Identifying and addressing sustainable pasture and grazing management options for a major economic sector – the north Australian beef industry

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Abstract. Sustainable use of the northern grazing lands is a long-standing issue for management and policy, heightened by projections of increased climatic variability, uncertainty on forage supplies, vegetation complexes, and weeds and diseases. Meat and Livestock Australia has supported a large study to explore sustainable grazing management strategies and increase the capacity of the sector to address climate change. Potential options were explored by bio-economic modeling of 'representative' beef enterprises defined by pastoralists and supported by regional research and extension specialists. Typical options include diversification, infrastructure, flexible stocking rates, wet season resting, and prescribed fire. Concurrent activities by another team included regional impact assessments and surveys of pastoralists' understanding and attitudes towards climate change and adaptive capacity. The results have been widely canvassed and a program of on-ground demonstrations of various options implemented. The paper describes the structure of this program and highlights key results indicating considerable scope to address sustainability challenges.

Keywords: Simulation modeling, grazing systems, stocking rate.

Introduction

The north Australian grazing lands span ~2.3 million km^2 and carry ~14 million cattle. Resource heterogeneity, climatic variation and poor grazing management have caused landscape degradation and reduced ecological services (Tothill and Gillies 1993) and much research has been invested in exploring sustainable management practices. In 2009 Meat and Livestock Australia initiated the Northern Grazing Systems (NGS) project, to identify and extend sustainable herd and land management strategies for 9 major bio-regions; involving: (1) scientific reviews of past research, (2) regional pastoralist workshops to explore options and define 'representative enterprises' for modelling, (3) bio-economic modelling of the impacts the most promising 'best bet' options have on landscape degradation and production, under current and projected climate regimes and (4) applied testing and extension of the 'best-bet 'options. Concurrent activities included assessments of regional impacts and pastoralists' understanding and attitudes to climate change and adaptive capacity (Stokes *et al.* 2012). The bio-economic modelling component explored the production, resource condition and financial implications of northern beef enterprises adopting more promising strategies that were revealed through the science review and pastoralist workshop phases. Simulation of these strategies combined a pasture and animal production model (GRASP) with a dynamic beef herd economic model (ENTERPRISE) calibrated to mimic representative beef enterprises defined by the regional workshops.

Four herd and pasture management strategies were explored in each region – (a) Stocking rates - fixed versus variable stocking rates (b) Wet season pasture spelling systems - variable paddock rotations, spelling commencement and duration; (c) Prescribed fire for woody vegetation control - fire regimes of varying frequency, starting tree basal area etc.; and (d) Infrastructure - strategic expansion and location of stock waters, fencing etc. The modelling process is illustrated with a comparison of fixed and variable stocking rates strategies in the Fitzroy River region using a hypothetical farm located at Duaringa, Queensland.

Methods

Overall NGS Process

The NGS strategy was to: (1) Formally review past research conducted across northern Australia to identify central themes and underlying principles that might be applied to management in the regions (McIvor *et al.* 2010). (2) Present strategies built around these themes at workshops of pastoralists, research and extension specialists in 9 agro-ecological regions, and those of interest listed for further exploration by simulation modelling of a representative beef enterprise defined for each region. (3) Application of bio-economic modelling to the selected strategies of interest. (4) Canvass modelling results at a second series of regional workshops and refine the scenarios where appropriate. The workshop outcomes in conjunction with the initial research review provided insight into further research to fill knowledge gaps or follow through on technical questions raised by the modelling effort. (5) Conclusions from the workshops and modelling process were used to support on-property confirmation and demonstration trials based on the most promising herd and pasture management strategies for each region.

Bio-Economic Modelling

The modelling method and outcome is illustrated for 1 of the 9 regions, Fitzroy in central Queensland (full details of all regions are presented in Scanlan and McIvor 2010). A representative beef enterprise, defined at a workshop in Emerald in April 2009, is characterised as a 10,500 ha property located near Duaringa (23.71^{o}S, 149.67^{o}E, 94 m AMSL, av. annual rainfall 1885-2006 = 704 mm, av. annual rainfall 1980-2006 = 613 mm) comprising 15 paddocks of native and sown pastures carrying ~1200 breeding cows and turning off ~600 kg/head slaughter bullocks. Starting paddock condition varies from 'B - good' to 'C - poor and degraded' as rated against a 4 category system (Chilcott *et al.* 2003).

