A re-assessment of the value of strategies for tracking climatic variation in semi-arid grazing systems

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Introduction

Climatic variability is an important cause of poverty in pastoral societies, because droughts result in the destruction of wealth and loss of potential output. This paper examines whether adaptive stocking and sales policies are successful in tracking environmental fluctuations and could be of value in limiting drought-induced mortality and maintaining animal production.

Methods

Policy analysis was conducted with a mechanistic model of rangeland dynamics that uses daily rainfall data to calculate vegetation growth and animal performance (Illius & Gordon 1999). Simulations used 20 years' rainfall data from Bulawayo, Zimbabwe (1975-94; MAR 575 mm; annual CV 0.388). Twenty-five replicates were run for each policy, by randomising the order in which each rain year's data were taken. This ensured that the mean and CV of annual rainfall over the 20 years in each replicate were the same, but changes to the sequence of years produced variation in the timing and severity of droughts. Sequence was treated as a block in ANOVA of the results.

Stocking and sales policies Our aim was to find effective tracking policies, as judged by increased animal sales. Policies designed to exploit spatial heterogeneity in vegetation conditions, such as transhumance or agistment, were not considered. Each policy included annual stock sales at the end of the rainy season to return stocking levels to the target of 0.15 Livestock Equivalents/ha (1 LE= 450kg). We also evaluated a female sales option (whether or not to sell adult non-lactating females to meet stock-reduction targets); and a restocking option (whereby a crash severe enough to reduce animal numbers to below 5% of the target stocking rate triggered restocking with 20% of the target stocking rate in the following wet season). Each policy (below) was repeated with the 2 x 2 female sales and restocking options.

Fixed stocking Sell all stock surplus to the target stocking rate of 0.15 LE/ha at the end of the growing season (**Policy 1**).

Pre-emptive sales These were designed to pre-empt mortality following poor rains, by selling 20% of stock if the rainfall by mid-season was below 70% of the long-term average rainfall by mid-Dec (**Policy 2**) or mid-Feb (**Policy 3**).

Tracking This adapted the target stocking rate at the beginning of the dry season as a function of the current season's rainfall, using a relationship derived from the ecological carrying capacities (**Policy 4**). To prevent stocking rates becoming so high that a crash was likely to occur in the following year even at average rainfall, the rate was either capped to 0.3 LE/ha (**Policy 5**), or the cap varied in accordance with the previous as well as the current year's rainfall (**Policy 6**).

Mortality tracking This was designed to detect the severity of drought by monitoring mortality, and by selling animals in proportion to the incident mortality rate, either in conjunction with the fixed stocking policy (**Policy 7**), or with the uncapped adaptive stocking rate (**Policy 8**).

Results 1

Rainfall sequence had a greater effect on system performance than any of the policies we examined, causing a roughly two-fold range in the 20-year mean of sales and mortality. The policy on female sales had the next largest effect on system performance (Table 1). Unless adult females are sold, as part of a policy to market animals and reduce stock numbers, the target stocking rate is exceeded, mortality is unacceptably high and annual sales are reduced. Re-stocking increased sales by only about 8%.

Table 1. Results (20-year means) for the female-sales and re-stocking options, averaged over all stocking policies.

	No Female sales		With female sales		
Response variable	No re-stocking	With re-stocking	No re-stocking	With re-stocking	s.e. diff
Sales (kg live weight/ha)	14.1	15.6	17.1	18.2	0.28
CV of sales (%)	106	94	113	105	2.7
Mortality (%)	42.2	41.6	16.9	15.5	0.60
Stocking rate (LE/ha)	0.19	0.21	0.14	0.14	0.030

Results 2

The various tracking policies produced no useful increase in mean annual sales, compared with fixed stocking (Table 2). This was partly due to the confounding effect of the policies on the mean annual stocking rate achieved, which varied between the policies (see Figure). Higher output were generally associated with policies that maintained high average stocking rates, despite the consequently higher mortality. There were large differences between policies in the CV of annual sales.

