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Systematic management of stocking rates improves performance of northern Australian cattle properties in a variable climate

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Abstract

The risks for extensive cattle properties in the rangelands of northern Australia arising from high inter-annual rainfall variability are predominantly managed through adjustments in stocking rates (SR). This modeling study compared the performance of SR strategies that varied considerably in the extent that they adjusted SR annually at 3 locations in northern Australia. At all locations, land types and pasture condition states, the SR strategies that achieved the best pasture condition were those that least increased and most decreased SR annually in response to changes in forage availability. At Donors Hill (Qld), these conservative strategies also achieved the highest cattle liveweight gains per hectare (LWG/ha). While conservative strategies produced the highest percent perennial pasture species at Fitzroy Crossing (WA), strategies which allowed larger increases and decreases in SR also performed well, enabling them to also achieve high LWG/ha with little deterioration of pasture condition. A similar trend occurred at Alice Springs (NT), although at this location the strategies with even larger annual increases and decreases in SR achieved relatively high percent perennials and the highest LWG/ha. While systematic management of SR appears to perform better than a constant SR strategy when rainfall variability is high, it is unclear if the magnitude of annual adjustments in SR needs to increase with increasing rainfall variability.

Resumen

En las grandes extensiones de sabanas del norte de Australia los riesgos de la ganadería extensiva por la alta variabilidad interanual de las lluvias son manejados principalmente mediante el ajuste de la carga animal (SR, por su sigla en inglés). Tomando como caso tres localidades del norte de Australia, en este estudio de modelado se compara el desempeño de estrategias de carga animal muy variada y anualmente ajustada. En las 3 localidades, los 2 tipos de tierra y las 3 condiciones de las sabanas, las estrategias de SR que resultaron en las mejores pasturas, fueron las que menos incrementaron y más redujeron la SR como respuesta a los cambios anuales en la disponibilidad de forraje. Con estas estrategias conservacionistas se obtuvo la mayor ganancia de peso vivo/ha en la localidad Donors Hill (Queensland) y el mayor porcentaje de especies perennes en Fitzroy Crossing (Western Australia). En esta última localidad, estrategias que implicaron incrementos y reducciones de la SR más altos, también fueron exitosas y resultaron en altas ganancias de peso vivo/ha con poca degradación de las sabanas. Una tendencia similar se observó en Alice Springs (Northern Territory); aquí, sin embargo, las estrategias que implicaron incrementos y reducciones anuales de la SR aún mayores, resultaron en porcentajes relativamente altos de especies perennes y en ganancias de peso vivo/ha más altas. A pesar de que el manejo sistemático de la SR aparentemente funciona mejor que una estrategia de SR constante cuando las lluvias son altamente variables, no es claro si la magnitud de ajustes anuales de la SR debe ser incrementada cuando la variabilidad de la precipitación aumenta.

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Introduction

Annual forage growth in the north Australian rangelands is predominantly driven by rainfall (McKeon et al. 1990). High annual variability in the supply of forage for livestock has significant implications for pasture condition and cattle productivity, where adjustments in stocking rate (head or adult equivalents per square kilometer) are the main means of managing these risks. Two broad approaches can be used to manage SR: fixed stocking (a constant SR); and flexible stocking (SR varying over time in response to changes in forage supply) (Buxton and Stafford-Smith 1996). A recent review of SR strategies (Scanlan and McIvor 2010) concluded that a constant light SR at close to the long-term carrying capacity appeared to be the most profitable and least-risky strategy, but acknowledged some variation in SR may be required to account for poor seasons and to take advantage of good seasons. The simulation study reported here compared fixed stocking with a number of flexible strategies, which vary greatly in the extent cattle SRs are adjusted annually in response to changes in forage availability.

Methods

The GRASP pasture and animal production model (McKeon et al. 2000) was used to compare the performance of SR strategies at 3 locations: Donors Hill (black soil and tea-tree communities) in the Gulf region of Queensland; Fitzroy Crossing (black soil and spinifex communities) in the Kimberley region of Western Australia; and Alice Springs (alluvial and mulga communities) in the Northern Territory. Mean annual rainfall, the percent coefficient of variation (%CV) for annual rainfall and the Bureau of Meteorology (BOM) index of rainfall variability (BOM 2013) for these locations are shown in Table 1.