Pasture yield, annual carrying capacity and animal liveweight gain for the management practices under review are estimated for each paddock using the GRASP pasture simulation model (McKeon *et al.* 1990). Annual liveweight gain kg/head/year is simulated as a function of forage utilisation and growing season length (green days). Land condition impact is assessed through a combination of % perennial grasses in the pasture sward and grass basal area (Scanlan *et al.* 2012). Projected liveweight gain and stocking rate for each paddock is input to the ENTERPRISE herd economic model (MacLeod and Ash 2001) that allocates the herd across the 15 paddocks. Herd fertility and mortality rates which underpin the herd population dynamics are estimated from the liveweight gain projections using regression equations based on herd records from Swans Lagoon R.S. (MacLeod and Ash 2001). ENTERPRISE projects total animal numbers by sex and age class, animal turnoff rates for each year of a simulation trial and a range of profit metrics, including gross margins, net profit and ranges for these measures. Simulations of 25 years were run using climatic data for Duaringa from 1986 to 2010.

Modelling example - fixed versus variable stocking rates

Declining pasture condition is typified by reductions in % palatable perennial grasses, and increases in annual grasses and forbs and also the amount of bare ground (McIvor and Orr 1991). Adopting conservative or flexible stocking rates is argued to be critical for sustainable pasture management (McKeon *et al.* 1990). The example simulation compares a fixed stocking rate strategy with 2 strategies that allow variation in annual stocking rate in response to changing seasonal conditions and associated forage availability. The 'safe' fixed stocking rate is set for each paddock at the assessed long term safe utilisation rate (~20-25%) of standing pasture dry matter at the end of the growing season. The 2 variable strategies are defined as *seasonally responsive* and *constrained variation*. The *seasonally responsive* strategy has a stocking rate in each paddock set each year according to a safe utilisation rate of standing dry matter (20-25%) at the end of the growing season and remains unchanged for the following 12 months. The *constrained variation* strategy allows no more than a 10% increase or 20% decrease in stocking rate between individual years subject to annual safe utilisation limits and an absolute limit of 20% above or 40% below the stocking rate that is set at the start of the simulation period. Comparisons were made of simulation outputs for each paddock over the 25-year simulation period.

Results

The representative enterprise included 7 land/vegetation types in 15 paddocks, 9 of which are in B condition and 6 are in C condition. The GRASP simulation results are presented for one of the 15 paddocks and its constituent land class - a cleared paddock comprising brigalow-blackbutt (*Acacia harpophylla-Eucalyptus cambageana)* vegetation type in B condition at the commencement of the simulation.

Stocking rate - the fixed stocking rate is set in accordance with the safe utilisation rate estimated for the average rainfall of the simulation run. The flexible stocking rates fluctuate within the limits defined above. The 2 variable stocking rate strategies decreased the carrying capacity of the paddock by the end of the simulation period (Fig. 1). This is largely because of pasture damage caused by holding excessive numbers on pastures when good rainfall

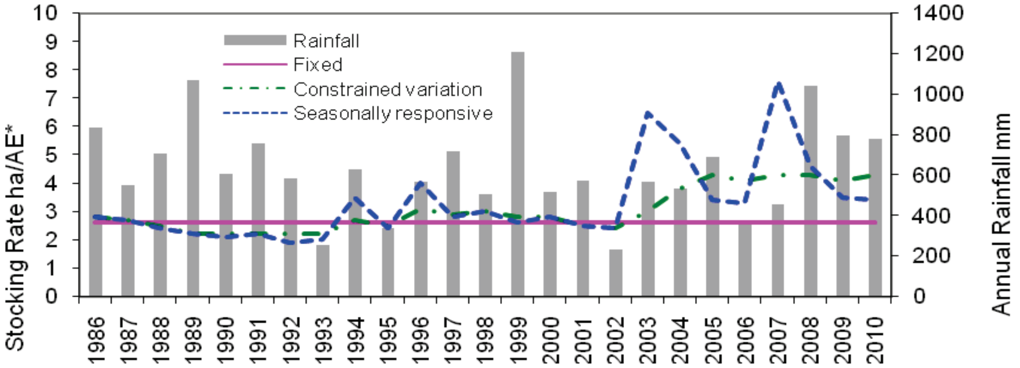

Figure 1. Projections of annual carrying capacity for 3 stocking rate strategies on B condition cleared brigalow-blackbutt pasture, Duaringa (1986-2010). * 1 Adult Equivalent (AE) = 455kg beast.

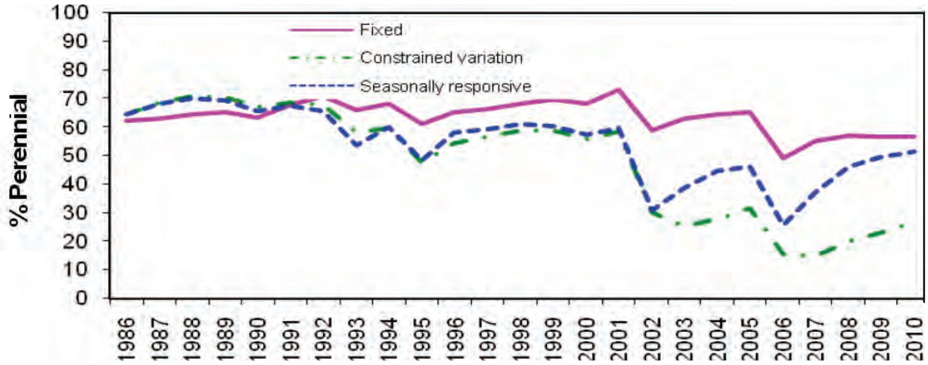

Figure 2. Projections on % perennials for 3 stocking rate strategies on B condition cleared brigalow-blackbutt pasture, Duaringa (1986-2010).