The fixed stocking and pre-emptive sales policies produced very similar sales, with substantial average annual mortality. The main effect of pre-emptive sales was to reduce the later stock sales and not to achieve a significant increase in output. The basic tracking policy, in which the stocking rate target was adjusted according to the current-season' s rainfall, had similar sales to the control and pre-emptive sales policies, and lower mortality and stocking rate, but higher CV of annual sales, implying zero sales in nearly one year in four. Mortality tracking, combined with a rainfall-dependent stocking rate, produced sales that were nearly as high as the control policy, with low mortality and low average stocking rate, but a high CV of annual sales.

Table 2. Comparison of fixed and tracking policies, all with female sales and re-stocking.

	Policy	Sales (kg/ha)	CV of sales (%)	Mortality (%)	Stocking rate (LE/ha)
1	Fixed stocking	19.6	63	19.4	0.16
2	Pre-emptive sales in Dec	20.0	61	19.4	0.16
3	Pre-emptive sales in Feb	19.9	63	19.3	0.16
4	Tracking, basic	18.2	149	12.5	0.13
5	Tracking, capped @0.3 LE/ha	18.4	143	12.4	0.14
6	Tracking, capped $\propto$ rainfall	14.5	140	9.4	0.10
7	Mortality tracking + fixed stocking	17.8	76	18.0	0.14
8	Mortality tracking + variable stocking	18.4	139	8.9	0.13
s.e. diff		0.39	7.8	0.85	0.0041

Discussion

Our results suggest that, despite their promise, policies designed to track unpredictable environmental variations do not readily yield the benefit of increased output, by comparison with a policy of fixed stocking, and they have the disadvantage of higher inter-annual variability of sales.

Tracking policies were less effective than expected for the following reasons.

(1) It is necessary to sell breeding females if large stock reductions are to be achieved, and this reduces future productive potential, thereby offsetting the benefits of reduced mortality. Drastic de-stocking may avoid drought losses, but it removes the ability to produce in the future just as effectively as does mortality. Full re-stocking could overcome this, but for all producers to sell their stock at the onset of a drought and then buy them back afterwards would require huge resources to be deployed, either by government or by some market or insurance mechanism. Our modest re-stocking option acknowledges the difficulty of financing such schemes.

(2) Although tracking the current season' s rainfall was effective in reducing mortality in the following dry season, it could not avoid the frequently larger mortality occurring as a result of late or low rain in the following season. The mortality tracking policies were designed to overcome this, but they generally failed by having to sell animals at a light weight, yet in large numbers.

(3) Pre-emptive sales policies are a gamble between selling less animals than would die in a drought and selling too many, risking future production loss in exchange for reduced mortality. Inability to gauge the severity of future mortality limits their usefulness.

(4) If breeding females are never sold, or sales coincide with mortality (as in the ' mortality tracking' policy) then the average size of the animals sold is reduced, leading to lower output.

The policy of not selling breeding females led to high stocking rates, low annual sales, and high mortality. It is consistent with the objective of maintaining high stock numbers and maximizing the reproductive capacity of the flock, but is not consistent with maximizing sales. In contrast, selling females to meet stocking targets, combined with a tracking policy that adapted stocking targets to rainfall by the end of each season, achieved higher annual sales at lower stocking rate and low mortality. These two approaches contrast a strategy of high animal numbers and low output with one of low numbers and high output: essentially the contrast in objectives usually attributed to the communal and commercial sectors, respectively, of African livestock keeping. It would appear that, in the absence of an ability to restock heavily after droughts, the traditional policy amongst subsistence pastoralists of maintaining the maximum size of breeding herd is well founded, given that animal sales are not the only priority. On this view, high mortality is merely the cost of maintaining high animal numbers in an unpredictable environment.

