Bio-economic modelling of beef grazing enterprises to inform sustainable grazing management of northern Australian grazing lands

Neil MacLeod[1], Joe Scanlan[2], Giselle Whish[2] and Lester Pahl[2]

[1]CSIRO Sustainable Ecosystems, 306 Carmody Rd, St Lucia Q 4067, www.csiro.au Email neil.macleod@csiro.au
[2]QDEEDI, 203 Tor St, Toowoomba Q 4350. www.deedi.qld.gov.au

Abstract

Landscape resource degradation is a well-recognised issue for the north Australian grazing industries. Past investment in R&D and extension has identified a suite of grazing management practices that offer opportunities for more sustainable management, including restoring degraded landscapes – such as variable stocking regimes, seasonal pasture resting and prescribed fire to manipulate species composition and reduce competition from timber regrowth. While the ecological performance of such practices has been explored in many studies, economic performance has either been ignored or assessed in elementary terms, such as comparisons of simple gross margins based on treatment differences involving single animal classes (typically 1-2 y.o. steers). Since 2009 CSIRO and QDEEDI has been developing bio-economic models of mixed-class beef grazing enterprises in 9 regions of northern Australia to explore the economic performance of a range of promising grazing and pasture management strategies. The practices were canvassed at regional workshops which considered their priority and applicability to local circumstances, and also defined the characteristics of a regional case study enterprise for modelling. A bio-economic model (ENTERPRISE) integrates data derived from a rangeland pasture simulator (GRASP) and tracks animal types and numbers grazed in up to 20 paddocks, over simulations of up to 100 years duration. ENTERPRISE presents a range of profit metrics, including gross margins, net profit, and ranges for these measures. The paper discusses the projected outcomes for one of the case studies (Queensland Tropical Tallgrasslands) specifically examining fixed versus variable stocking rates, wet season pasture spelling and use of prescribed fire.

Key Words

modelling, economics, stocking rates, spelling, fire

Introduction

Beef cattle grazing is the main agricultural economic exploitation of the northern Australian grazing lands. Sustainable use of this extensive pasture resource is a principal concern following past wide-scale degradation of land resources due to overgrazing (Tothill and Gillies 1992), which may now be exacerbated by increased climatic variability associated with projected climate change (Stokes and Howden 2010). While an array of remedial strategies have been explored in research studies and producer demonstrations over the past two decades, little evidence exists of the potential economic value for beef producers of pursuing such strategies. Where empirical data are lacking, there remains scope for bio-economic simulation modelling to offer insights into the potential opportunity from various rehabilitation options.

In early 2009, Meat and Livestock Australia funded a series of studies of best-practice grazing land management strategies in 9 regions sited across northern Australia. Current management practices, potential best-practice strategies and a 'representative' beef grazing enterprise were described for each region in workshops attended by beef producers, grazing land research scientists, and bio-economic modellers. The economic implications of applying these strategies were explored through bio-economic modelling. Results from the modelling simulations are presented in this paper for the application of three of the practices - viz. variable versus set stocking rates, wet season spelling of degraded pastures, and prescribed use of fire for woody shrub control, for one of the regions - the Fitzroy River Basin in central Queensland. The representative property is located near Duaringa (23.71^{o}S, 149.67^{o}E, 94 m AMSL, av.

annual rainfall 1885-2006, 704 mm; av. annual rainfall 1981-2006, 613 mm) and encompasses 10,500 ha comprising 18 paddocks of native and sown pastures carrying approximately 1200 breeding cows and turning off 590-600 kg bullocks to north Asian markets.

Methods

Pasture production, carrying capacity and liveweight gain for the suite of management practices that were explored were estimated for each of the 18 paddocks using the GRASP pasture production simulation model (McKeon et al. 1990). GRASP is a dynamic, deterministic, point-based model that simulates soil moisture, pasture growth and animal production from daily inputs of rainfall, temperature, humidity, pan evaporation and solar radiation - values for these parameters and the soil types of the 18 paddocks of the representative property were inputted for Duaringa. The land condition of the 18 paddocks varied from 'very good' to 'poor and degraded' according to the ABCD land condition rating system that is commonly employed by State land management agencies and NRM groups in Queensland (Chilcott et al. 2003). The annual liveweight gain of animals was simulated within GRASP as a function of forage utilisation and length of growing season. The effect of different land condition in each paddock was assessed using a combination of the percentage of perennial grasses in the pasture sward and the basal area of grasses. The projected liveweight gain and stocking rate for each of the 18 paddocks derived from GRASP was inputted to the ENTERPRISE herd economic model (MacLeod and Ash 2001). This model projects total animal numbers and turnoff rates for each year of a simulation and provides a range of profitability measures, including gross margins, net profit and ranges for those measures (Figure 1). Simulations of 26 years were run using climatic data for Duaringa from 1981-2006.

