Sustainable Grazing Systems: experimental results and the implications for temperate-zone grazing enterprises

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Introduction

Grasslands, both sown and native, make up approximately 83% of the agricultural zone of temperate Australia and produce a large proportion of the meat and wool in southern Australia. Grassland types range from pastures based on introduced perennial and annual grasses with clovers (especially *Trifolium subterraneum* and *T. repens*) and medics (*Medicago* spp.) to those based on native grasses.

Over the past three decades, however, stocking rates have declined on all pasture types across temperate Australia so that actual stocking rates are now considerably below their potential. The value of this lost production has been estimated at $230 million annually in New South Wales alone (Dellow *et al.*, 2002). Declining perennial grass content is one of the primary causes of the reduction in livestock carrying capacity.

Lower perennial grass contents of pastures may also increase the risk of on-site or downstream salinity through decreased water use, since pastures with a dominant winter-annual component use less water than those with a strong perennial grass component. Annual pastures have been shown to have substantially more water loss from deep drainage (i.e., water moving below the root zone). This increased deep drainage contributes to a rise in water tables that may bring subsurface salt into the root zone and into waterways lower down in the landscape. The temperate perennial pasture zone of New South Wales and Victoria is a major recharge area for the Murray-Darling catchment, and the impact of increasing deep drainage is already affecting the water quality of many rivers.

Previously, resowing has been the key strategy for increasing perenniality; but due to the high cost of replacing a perennial pasture (about $250/ha), this practice has become less common. A number of management strategies may be used to rehabilitate degraded pastures. Fertiliser and lime can be used to manipulate pasture composition, as can herbicide application; and changes in grazing intensity and frequency may also be effective. It is likely, however, that the development of sustainable management strategies will involve a combination of all the above tactics, adapted to local conditions.

Whatever species or production systems are used, the ongoing management of pastures in the temperate perennial pasture zone must be based around the notion of sustainability. The sustainability goal is to manage a set of natural resources (water, nutrients, soils, pastures, animals, and biodiversity) so as to maintain their value over the long term. Ideally, these values should be derived not only from the production outputs of these resources (i.e., wool and meat), but also from the changes in the state of all resources.

In the temperate perennial pasture zone (> 600 mm annual rainfall) of southern Australia, the Sustainable Grazing Systems (SGS) program addressed the issues of pasture productivity and sustainability by undertaking research at a number of sites that collectively formed the SGS National Experiment. This research focused on identifying the constraints to achieving productive and sustainable grazing systems based on sown and native perennial grasses.

This paper summarises some of the major outcomes for the cross-site ‘themes’ (pastures, animal production, water, nutrients, and biodiversity). The implications for temperate-zone grazing industries follow afterwards. For details of the SGS National Experiment, its themes, and the tools developed to enable cross-site analyses (database, SGS pasture model), refer to Andrew and Lodge (2003) and Andrew *et al.* (2003).

Research outcomes

1. Grassland herbage accumulation and livestock carrying capacity

Growing season length, unlike annual rainfall, was a reasonably good predictor of both grassland herbage accumulation (Figure 1; see Sanford *et al*. (2003) for full details) and livestock carrying capacity.

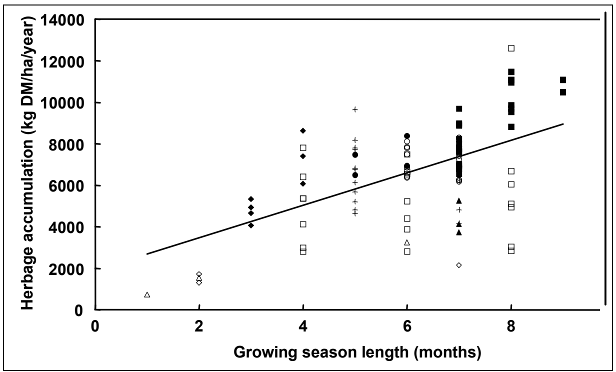
For herbage accumulation, much of the remaining variation (70%) was explained by soil-available phosphorus (+), the proportion of native species in the sward (-), and stocking rate (-) together with interactions with other factors, such as legume content.[1]

Carrying capacity was also affected by soil-available P (+), soil pH (+), grazing method (+, mainly strategic resting, defined as livestock grazed outside the experiment to rest pastures), sub clover content (+), and growing season length (+).