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Reference

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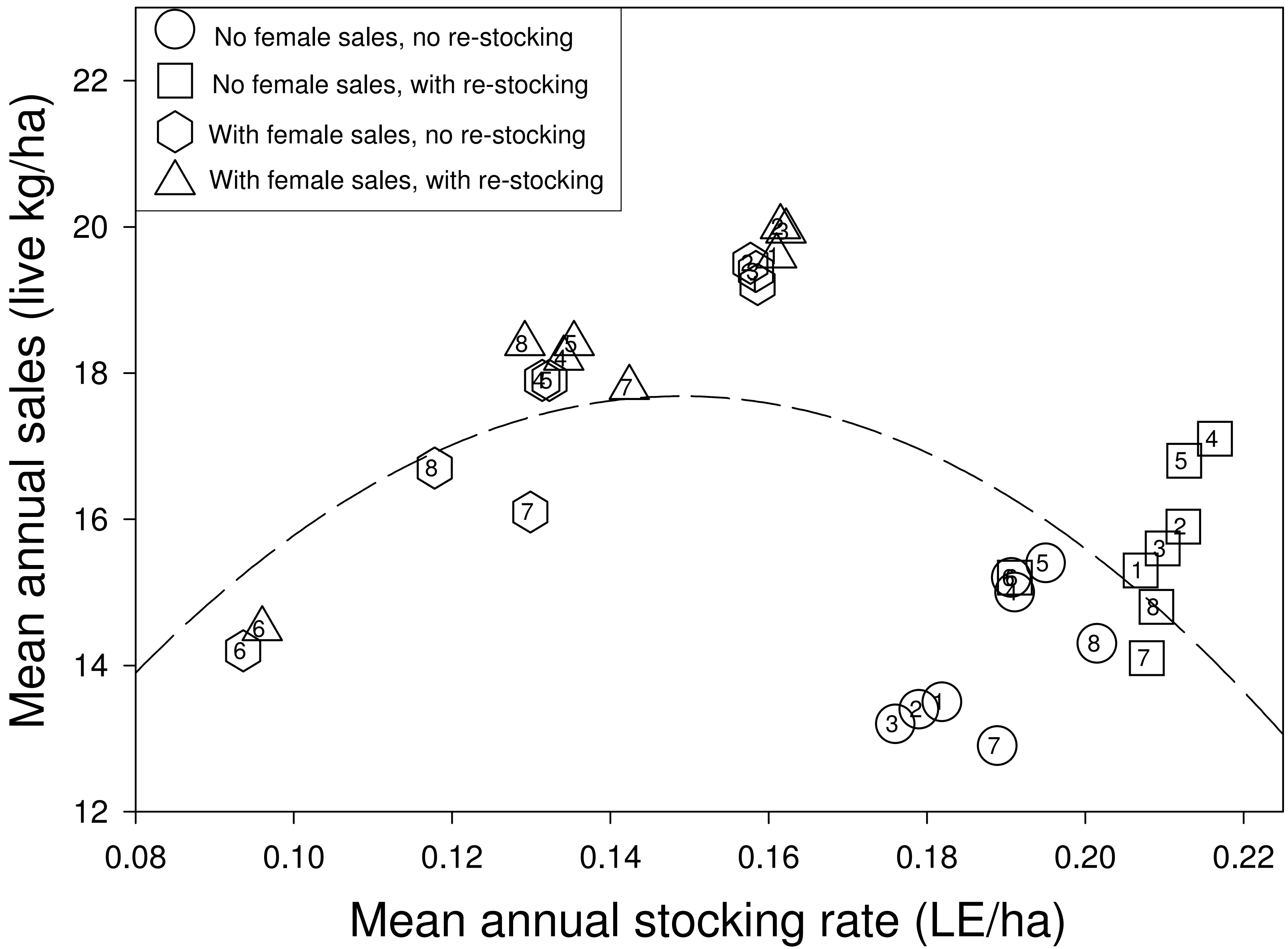

No female sales, no re-stocking
No female sales, with re-stocking
With female sales, no re-stocking
With female sales, with re-stocking
Mean annual sales (live kg/ha)
Mean annual stocking rate (LE/ha)
12
14
16
18
20
22
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.22