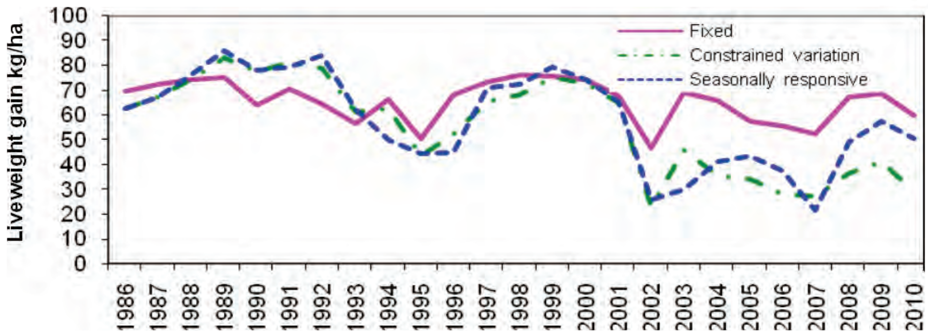

Figure 3. Projections on liveweight gain per hectare for 3 stocking rate strategies on B condition cleared brigalow-blackbutt pasture, Duaringa (1986-2010).

years are followed by poor rainfall years (Scanlan and McIvor 2010). The fixed stocking rate by definition did not change over the simulation period.

Pasture condition - the impact of stocking rates on pasture condition as measured by % composition of perennial grasses in the sward (Fig. 2). The seasonally adjusted stocking rate strategies can potentially reduce cattle numbers when forage availability is low, and reduce overgrazing risk. However, all 3 strategies overshot animal numbers early in the simulation period with subsequent decline in % perennials (Fig. 1). The more restrictive constrained strategy, unlike the seasonally constrained strategy, prevented sufficient reduction in cattle numbers to stop serious pasture damage which lead to a longer recovery at the end of the simulation (Fig. 2).

Animal production - the `safe' fixed stocking rate maintained pasture condition better than either variable strategy, and produced higher average liveweight gains per hectare at the end of the period (Fig. 3). The variable stocking strategies generally yielded higher gains at the beginning of the simulation when pasture conditions improved (Figures 2 and 3). The seasonally responsive strategy outperformed the constrained variation strategy because animal numbers were adjusted more rapidly in the face of changing conditions.

Profit - The safe fixed stocking rate strategy produced the highest annual average profit (total revenue minus total costs), followed by seasonally responsive and constrained variation strategies (Table 1). Fixed stocking had the highest minimum profit and the least number of years when profit was negative. As stocking rate flexibility increased, the number of years when annual profit was negative tended to increase.

Discussion

The results are presented to illustrate the utility of the NGS approach. For the Duaringa example the projected response for carrying capacity, resource condition, animal production and profitability for the 3 stocking rate options revealed the 'extremes' of the flexibility strategies were generally the most profitable under the climatic conditions between 1986 and 2010. The results are highly context-dependent and reflect a combination of the stocking rate strategies, land/vegetation types, land condition and climatic conditions at the time of the simulation trial. The results from each of the regional simulations were endorsed at subsequent workshops and the insights for the various strategies (*i.e*. stocking rates, seasonal resting, prescribed fire) have been incorporated into local extension materials and on-farm demonstrations. The herd and land

Table 1. Estimated annual total profit (AU$) for 3 stocking rate management strategies on the representative Duaringa enterprise (mean values for simulation period 1986-2010).

	Fixed Stocking Rate	Constrained variation	Seasonally responsive
Average	$204,401	$77,370	$135,536
Minimum	-$64,425	-$183,421	-$313,983
Maximum	$490,670	$346,240	$743,838
Negative Yrs	3	8	11

management strategies have been explored under different climatic sequences in the 9 regions including under projected climate change, to seek scope for enhanced forecasting to inform management.

Conclusion

The NGS process which includes the simulation of 'representative' grazing enterprises constructed around a process of science review and local pastoralist consensus offers considerable scope for defining sustainable land management practices with both economic potential and high levels of producer ownership. The results presented offer only a limited insight into the full potential of the models to explore management options in detail. The simulation modelling approach offers a useful alternative to trials for screening large numbers of management options and strategies for future application in research or practice.

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