Table 1. Mean annual rainfall, %CV for annual rainfall between 1890 and 2010, and BOM rainfall variability index for Donors Hill, Fitzroy Crossing and Alice Springs.

Location	Mean (mm)	%CV	BOM Index
Donors Hill (Queensland – Gulf country)	629	39	1.10
Fitzroy Crossing (Western Australia – Kimberley)	543	36	0.90
Alice Springs (Northern Territory – central Australia)	259	59	1.30

The simulated SR strategies differed in the extent that SR could be adjusted annually in response to the safe utilization of the forage present at the end of the growing season (May). Fixed stocking did not allow any change in SR, while full flexibility changed SR in full proportion to changes in forage availability. A further 54 strategies with intermediate levels of flexibility were simulated. This included 6 core strategies, which set different limits (5, 10, 20, 30, 50 and 70%) to the extent that SR could be increased annually, providing forage availability increased by at least these amounts. Each of these core strategies was simulated with different limits to the extent SR could be decreased annually (5, 10, 20, 30, 40, 50, 60, 70 and 80%), providing forage availability decreased by at least these amounts.

At each location, each strategy was simulated on 2 land types (high and low productivity) with each in 3 initial pasture condition states (excellent, good and poor). Strategies were simulated with the same SR for each combination of land type and pasture condition state. This SR was the fixed SR that maintained the perennial grass content of pastures over the simulation period (Scanlan et al. 2010). Strategies were simulated for 20 different randomly chosen 30-year climate periods, commencing between 1890 and 1981. Climate records were obtained from BOM (SILO 2011). The average percentage perennial grass composition of pastures (percent perennials) and the average cattle liveweight gain per hectare (LWG, kg/ha) achieved for the twenty 30-year climate periods were the values used to compare strategies.

Results

The results of average percent perennials and average LWG/ha achieved by SR strategies are shown for the high productivity land type in good pasture condition at each location. These demonstrate the main findings of this simulation study. The values for percent perennials achieved by the 6 core SR strategies at Donors Hill, Fitzroy Crossing and Alice Springs are shown in Figures 1–3.

The highest values for percent perennials were achieved by strategies that limited annual increases in SR to 5% (Figures 1–3). The percent perennials declined with higher permitted annual increases in SR. For each core strategy, percent perennials increased with higher permitted annual decreases in SR. Consistent with this, the percent perennials achieved by full flexibility was lower than that for the core strategies with high limits for annual decreases in SR. These trends occurred for all land types and pasture condition states at all locations.

Relative to the 60% perennial grasses achieved by fixed stocking at each location, the percent perennials achieved by the core strategies was lowest at Donors Hill (Figure 1), moderate at Fitzroy Crossing (Figure 2) and highest at Alice Springs (Figure 3). This is particularly true for the core strategies, which had high permitted annual increases in SR. It can be seen that the percent perennials achieved by these strategies increased at the fastest rate and to the greatest extent as permitted annual decreases in SR rose at Alice Springs (Figure 3), followed by Fitzroy Crossing (Figure 2) and Donors Hill (Figure 1).

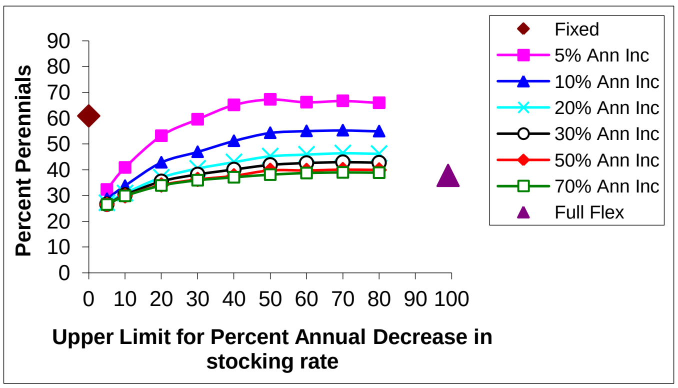

Figure 1. Average percent perennials achieved by SR strategies on black soil at Donors Hill.

