A Comparison of the 'Sustainability' of Three Grazed Perennial Pastures

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Abstract

Long-term grazing of pastures, sown in 1966 to phalaris (*Phalaris aquatica*) and white clover (*Trifolium repens*), resulted in three mature plant communities with the same fertilizer history but different botanical compositions. One pasture was dominated by phalaris and had been re-sown with white clover (phalaris/white clover); a second was dominated by phalaris but white clover had been lost (phalaris); and a third was dominated by volunteer naturalised pasture with low levels of phalaris and white clover (degraded). Duplicate paddocks of each of these three pastures were grazed continuously with sheep over four years from 1994 to 1997 whilst assessments were made of sustainability characteristics of the systems represented. Measurements made of hydrology, nitrogen cycling, botanical composition and animal production showed that the presence of adequate phalaris and white clover resulted in an improvement of the soil and pasture resources, which in turn resulted in greater animal production and gross revenue without apparent environmental damage.

Keywords

Nitrogen leaching, run-off, hydrology, perennial grasses, white clover, sustainability matrix

Introduction

The literature contains many definitions of 'sustainability' (e.g. 4). These definitions include concepts of inter-generational transfer of resources, systems which allow current production without compromising future productivity, and definitions which include economic interactions (e.g. 3) and/or ecological sustainability (e.g. 5). Because of this complexity it is not possible for a single measure to adequately represent this multi-faceted attribute of agricultural and natural systems. Sustainability is essentially a social construct (1), and perceptions vary as to the timeframes over which it needs to be demonstrated. Thus, some farmers focus on short-term profitability and financial viability whilst others in the community concerned with nature conservation may see sustainability as having no economic component and only being relevant when measured over periods of many decades (2).

This paper reports measurements of 'sustainability' which have been made over recent years within a large national experimental program (the Temperate Pastures Sustainability Key Program organised by the Meat Research Corporation). The aim was to measure the sustainability of managed ecosystems such as those found in grazed pastures. We have attempted to quantify a wide range of characteristics using a sustainability matrix to compare major components of sustainability of three grazed pasture systems.

The matrix attempts to take into account measurements of both the resource and of the products from that resource. Because grazing enterprise profit depends firstly on animal productivity and indirectly on the plant and soil layers, factors from each of these sustainability layers were included in the measurements. Soil hydrology measurements reflect the pasture's ability to utilise water to support growth as well as to maximise infiltration and minimise run-off. Soil mineral nitrogen status in the topsoil reflects the capacity of the soil to support pasture growth whilst nitrogen at depth indicates potential for loss of nitrogen through leaching and subsequent soil acidification. Changes in botanical composition can be related to increases in vegetable fault due to weed ingress and adverse effects on stock carrying

capacity may occur if the nutrient responsive grass component declines. These changes in stored soil moisture, nutrient status and botanical composition are linked to the animal production derived from the land in the short term, but they are also indicators of future productivity and thus are important components of sustainability.

Materials and Methods

This grazing experiment was conducted from January 1994 to December 1997 at the CSIRO Pastoral Research Laboratory, Chiswick, 17 km south of Armidale NSW on a predominantly grey brown podzolic soil. The pastures were based upon a phalaris (Phalaris aquatica cv. Australian) dominant pasture sown originally with white clover in 1966 but which had since lost its white clover component. One of the pasture types included in the study (termed 'degraded') had been subjected to high stocking rates in the 1970s and 1980s and as a result had a low phalaris content. At the commencement of this experiment in 1994 this pasture was dominated by Eleusine tristachya and Danthonia spp. The second pasture ('phalaris') consisted of a phalaris dominant pasture with little legume content. The third pasture ('phalaris/white clover') had been phalaris dominant but white clover was re-sown by direct drilling in 1994 to re-introduce a source of nitrogen. Thus the pastures varied in their capacity to act as either a source and/or a sink of nitrogen.