Perennial grass content and basal cover were both significantly influenced by growing season length (+),

[1] + means ‘more is better’; - means ‘less is better’.

grazing method (strategic rest is better than rotation, which is better than set-stocked) and an interaction between stocking rate and soil pH. Sub clover content of grasslands increased in response to continuous grazing and increased stocking rate.



Manilla (◇), Barraba (△), Carcoar (□), Wagga Wagga (▲), Yass (+), Vasey (○), Esperance (◆), Albany (■), and Kendenup (●). Data are for different treatments at each site. The fitted line depicts best-fit, R^2 = 0.30.

Figure 1. Relationship between growing season length and herbage accumulation (kg DM/ha/year) for SGS National Experiment sites from 1997 to 2001.

2. Grasslands and soil water

While deep drainage is a key component in the assessment of sustainability, it is very difficult to measure directly. In SGS, soil-water deficits (SWDs) were calculated, representing the water 'buffering' capacity of the soil (White *et al.*, 2003). (Soil-water deficits are the difference between the soil-water content at saturation and at the time of measurement.)

Of the perennial grasses, kikuyu (*Pennisetum clandestinum*) had the highest SWDs, an increase of between 55 and 71 mm when compared with pastures dominated by annual species. Differences in SWDs for other perennial grasses, such as phalaris (*Phalaris aquatica*), were moderate (18 to 45 mm) compared with annuals (Figure 2). Trees in grasslands, in either belts or parkland configurations, reduced the probability of surplus water in winter to zero in their immediate vicinity.

Long-term model simulations indicated that plant root depth was crucial in decreasing deep drainage. Soil type affected SWD primarily through controlling the rooting depth of the vegetation, but it also changed the partitioning of surplus water between runoff and deep drainage. Overall, grazing method and grassland management had only a marginal effect on SWD.

3. Plant diversity

More than 200 plant taxa were recorded over the experimental period (1997 to 2001). (See Kemp *et al.*, (2003) for full details.) About one-third of these were native species, most of which persisted even when fertilised and oversown with introduced species. Where grasslands were less intensively grazed (average herbage mass > 2,000 kg DM/ha), the number of native species increased by one or two; but the number tended to decrease in more heavily grazed treatments. Native grasses made a higher contribution to herbage mass than other native species, most of which were forbs. As total species richness increased, there was a tendency for herbage accumulation to decline.

Implications/discussion

Matching livestock demands with short-term and long-term forage availability and linking these with the vagaries of markets is a formidable, complex task requiring high-level decision-making. Many factors may be outside the producers' direct control, but others are becoming manageable as we obtain a greater understanding of the mechanisms involved. One such factor is how to cost-effectively manage pastures and grasslands to achieve better returns with more sustainable livestock production systems.

Maintaining or enhancing perenniality in high-rainfall–zone pastures within temperate Australia has been identified as a key strategy in developing sustainable livestock grazing systems. In terms of productivity over the long term, perennials can maintain available forage for a greater part of the year, resulting in more livestock being carried. In addition, perennials can use more water, resulting in less ground-water recharge, and can compete more effectively with annual weedy species (see Figures 3 and 4 for examples from the Carcoar site). With appropriate management, native species may be retained in perennial pastures

Research results from the SGS National Experiment and elsewhere have consistently shown that, to improve the perennial grass component, some form of targeted rest is needed. Some producers, however, still have reservations about adopting a tactical grazing rest as part of their pasture management program because of the protracted period of deferment required (up to 12 weeks) and the financial impact this has in the short term.

Clearly, if producers are to adopt new grazing strategies and stocking rates that are ecologically sustainable, then these practices must also be profitable. Where reductions in stocking rate and grazing rests are recommended, however, profitability is difficult to demonstrate *in the short term.* Over the longer term, though, maintaining and encouraging perenniality can be shown to be profitable when appropriate values are used for the resources (e.g., perennial grasses, soil, water) that are enhanced by this process. For instance, economic analysis of pasture systems with contrasting levels of perenniality (and, therefore, contrasting carrying capacities) has shown that a pasture with a 20% perennial grass component will generate a net return of only $40 per hectare, whereas a pasture with a 60% perenniality component has a net return of more than $230 per hectare.

