# Rainfall use efficiency, natural resource management and profitable production in the rangelands

Gardiner, B.

Border Rivers – Gwydir Catchment Management Authority

PO Box 411, Inverell, NSW, 2360

**Keywords:** rainfall, use, efficiency

## Abstract

Rainfall use efficiency (RUE) is suggested as a measure of the productive use of the weather and measures the amount of rainfall that is converted into agricultural products. Rainfall use efficiency measures the interaction between rainfall, solar energy inputs and wind run and plant primary production. The greater the proportion of available rainfall that is productively used by plants, the more profitable and productive is the agricultural system. Natural resource management practices that address wastage in rainfall use and maximise RUE will maximise the profitability and productivity of farm businesses. These practices will also be shown to provide the best chances for maintaining landscape resilience to natural and man-made shocks to these systems. The conditions that maximise rainfall use efficiency are:
1) sufficient groundcover to minimise run off and soil loss by wind and/or water erosion,
2) sufficient litter to minimise evaporative water loss and maintain surface soil structure,
3) sufficient green pasture mass to maximise photosynthetic efficiency, 4) a diversity of plant species sufficient to ensure that rainfall at any time of the year can be utilised productively,
5) sufficient shelter to minimise water loss to evaporation, excessive evapotranspiration and heat and wind stress on animals, and 6) soil that is not limiting to plant production due to biological, chemical or physical constraints. Maintaining these conditions ensures that rangelands are kept in a more resilient state.

## Introduction

The sustainability of rangeland production is far from assured, raising questions about the ability of primary producers to conserve soil and water resources despite the best intentions. The problems include degradation of soil, water and air, both on and off-site, declining primary productivity, undesirable changes in vegetation due to overuse, over-extraction of water resources, introduced plant and animal pests, human-induced climate change and loss of habitats and biodiversity (Gardiner and Reid, 2010).

How can rangeland managers tell if their management is maximising pasture productivity and enterprise profitability? A biophysical solution is presented in the form of six key paddock indicators for maximising pasture rainfall use efficiency and net primary productivity while also retaining many of the ecosystem services commonly associated with well managed remnant vegetation (Williams and Chartres 1991, Tilman 1997).

*Why Maximising RUE Maximises Profit*

Rainfall use efficiency (RUE) is critical to best-practice farming (Gardiner and Browne, 2009). Primary producers should make maximum use of the rainfall and solar radiation that falls on their properties to maximise plant productivity and profit. All else being equal, practices that are more efficient at utilising rainfall will be more productive because a production function that maximises RUE (Q, in Figure 1) will lie above one that does not (Q* in Figure 1) over the range of possible input–output combinations. Practices that maximise RUE maximise profitability because they minimise the volume and cost of purchased inputs that are necessary to achieve a given level of production.