The paddocks were stocked continuously with weaner sheep which were replaced each year in December. The stocking rate was varied according to the availability of herbage and sheep liveweight.

Measurements were made at regular intervals and included soil hydrology (soil moisture and run-off), nutrient movement, pasture botanical composition, animal intake, animal liveweight and wool growth. The analysis presented in this paper is restricted to several key measurements which contribute to sustainability, namely:

- **Soil** - the ability of the soil to convert rainfall into stored soil moisture and reduce run-off whilst minimising drainage below the root profile;
- **Pasture** - the degree of dominance of the nutrient-responsive perennial grass, phalaris, and of the legume, white clover, compared to the changes in other grasses and broadleaf weeds;
- **Animal production** - liveweight gain and wool production; and
- **Economic** - gross revenue.

Results and Discussion

The changes in botanical composition, as estimated by Botanal, are shown in Figure 1. Whilst the degraded pasture showed a major increase in other grasses and broadleaf weeds, it also showed some increase in clover content and, to a lesser degree, phalaris content. In contrast the phalaris treatment showed a major decline in phalaris and an increase in the other three components. The phalaris/white clover treatment showed a decline in phalaris (the herbage mass on offer declined but the basal cover remained high - data not shown) and broadleaf weeds, a modest increase in other grasses and a major increase in the clover component. These changes resulted in marked differences in animal production (see Table 1) due to the high availability of digestible green leaf in the phalaris/white clover treatment. Favourable seasons during the summers of 1995/96 and 1996/97 certainly contributed to the size of the differences. Nevertheless, even in the dry summer of 1997/98, botanical composition and animal production differences remained large. The phalaris/white clover treatment also suffered from less invasion by low productivity species and the phalaris component was more resilient than in the phalaris treatment, presumably due to the greater vigour promoted by the markedly increased nitrogen cycling.

The sustainability matrix (Table 1) shows a summary of some key parameters relating to the soil, animal production and economic layers of these grazed pasture systems. The soil hydrology data show that the phalaris/white clover treatment was able to extract more water during a dry autumn period leaving more capacity for the soil to store water from any subsequent rainfall. The run-off following a major rainfall event was lowest on the degraded and phalaris/white clover treatments due to their greater ground cover than that of the phalaris treatment. Also, water extraction from deep in the profile was greater from those

pastures having a high phalaris content (data not shown) thus resulting in the potential for less deep drainage.

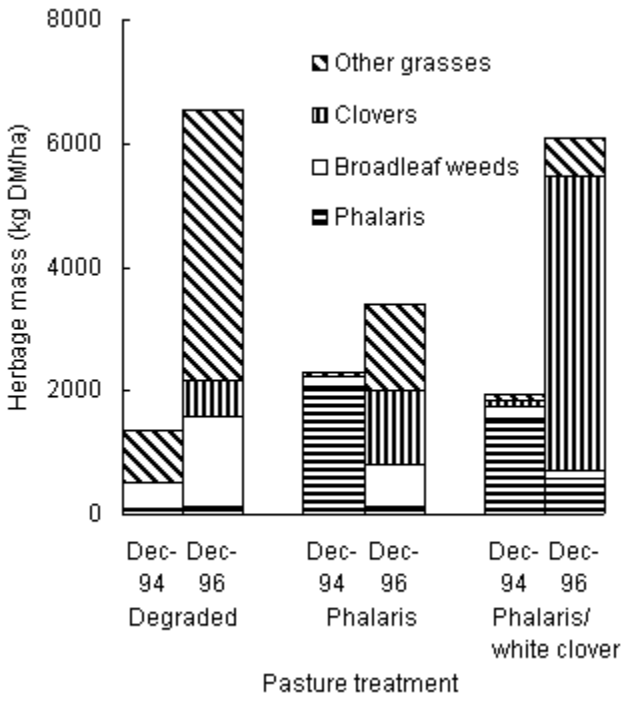

Figure 1. Changes in botanical composition of degraded, phalaris and phalaris/white clover pastures between December 1994 and December 1996.