Other approaches to increasing profitability may involve the careful consideration of livestock enterprise and landscape capability. The change from Merino wethers to first-cross lambs at Carcoar provides an example of this. While lambs could be raised to

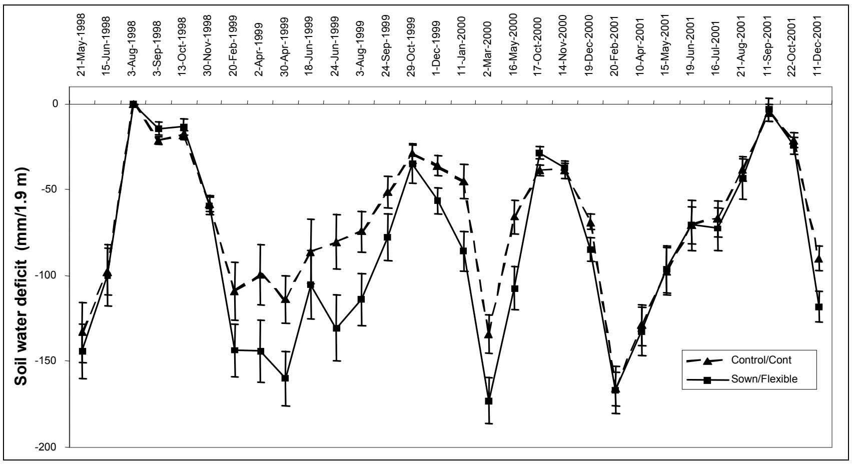


Figure 2. Comparison of soil-water deficits under continuously grazed native perennial pasture (Control/Cont) and flexibly grazed cocksfoot/phalaris pasture (Sown/Flexible) at Carcoar.

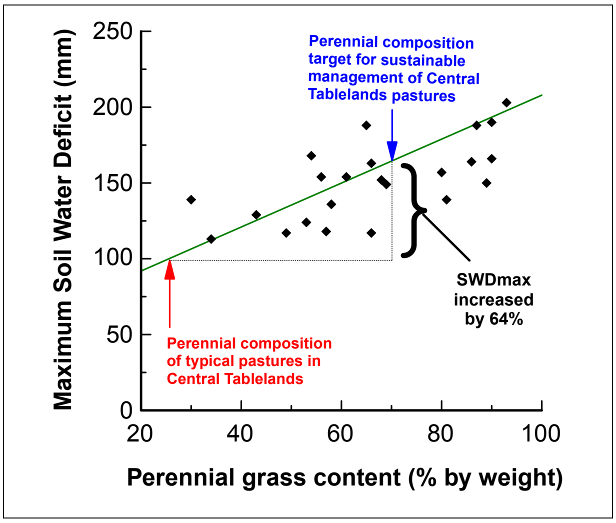


Figure 3. Relationship between perennial grass content and maximum soil-water deficit measured each year over the 4 years of study at the Carcoar site.

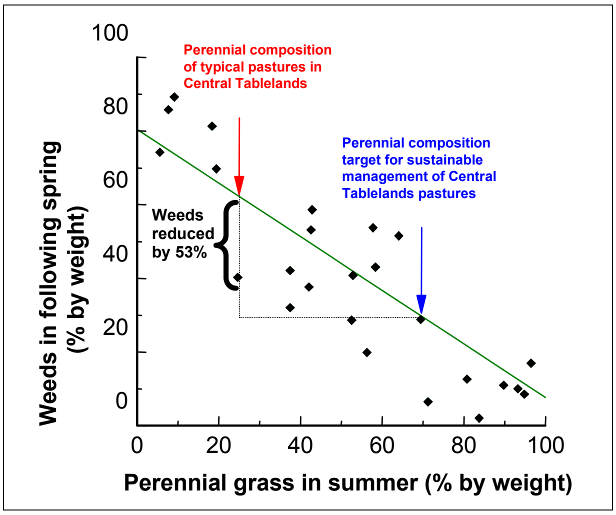


Figure 4. Relationship between perennial grass present in summer and the amount of weed present in the pasture in the following spring measured at the Carcoar site.

weaning on all pasture types (provided that the stocking rate was adjusted accordingly), rarely could they be finished to market specification. It was shown, however, that the use of a specialist forage crop (chicory in this instance) was ideal to finish lambs earlier and to export specification. Planting such forages in locations that recognise the landscape's potential is more likely to result in greater forage growth and water use. Alternatively, the lambs could be sold as stores or finished in feedlots.