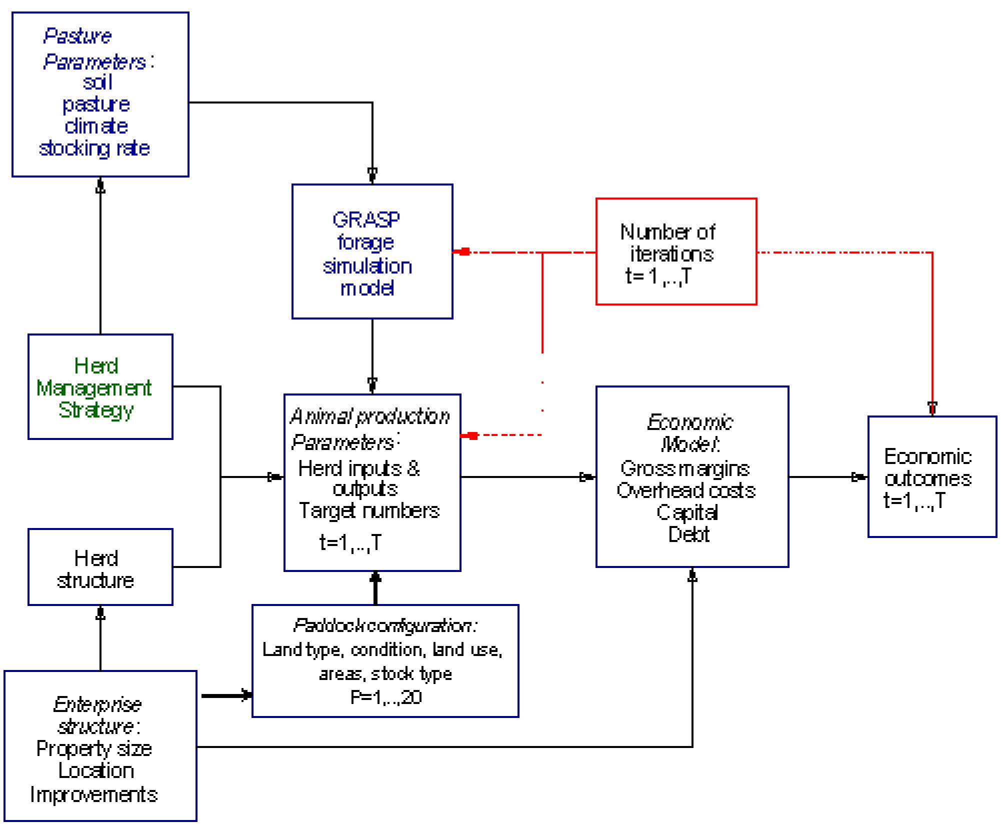

Figure 1. General structure of the GRASP-ENTERPRISE simulation modelling processes.

Study 1- fixed versus variable stocking

Deleterious changes in rangeland pasture condition typically include reductions in the proportion of desirable perennial tussock grasses, increases in annual grasses and forbs, and increases in the amount of bare ground. As overgrazing is a principal cause of such changes, adopting conservative stocking rates or ensuring flexibility in setting annual stocking rates is argued to be a critical consideration for pasture management (McKeon et al*.* 1990). The first simulation compared a fixed stocking rate strategy with two strategies that allowed some variation in annual stocking rate, in response to changing seasonal conditions and associated forage availability. The two strategies included *seasonally responsive* where the rate is set on a safe utilisation rate of standing dry matter at end of the growing season and remains unchanged for the following 12 months, and *constrained variation* which allows a 20% increase or decrease between individual years, subject to an absolute limit of 40% above or below the opening rates. These comparisons occurred through simulations that were applied to each paddock over the 26-year period.

Study 2 - wet season spelling

Perennial tussock grasses are the major component of northern pastures and are sensitive to heavy grazing, particularly during the early growing season. Resting of pastures from grazing (spelling) has been suggested to avoid deleterious impacts of defoliation at this time (Ash *et al.* 2001). For the second simulation, 4 of 18 paddocks which were in poor condition were subjected to a 1-year-in-4 sequential rest from grazing for 6 months, commencing 1 December each year. The percentage of perennial grasses in the pasture sward commenced at 20%, fell to >10% under the 'do nothing' option and increased by the middle of the simulation under the pasture spelling option to ~80%. Cattle displaced from the spelled paddocks were held on short-term agistment on another property 200 km distant. The stocking rate strategy used for this simulation was the same as the *constrained variation* option in Study 1.

