# Optimising the Utilisation of Semi-Arid Rangelands

Existing knowledge of the key processes affecting rangeland productivity was brought together and combined with improved descriptions of animal foraging strategies and diet selection. Models of rangeland function were produced to assess the components to which the system is most sensitive and identify where knowledge is lacking.

## Background

Many of the world's poorest countries are in arid and semi-arid areas, where the connection between land degradation and livestock management is an acknowledged problem. Improvements in livestock management strategies are needed, but land use planning is impeded by the lack of a framework for predicting how rangeland systems respond to livestock stocking policies, management practices and interactions with wildlife.

There are currently few scientific and objectively based strategies for optimising long-term utilisation of vegetation resources, matching the mix of animal species to vegetation structure, accounting for the impact of wildlife or of combining wildlife management goals with pastoralism. Annual and seasonal variability in rainfall is an important cause of instability in semi-arid environments, so rigid stocking policies may increase the risk of vegetation degradation. Flexible and opportunistic management practices are required to realise the sustainable economic yield from rangelands.

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## Research highlights

Although an extensive body of literature on semi-arid rangeland systems exists, there is considerable variation in the depth of knowledge of the key processes in such systems.

Relationships between soil moisture and plant growth are fairly well understood, and models can produce quite accurate results. There is less clear agreement on how herbaceous and woody plants differ in water-use efficiency, and the annual production of woody species is poorly understood. Variability of rainfall appears to be of considerable importance; it is the main cause of variation in primary production, and has a greater impact on vegetation change than grazing intensity or fire.

Research on food intake and diet quality, which have a major impact on performance of animals, is scarce and the principles on which to base model predictions have been slow to emerge. Spatial variation in forage distribution and accessibility may constrain feeding behaviour and food intake. Soil fauna, especially termites, may have a surprisingly large impact on dry-season vegetation biomass, but also significantly affect infiltration and nutrient cycling.

There has been active debate on the management paradigms appropriate for rangeland systems. The difficulty of translating theoretical insights to the real world has perhaps been underestimated.

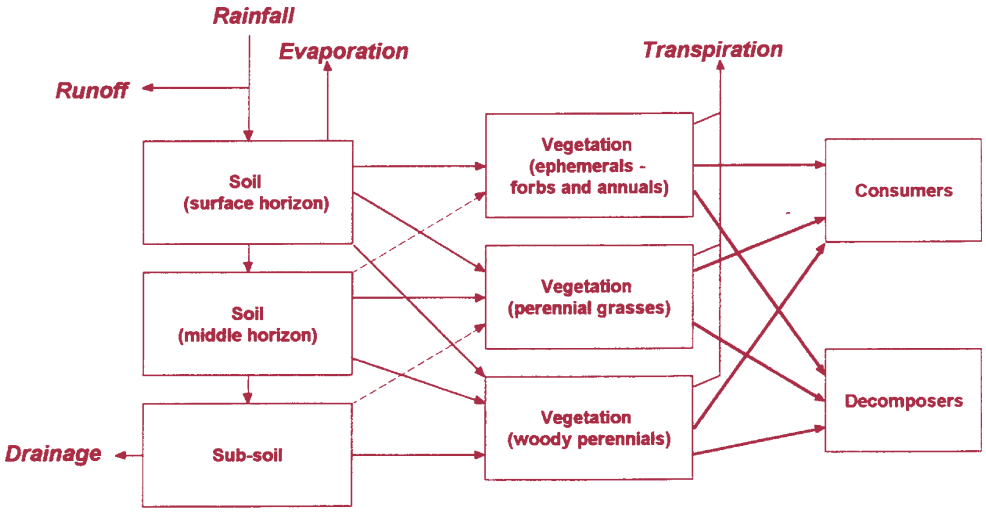
The model successfully predicts many of the phenomena of semi-arid grazing systems. Animal diets and performance levels, the relationship between rainfall and stocking rate, and bush encroachment are all close to those observed. Performance was sensitive to climatic variability and the separate effects of the mean annual variation in rainfall were established. With increased annual variability of rainfall, but without changing mean annual rainfall, the mean carrying capacity declines by half. Bush encroachment is an important process and reduces grass yield and predicted diet quality; bush utilisation by goats reduces encroachment. Diet quality was predicted to be the first limiting constraint on nutrient intake rates – animal production is limited by the quantity of high-quality forage. However, knowledge of the nutritive quality of savannah vegetation components is poor.

| | Predicted carrying capacity (livestock units/ha) | | |
|---|---|---|---|
| | Cattle | Goats | Combined |
| Cattle only | 0.15 | — | 0.15 |
| Goats only | — | 0.27 | 0.27 |
| Mixed stocking | 0.015 | 0.16 | 0.175 |

*Goats can be maintained at higher equivalent stocking densities than cattle before performance is reduced.*

## Uptake

The project provided information on the constraints that apply to livestock production in semi-arid systems. Inter-annual variation in the supply of high quality forage is the single most important constraint on production from semi-arid rangelands. Low quality




*Outline of a grazing system, governed by rainfall and water use (thin lines) and flows for the resulting plant material (thick lines) to livestock and wildlife consumers, or lost to decomposers such as termites. Dashed lines indicate weak uptake of water due to restricted rooting depth of short-lived plants. Feedback such as the effect of vegetation on runoff or decomposers on nutrient cycling have been omitted for clarity.*

dry-season forage is the main constraint on nutrient intake and directly affects mortality. Poor ability to predict droughts, and to rebuild herds following mortality or de-stocking, were identified as constraints on the adoption of flexible stocking policies.

## Linkages

This research forms part of a continuing programme of research. The modelling developed by this project has important implications for continued research into improved livestock development in semi-arid zones.

## Relevance to sustainable livelihoods

Flexible stocking strategies designed to tackle climatic variation have so far shown only limited scope for improved output over fixed stocking. The main reasons for this are that major stock losses are associated less with single-year droughts than with two-year droughts – these are difficult to track. Furthermore, de-stocking can be really effective only if the productive potential of the herd can be re-established more rapidly than is possible from the depleted herds.

If re-introductions of significant numbers of breeding stock from elsewhere are not possible, livestock numbers will lag behind climatic fluctuations – producing a succession of population crashes and missed opportunities.

Inadequate infrastructure is likely to be a constraint on restocking. There is also some scepticism about the feasibility of de-stocking/restocking schemes. Schemes to distribute supplements to livestock *in situ* during drought would break the regulating effect of drought on animal numbers – an effect that may limit the degradation caused by high stocking rates. However, the traditional pastoral policies of maintaining the maximum number of breeding stock, and of hoping that most will survive periods of drought, may be as close as 'opportunistic' management can get to dealing with the effects of drought.

## Selected project publications


- Illius, A.W., Derry, J. and Gordon, I.J. (1997) *Modelling the Dynamics of Semi-Arid Grazing Systems.* Manuscript copy. 63 pp.

- Derry, J.F. (1998) Modelling ecological interaction despite object-oriented modularity. *Ecological Modelling,* **107**: 145–158.

- Illius, A.W., Derry, J. and Gordon, I.J. (1998) Evaluation of strategies for tracking climatic variation in semi-arid grazing systems. *Agricultural Systems*, **57**: 381–398.

- Illius, A.W. and Gordon, I.J. (1998) Scaling up from functional response to numerical response in vertebrate herbivores. In: *Herbivores: Between Plants and Predators.* Olff, H., Brown, V.K. and Drent, R.H. (Eds.). Blackwell Science, Oxford, UK.



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