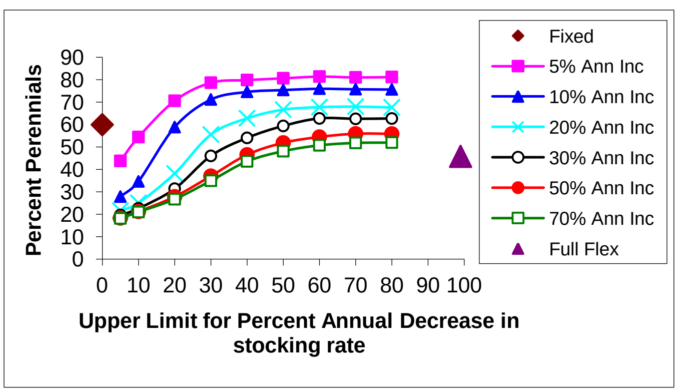

Figure 2. Average percent perennials achieved by SR strategies on black soil at Fitzroy Crossing.

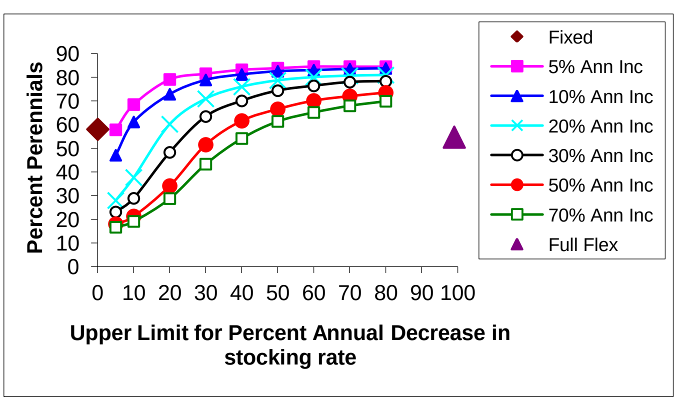

Figure 3. Average percent perennials achieved by SR strategies on alluvial soil at Alice Springs.

Figures 4–6 show the average LWG/ha achieved by the same strategies under the same conditions described above for percent perennials. Again, the benchmark for comparison of the performance of core strategies was the LWG/ha achieved by fixed stocking at each location. At Donors Hill (Figure 4), only the strategies, that limited annual increases in SR to 5% and annual decreases in SR to 30% or more, achieved a LWG/ha that was higher than that achieved by fixed stocking. The LWGs/ha for all other strategies were lower than fixed stocking, and decreased with higher annual increases in SR. As such, fully flexible stocking achieved the lowest LWG/ha of all strategies.

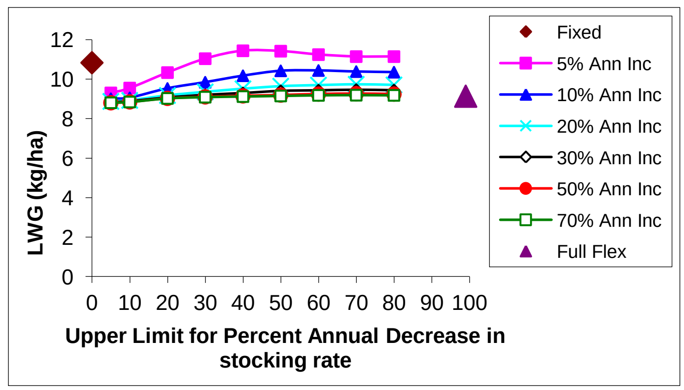

Figure 4. Average LWGs/ha achieved by SR strategies on black soil at Donors Hill.

At Fitzroy Crossing (Figure 5), all 6 core strategies achieved LWGs/ha that were higher than that achieved by fixed stocking, although this often required progressively higher limits to annual decreases in SR.

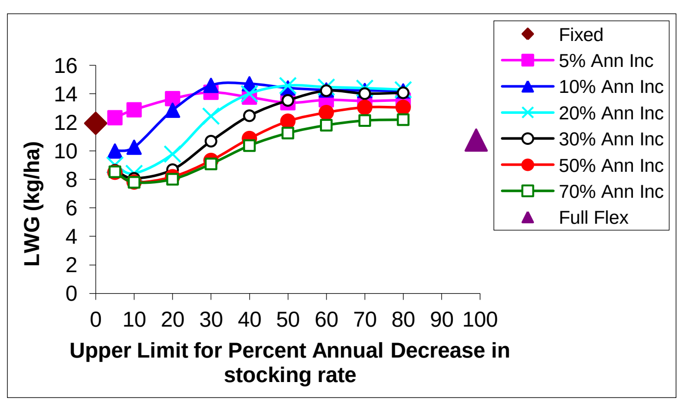

Figure 5. Average LWGs/ha achieved by SR strategies on black soil at Fitzroy Crossing.