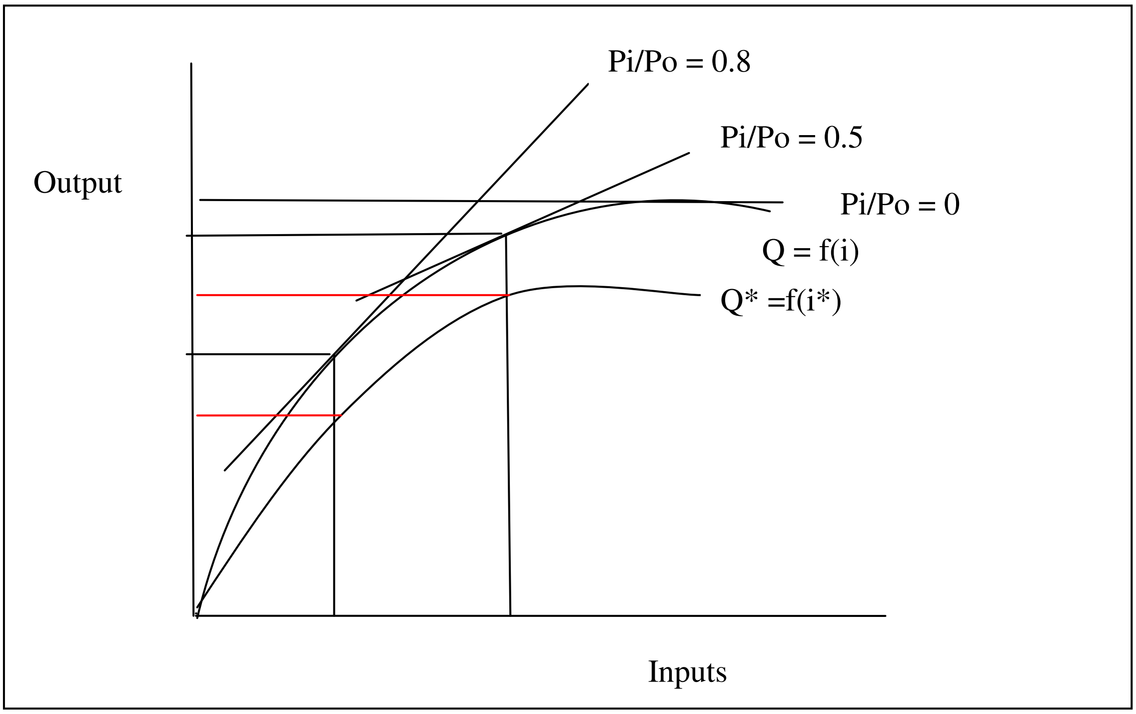


*Fig.1. Relationship between a production function, the prices of inputs and outputs and profit maximisation*

RUE can be maximised by maximising the infiltration of rainfall into the soil, minimising runoff, deep drainage and evaporation from soil and plant surfaces, and maximising the amount of soil moisture transpired by productive crops and palatable pasture plants. Livestock producers in Australia can achieve this in a practical way by observing six key paddock indicators.

*1. Maintain sufficient ground cover to minimise run off and soil loss*

Ground cover in the form of pasture biomass and dead and detached litter is important in terms of minimising runoff and erosion. For minimising soil erosion in higher rainfall regions, 70% ground cover is the generally specified target. However, in conservatively grazed semi-arid woodlands, much less than 70% ground cover is usual in sparsely vegetated interspaces between denser patches of vegetation.

*2. Maintain sufficient litter to minimise evaporative water loss and maintain surface soil condition*

Two t/ha of litter reduced evaporation of soil moisture by an average of 1.04 mm/day over 1 year on the North-West Slopes of NSW, compared with no litter (Murphy, 2002). This quantity of litter is also important in terms of soil health because it improves soil structure, permeability and water-holding capacity, provides food for soil decomposers, and its breakdown is a source of plant-available nutrients.

*3. Maintain sufficient pasture green dry matter to achieve maximum photosynthetic efficiency*

If the use of photosynthetic radiation is to be maximised, a biomass of green dry matter (GDM) of at least 1.5 t/ha is desirable in all seasons and locations. While a few classes of livestock can maintain weight on lower quantities of GDM high levels of animal performance, rapid pasture regrowth after defoliation or rain and good soil health require between 5 and 15 cm of retained pasture height (equivalent to 1.5–3.0 t GDM/ha) (Bell, 2006). Retention of this amount of GDM means that even small rainfall events can be efficiently converted into photosynthate and biomass.

*4. Maintain a diverse pasture sward*

If pastures are to make maximum use of all incident rainfall, a variety of functional types of plants are likely to be more successful at maximising plant productivity and RUE than just one or two species. Depending on the restrictions set by the regional climate, soil and plant species, the pasture should ideally include a mix of summer and winter-active species and year-long green plants. Woody perennials in some systems also contribute browse or edible fruits for livestock and fill seasonal shortfalls in pasture-based feed.

*5. Maintain sufficient landscape under tall woody vegetation for shelter*

The shelter provided by trees and shrubs impacts on plant and animal productivity in various ways. The reduction in wind speed across farm scapes reduces excessive evapotranspiration of soil moisture, the wind-chill experienced by livestock in cold weather, wind erosion, and sand-blasting and wind damage to sensitive crops and pastures. Trees and shrubs provide shade, reducing the impact of heat stress on livestock growth, fecundity and mortality in hot weather. Trees and shrubs are also important for reducing deep drainage below pasture root zones (Gardiner and Reid, 2010).

*6. Maintain optimal soil health*

The productivity and profitability of grazing systems is determined by maintaining an adequate quantity of highly digestible, nutritious pasture that enables grazing animals to approach their genetic potential. Maximising RUE and plant productivity depends on optimal soil health and also depends on eliminating soil limitations to plant growth where it is economic to do so. Soil health can be improved by maintaining pasture and litter biomass and ground cover above the thresholds specified above (Indicators 1–3), in order to maintain high soil carbon and organic matter levels, and reduce soil crusting.

*Land condition of pastures in tropical savannas*

Rangeland scientists in the wet–dry tropics have developed a functionally-based, range condition assessment system, using benchmarks for livestock carrying capacity to score rangeland condition (Chilcott et al., 2003). Land condition is the capacity of rangeland to respond to rain and produce useful forage relative to the productive potential of the same range type in a non-degraded, fully functional state. Land condition has three components. Soil condition is the capacity of the soil to absorb and store rainfall, store and cycle nutrients, provide a medium for seed germination and plant growth, and resist erosion. Pasture condition is the capacity of pasture to capture solar energy and convert it into palatable green leaf, use rainfall efficiently, maintain soil condition, and cycle nutrients. Woodland condition is the capacity of woodland to grow pasture, cycle nutrients and regulate groundwater.

