR and R/Spell were all destocked, and subsequently rested for the full 2022/23 season. In contrast, as the progressive adjustment of stocking rates in preceding years had ensured sufficient forage for the approaching dry season, the two Flexible strategies were able to remain stocked in 2022/23, albeit at a very light rate (20 ha/AE). The MSR and R/Spell were fully restocked in 2023/24, while the former HSR strategy was changed to a new short duration grazing treatment (Walkington et al. 2025) to facilitate recovery of the degraded land condition. Accordingly, the data presented below are for 26 years for the HSR compared to 27 years for the remaining strategies.

Animal production and economics

Individual liveweight gain (LWG) was by far the lowest of all strategies in the HSR (Table 1). These differences in LWG were amplified in dry years with HSR steers losing 54 kg in the extremely dry (246 mm) 2014/15 season. As a result of the generally poorer LWG, carcass weights and grading were lower for HSR steers resulting in a lower product value. These findings are consistent with those reported in more detail by O'Reagain et al. (2009 and 2023).

Table 1: Average (+/-standard error) liveweight gain (LWG) per steer, LWG per hectare (ha) and gross margin (GM) per ha for different stocking strategies over the 27-year Wambiana trial. The number of years that drought feeding was needed and the number of years with negative GM are also shown. (See text for treatment abbreviations).

Treatment	LWG/hd (kg)	LWG/ha (kg/ha)	Yrs drought feeding	GM/ha (AU$/ha)	Years with a negative GM/ha
Flex	118 (+/-8.3)	15 (+/-1.7)	1	12 (+/-2.2)	3
Flex+Spell	116 (+/-6.5)	15 (+/-1.6)	1	13 (+/-2.0)	3
HSR[1]	97 (+/-10.6)	18 (+/- 2.3)	7	5 (+/-2.0)	14
MSR	116 (+/-8.1)	13 (+/-1.1)	1	12 (+/-4.3)	4
R/Spell	115 (+/-8.0)	14 (+/- 1.2)	1	12 (+/-2.0)	4

[1]HSR based on 26 years of data

In contrast, average LWG per ha was highest in the HSR (Table 1). This difference was most pronounced in wet years but was much reduced or even negative in drought years (O'Reagain et al. 2023). However, the higher LWG/ha in the HSR was only achieved with expensive drought feeding in seven of the trial years compared to only one year in the other strategies. As a result, average annual GM/ha in the HSR was less than half ($5/ha) that of the other strategies ($12 and 13/ha) due to reduced product value and higher costs (Table 1). Gross margins in

the HSR were also extremely variable with a far greater number of years with a negative GM/ha relative to the other strategies (O'Reagain et al. 2023).

Land condition

Land condition, as indexed by the % contribution of 3P grasses to yield, declined rapidly under heavy stocking with the onset of the first drought post 2001 (O'Reagain et al. 2023). This decline continued in the second drought, resulting in the 3P contribution falling from 25% in 1998 to only 4% of yield in 2021. Note that in 2024 relatively little recovery had occurred in the former HSR treatment despite good seasons and the paddocks being largely unstocked or only very lightly grazed since May 2022.

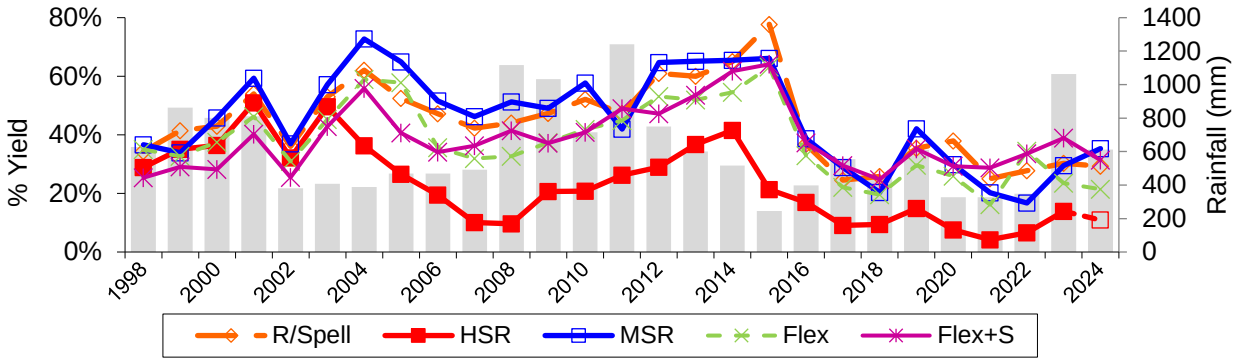

Figure 1: The change in contribution (%) of 3P grasses (palatable, productive, perennial) to pasture yield versus rainfall (grey bars) over 27 years under five grazing strategies at the Wambiana grazing trial. See text for treatment abbreviations. NB: The HSR treatment ended in May 2023.

The Flex and Flex+S strategies performed far better than the HSR in terms of land condition (Fig. 1). Nevertheless, the initial heavy stocking rates applied in these flexible strategies resulted in the %3P grasses being lower than the other strategies until about 2003. Despite the subsequent sharp reduction in stocking rates, the overgrazing at the start of the first dry cycle had a lasting negative legacy, as evidenced by the relatively lower 3P% in the Flexible relative to the MSR and R/Spell strategies until around 2014. In later, more recent years, land condition in these two strategies appears to be as good, if not better, than in the MSR and R/Spell (Fig.1).

In the moderately stocked MSR and R/Spell, land condition was largely maintained for the first 18 years of the trial. However, condition declined drastically post 2015 due to the extremely low rainfall that year and the drought conditions that ensued (Fig.1). This decline was undoubtedly largely due to drought, but the maintenance of the stocking rates in the MSR and R/Spell inevitably led to overgrazing and was thus also partly responsible for the land condition decline (pers. obs.).

Conclusion

These long-term results show that constant heavy stocking is a high risk, unprofitable strategy which leads to a marked loss of land condition. This in turn reduces carrying capacity and drought resilience making the strategy ultimately unsustainable. Although fixed, moderate stocking strategies are more profitable and have much lower risk, they can still lead to overgrazing and degradation if stocking rates are not reduced in dry years to match forage availability. Flexible stocking was as profitable as fixed moderate stocking, had similar if not better impacts on land condition and importantly, avoided the need to fully destock in the recent drought. However, flexible strategies need to be applied in a risk averse manner with upper limits set to stocking rates and stock numbers adjusted rapidly with the onset of drought. While the results presented do not show a strong benefit from wet season

spelling, other data from the site (O'Reagain et al. 2023), and many other studies, e.g., Ash et al (2011), indicate that wet season spelling is essential for maintaining and improving pasture condition.

In conclusion we recommend that climate variability be managed using flexible stocking rates in a pro-active, risk averse manner coupled with regular wet season spelling. These principles should be applied adaptively based on seasonal conditions and observed responses to management actions.

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