This trend continued at Alice Springs (Figure 6), where almost all strategies achieved a higher LWG/ha than fixed stocking. The highest LWG/ha was achieved by the strategy with a 70% limit for annual increases and an 80% limit for annual decreases, and this was only marginally higher than the LWG/ha for full flexibility.

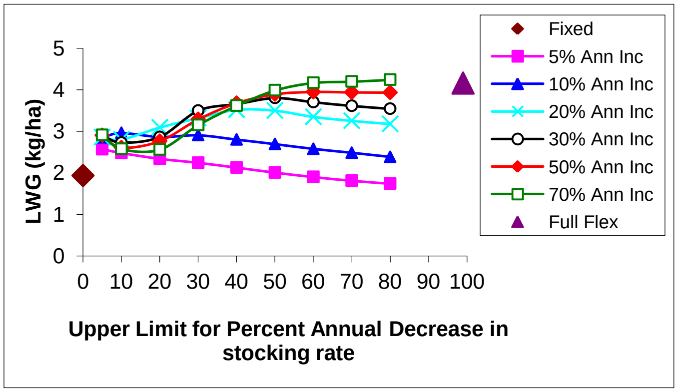

Figure 6. Average LWGs/ha achieved by SR strategies on alluvial soil at Alice Springs.

At Alice Springs, the strategies, which achieved the highest LWGs/ha, had the highest limits for annual increases and decreases in SR. In comparison, the strategies with the lowest limit (5%) to annual increases produced the highest LWG/ha at Donors Hill, while at Fitzroy Crossing the core strategies with 10, 20 and 30% limits to increases in SR achieved the highest LWGs/ha.

Conclusions

In this simulation study, the most consistent trend across locations, land types and pasture condition states was that the highest percent perennials was achieved by strategies, which least increased and most decreased SR annually in response to changes in forage availability. In regions where wet season rainfall is highly variable, this occurs because a SR, that is appropriate at the end of one wet season, is maintained through until the end of the following wet season. For example, if the SR is increased substantially at the end of a high-rainfall wet season, then it is likely that the following wet season will have lower rainfall, resulting in over-grazing and deterioration of pasture condition.

Given the success of this conservative approach to managing SR, it could be expected that the percent perennials achieved by strategies, which allow large increases in SR, would decline as annual rainfall variability increases. However, this does not appear to be the case. Alice Springs has the highest rainfall variance indices (Table 1), yet the strategies that allowed the highest annual increases in SR achieved the highest percent perennials of all locations. Also, strategies which allowed high increases in SR, achieved higher percent perennials at Fitzroy Crossing than at Donors Hill, yet Fitzroy Crossing has lower rainfall variability. It is likely that there are interactions between SR strategies, average annual rainfall and seasonal variation in pasture growth on different land types, which could diminish correlations between the annual rainfall variability and the performance of SR strategies.

At Alice Springs, the highest LWG/ha was achieved by strategies, which allowed the greatest increases and decreases in SRs annually. Only these strategies could increase SR quickly enough to benefit from the occasional short periods of high pasture productivity, and then lower them rapidly to limit pasture degradation. Given that these strategies did not cause major declines in percent perennials (pasture condition) at Alice Springs, the high LWG/ha could be maintained over time. At Donors Hill, these same strategies caused deterioration in pasture condition, and hence the strategies, which most limited (5%) increases in SR annually, achieved the highest LWG/ha. At Fitzroy Crossing, the highest LWG/ha was achieved by strategies with 10, 20 and 30% limits to increases in SR annually, although this was to some extent at the expense of pasture condition. As with percent perennials, the limits to annual adjustments in SR needed to achieve the highest LWG/ha did not appear to be correlated with differences in the rainfall variability of locations.

Acknowledgments

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