Four categories of land condition are recognised (Figure 2): 'A' is excellent carrying capacity for the range type, with no loss of productive potential or carrying capacity due to past grazing history or other management intervention (fire, cultivation, mining etc.). 'B' is good condition, with carrying capacity reduced by up to 25% owing to loss of landscape function due, say, to grazing. 'C' is poor condition, with carrying capacity reduced by 25–45%. 'D' is severely degraded with productive potential reduced by 45–80%.

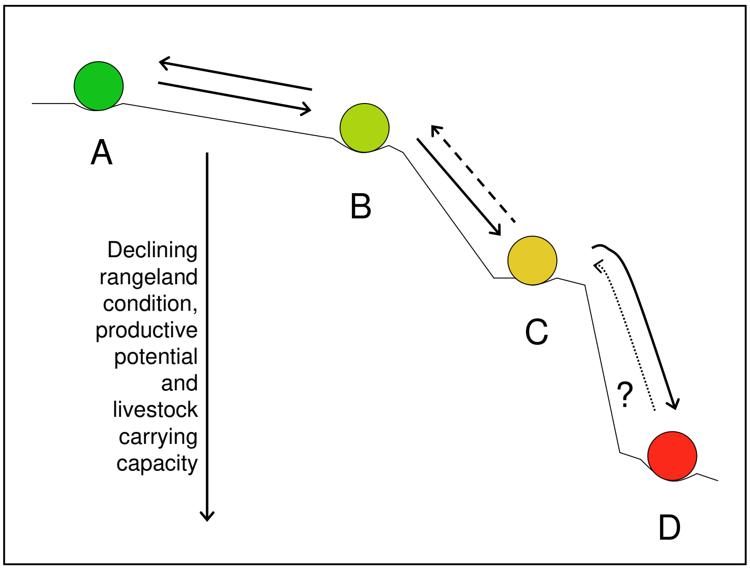


*Fig.2. The rolling ball model of land condition, representing the ease with which grazing management can effect transitions between condition states A–D. Source: adapted from Chilcott et al. (2003).*

Managing rangelands within the boundaries prescribed by the 6 paddock indicators for sustainable livestock production will ensure that the majority of these areas can be maintained in A or B condition, thus maximising their resilience and minimising the chances of broad scale degradation.

## Conclusion

Economic theory, plant and animal physiology and the conditions that define landscape resilience determine that profitability, productivity and sustainability are driven by the same conditions that maximise rainfall use efficiency. These are:

1. Sufficient groundcover to minimise run off and soil loss by wind and/or water erosion.
2. Sufficient litter to minimise evaporative water loss and maintain surface soil structure.
3. Sufficient green plant mass to maximise photosynthetic efficiency.
4. A diversity of plant species sufficient to ensure that rainfall at any time of the year can be utilised.
5. Sufficient shelter to minimise water loss to evaporation from soils, excessive evapotranspiration from plants and heat and wind stress on animals, and

6. Soil that is not limiting to plant production due to biological, chemical or physical constraints.

Maintaining these conditions in rangelands environments will have implications for future management strategies.

## References

Bell, A. (2006). Pasture assessment and livestock production NSW DPI Primefacts 323 1–6.

Chilcott, C.R., McCallum, B.S., Quirk, M.F. and Paton, C.J. (2003). Grazing Land Management Education Package Workshop Notes—Burdekin, Meat and Livestock Australia Limited, Sydney.

Gardiner, B. and Browne, W. (2009). Property Management Planning and Customised Management Systems, 145 pages, Border Rivers – Gwydir Catchment Management Authority, Inverell.

Gardiner, B. and Reid, N. (2010). Sustainable Livestock Production in Cottle D (ed) International Sheep and Wool Handbook, pp 445 – 471, NUP, Nottingham, UK.

Murphy, S. (2002). The Nature, Behaviour and Management of Surface Runoff from Grazing Lands on the North West Slopes of NSW PhD Thesis, University of New England, Armidale.

Tilman, D. (1997). Distinguishing between the effects of species diversity and species composition. *Oikos* **80**, 185-185.

Williams, J., and Charters, C.J. (1991). Sustaining productive pastures in the tropics. 1. Managing the soil resource. *Tropical Grasslands* **25**, 73-84.

Gardiner, B. (2010). Rainfall use efficiency, natural resource management and profitable production in the rangelands (2010). In: *Proceedings of the 16th Biennial Conference of the Australian Rangeland Society*, Bourke (Eds D.J. Eldridge and C. Waters) (Australian Rangeland Society: Perth).