Study 3 - prescribed fire

The competitive effect of tree or shrub re-growth on rangeland pasture production is generally well known (Scanlan and Burrows 1990). For the third study, 4 of 18 paddocks with woody shrub regrowth potentially retarding pasture growth were subjected to a 1-year-in-4 sequential application of prescribed fire. Initial mean tree basal area in the treatment was 4 m^2/ha and was projected by GRASP to increase to 15 m^2/ha by the mid-point of the simulation period if left untreated. Tree basal area was projected to remain ~4 m^2/ha following a successful burn. The stocking rate strategy used for this simulation was the same as the *constrained variation* option in Study 1.

Results

Profitability estimates for the three management strategies, summarised as average gross margin/ha and total net profit for the 26-year simulations are presented, respectively, in Tables 1 and 2. Also presented are the minimum and maximum values for any year in the simulation sequence to give a measure of the relative riskiness of each strategy. For the total net profit projections, there is also a measure of how many years in the sequence the value was actually negative. The cumulative value of the gross margin/ha and total net profit values are also presented as the net present value (NPV) of the each of the annual values when calculated using a 4% discount rate. Note that the three studies are mutually exclusive since they relate to the same case study enterprise, but the underlying assumptions make the baseline case different for each.

Table 1. Projected gross margin/ha for three management studies for 26-year simulation runs (1981-2006)[A].

	Stocking rate			Wet season spelling		Prescribed fire	
	Fixed	Responsive	Constrained	No spell	Spelling	No fire	Fire

Average	$31.97	$33.79	$39.25	$27.58	$31.31	$21.59	$24.87
Minimum	$8.50	$1.53	$7.07	$5.57	$1.01	$0.49	$3.83
Maximum	$58.70	$78.89	$74.91	$49.00	$57.16	$49.67	$52.44
NPV@ 4%	$559	$626	$688	$466	$515	$386	$429

[A]Gross margin/ha = (Total revenue – Total variable costs)/Property area (ha).

Table 2. Projected total net profit for three management studies for 26-year simulation runs (1981-2006)[A].

	Stocking rate			Wet season spelling		Prescribed fire	
	Fixed	Responsive	Constrained	No spell	Spelling	No fire	Fire
Average	$126,437	$120,775	$186,091	$84,035	$141,537	$207,285	$238,826
Minimum	-$152,570	-$206,270	-$154,299	-$251,907	-$134,688	$4,725	$36,763
Maximum	$421,796	$548,088	$452,279	$252,011	$372,973	$477,003	$503,537
Years -ve	6	13	7	7	7	0	0
NPV@ 4%	$2,457,607	$2,795,454	$3,627,680	$1,635,408	$2,413,566	$3,707,903	$4,117,848

[A]Total net profit = Total gross margin – Total fixed costs + Annual Cattle Inventory Change.

For each of the three studies, application of the proposed alternative practice suggested an improvement in the profitability of the modelled enterprise for the 26-year simulation run. Because they are directly related, the two profitability measures generally ranked the alternative strategies in the same order. For the particular seasonal sequence that was used for the simulation modelling, the variable stocking rate strategies were both better than the fixed stocking rate strategy in terms of projected gross margin/ha. The seasonally responsive stocking rate strategy intermittently incurred severe penalties of forced selling and crisis feeding in a dry year with animal numbers building up in runs of favourable seasons, and then being quickly reduced in subsequent dry seasons, adding a penalty of increased inventory costs. As a result, the average value of the annual total net profit estimates was actually lower than that of the fixed stocking rate strategy. Moreover, the number of years in which the seasonally responsive stocking rate strategy yielded a negative projected total net profit was almost twice that of the other two stocking rate strategies.

Both the wet season spelling and prescribed fire strategies appeared to offer substantial economic advantages over the alternative ‘do nothing’ strategies. While this result is encouraging, there is actually limited empirical data available from either prior research or property production records to quantify the responses to different spelling and fire regimes - especially frequency and duration of spelling and frequency and intensity of prescribed fires (e.g. McIvor et al. 2010).

Conclusion

The bio-economic modelling of 'representative' grazing enterprises constructed around a workshop process of science review and pastoralist consensus offers considerable scope for defining sustainable grazing land management practices with both economic potential and prospectively high levels of producer ownership. The results presented provide only a limited insight into the full potential of the pasture production and herd dynamic models, GRASP and ENTERPRISE, to explore grazing land management options in some detail. Nevertheless, with declining funds for conducting grazing management studies, the simulation modelling approach offers a genuinely useful alternative for screening large numbers of management options and strategies for future application in research or practice.

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