Table 1. Matrix of sustainability showing a range of measures of sustainability (mean of two replicates) for degraded, phalaris and phalaris/white clover pastures grazed with weaner sheep from 1994 to 1997.

Sustainability layer	Attribute	Units	Degraded	Phalaris	Phalaris/ white clover
Soil:	Water extracted in 4 week drought in autumn	mm	28.0	38.0	51.0
?	Run-off following a 106 mm rainfall event	mm	3.0	24.0	0.0
?	Mineral N (0-5 cm) at Feb-97	µ g N/g soil	13.5	13.0	29.0
?	Mineral N (40-60 cm) at Feb-97	µ g N/g soil	1.6	3.1	1.4

Animal:	Wool growth	kg/hd/yr	3.0	3.4	4.6
?	Liveweight gain	kg/hd/yr	5.5	10.0	15.0
Production and income in 1996:	Stocking rate	dse/ha	9.9	14.0	14.8
?	Liveweight gain/ha	kg/ha/yr	54.5	140.0	222.0
?	Wool produced/ha	kg/ha/yr	29.7	47.6	68.1
?	Gross return/ha (@$1.00/kg LW and $6.00/kg wool)	$/ha/yr	$232.70	$425.60	$630.50

The mineral nitrogen concentration of the surface layer of the soil in February 1997 in the phalaris/white clover treatment was more than twice that of the other treatments. In spite of this, the levels of mineral nitrogen at depth were similar and low indicating a low potential for leaching of nitrogen below the root zone in all treatments; this was associated with the ammonium domination of mineral nitrogen in the soil profile.

Wool growth and liveweight gain per animal were greater in the phalaris and phalaris/white clover treatments in spite of these two treatments carrying substantially more stock. This was related to the higher amounts of digestible green leaf on offer in these two treatments. Animal production per hectare was substantially higher in the treatments containing high levels of phalaris and especially where the clover content was high. Liveweight gain per hectare in the phalaris/white clover treatment was far greater than in the phalaris treatment due largely to the greater sensitivity of meat production to clover content in the diet than that of wool production.

Gross economic return from the phalaris pasture was 1.8 times that of the degraded pasture, largely due to the higher stocking rate supported by that pasture. Economic return from the phalaris/white clover pasture was 2.7 times that of the degraded treatment.

When considered over all of the sustainability layers measured, the data reinforce those of Lambert et. al. (1) who showed that the presence of nutrient-responsive grasses was a key to sustainability. However, in the phalaris treatment, any superiority would be short-lived as the phalaris content of that pasture declined rapidly when continuously stocked at these relatively high stocking rates. When the phalaris was augmented by a functional white clover component, overall productivity rose substantially as did the vigour of the companion phalaris thus leading to a more resilient botanical composition at the end of the experimental period. By maintaining a vigorous phalaris/white clover pasture it is possible to capture substantial benefits of the companion clover, minimise nutrient losses due to leaching and maximise the efficiency of rain on that area of land upon which it falls by minimising run-off and deep drainage.

With grazing and fertilizer management, together with the occasional resowing of white clover (if required due to loss of white clover from the pasture after poor seasons), it should be feasible to maintain a perennial grass based pasture such as phalaris/white clover indefinitely into the future. Compared to the other two pastures in this study, a phalaris/white clover pasture has the potential to reduce off-site negative effects due to run-off of water, nutrients or sediment and leaching of nutrients into the water table. Further, by enabling a grazier to support higher stocking rates and individual animal performance, long-term financial viability will be enhanced by such pastures. Providing sufficient cash returns is essential if graziers are to afford inputs needed to balance outputs taken from the land supporting a

productive system. The greater meat and wool production will also assist in increasing a grazier's diversification which can be an important means of insuring against low prices in any one commodity.

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