Fertiliser application (mainly superphosphate) is another management tool that can be used to increase the content of perennial grasses. This approach is particularly effective where the pasture already has a high proportion of productive, competitive species, such as phalaris, cocksfoot (*Dactylis glomerata*), tall fescue (*Festuca arundinacea*), or perennial ryegrass (*Lolium perenne*).

However, results from Carcoar show that fertiliser can have negative impacts where the composition is suboptimal in terms of perennial grasses and includes a prominent annual grass component. Since superphosphate is usually applied in autumn, annual grasses, not perennials, are the main beneficiaries of the improved nutrition. This response of annual grasses is shown in Figure 5 in the comparison between unfertilised and fertilised continuously grazed naturalised pasture. In contrast, where tactical management was imposed, the increase in perennial grasses resulting from the summer rest meant that the perennial grasses were also able to benefit from the fertiliser addition.

This highlights the importance of carefully assessing pasture composition before fertiliser application. If the perennial content is low, a tactical rest should be imposed over summer to increase the perennial grass content *before* applying the fertiliser in the following autumn.

These grazing strategies enable producers to take more control of their environment. While these

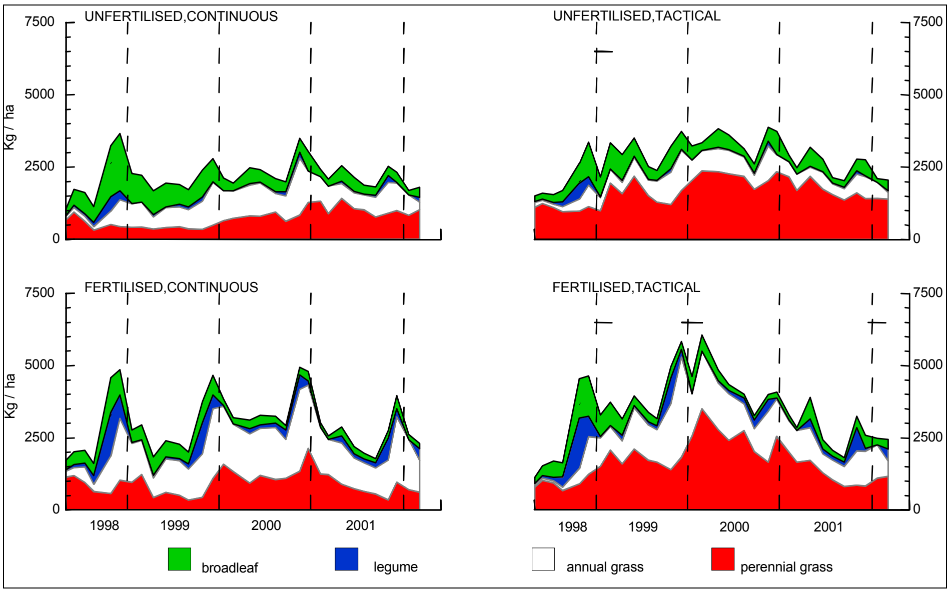


Figure 5. Effect of superphosphate application (unfertilised, fertilised) and grazing management (continuous, tactical) on availability (kg DM/ha) of broadleaf, legume, perennial grass, and annual grass components in a naturalised pasture at the Carcoar site.

management tools do not solve all the problems out there in the paddock, they empower producers to meet realistic goals by implementing relatively simple practices. With empowerment comes the confidence that the producer can make a real difference in managing environmental problems that extend well beyond the farm boundary, but at the same time provide sustainable practices within the paddock.

Managing for perenniality must be the focus of all future farming systems in temperate Australia.

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