A REVIEW OF SUSTAINABLE PASTURE PRODUCTION ISSUES IN TEMPERATE NATIVE AND IMPROVED PASTURES


^A^ NSW Agriculture, Tamworth Centre for Crop Improvement, Tamworth, NSW 2340
^B^ Division of Agronomy and Soil Science, University of New England, Armidale, NSW 2351
^C^ CSIRO Division of Animal Production, Chiswick, Armidale, NSW 2350

SUMMARY
Increasingly, graziers are being confronted by production, economic, climatic, land degradation and environmental issues. Despite increased community concerns, graziers need to be both profitable and viable. To more fully understand the processes that interact in a pasture system (soil-plants-animals-$), an ecosystem approach is used to give soil organisms and grazing animals comparable attention. Traditionally, most management decisions are concerned with monitoring or supporting the animal production component of the system, with little regard for soil organisms. Importantly, there are as yet few cost penalties associated with degrading the system; animal degradation as evidenced by lower prices for poorly finished livestock is the only short-term penalty. The role of native and improved pastures in livestock production, and issues such as fertiliser use and grazing management strategies are discussed. The need for graziers to develop good pasture and soil health assessment skills is highlighted. Practical guidelines for managing pastures in drought and for paddock assessment of the productivity and sustainability of a pasture are also given.

Keywords: native pastures, improved pastures, grazing management, ecology, economics

INTRODUCTION
Graziers terms of trade are declining (eg McWilliam 1993) and, with low beef and wool prices, it is increasingly difficult for producers to achieve adequate cash flows and returns on their capital investment. Coupled with this, there is an increasing community expectation for graziers to adopt agricultural practices that are ecologically sustainable. The political response to these expectations has seen the introduction of often unpopular and cumbersome legislative restrictions on agricultural practices (eg State Environment Planning Policy No. 46 in New South Wales). However, against a backdrop of a cost-price squeeze and severe droughts in the 1980s and 1990s, producers have accepted the challenge as evidenced by their participation in Landcare groups across Australia (Campbell 1994). For most producers the reality is that, in order to operate in an ecologically sustainable way, they also need to be both profitable and viable.

Current and past grazing management practices of overgrazing (particularly in droughts) and the decline of trees in some environments has lead to ecosystems that are dysfunctional. In New South Wales alone, over 70% of the land has been adversely affected by erosion, acidification, salinisation and woody weed invasion (Reed 1990). One consequence of land degradation is pasture decline; Wheeler (1986) reported a 47% reduction in carrying capacity of grazing lands from 1970 to 1984, and there is no reason to believe that this decline has stopped. In many areas, surveys (eg Kemp and Dowling 1991; Schroder et al. 1992; Quigley et al. 1992; Bowcher and Virgona 1997) have reported a declining or low perennial grass component in sown pastures. It appears that this decline may have commenced around the time of the removal of the superphosphate bounty in 1974 (Crofts 1997). One approach to arresting this decline has been the Grassland Productivity Project in Victoria (Saul et al. 1993; de Fegely 1997) which aims to increase short-term profitability by increasing rates of fertiliser application.

The consequences of land degradation include loss of biodiversity (eg Recher 1992), increasing soil acidity (Helyar 1991; Blair 1992), increasing soil salinity (Dyson 1992; Clifton et al. 1996) and soil erosion by the action of wind (in marginal semi-arid environments) and water (particularly where high intensity summer rainfall is prevalent). All of these processes interact and have both on- and off-site effects. On-site, these processes affect soil health, which in turn affects sustainable biological productivity, plant and animal health and environmental quality (Pankhurst et al. 1995). Importantly, while the clinical symptoms of land degradation are readily evident (eg declining soil pH, rising water tables, erosion gullies) and are receiving most of
the attention, there are also a large number of problem soils with sub-clinical symptoms of poor soil health (eg surface sealing, low nutrient status, low organic matter, poor water holding capacity). Most available soil nutrients, organic matter and root biomass are in the top (0 to 10 cm) soil layer. Similarly, most of the soil biota (King 1997) are also in the top 10 cm of soil and microbial activity decreases as soil acidity increases (Wardle 1992). For areas such as the North West Slopes of New South Wales, at a typical level of around 40% ground cover, annual soil losses of approximately 4.5 mm (45 tonnes/ha) are predicted (Lang 1979), and this has serious consequences for soil structure, organic matter, nutrients and biota. Off-site effects of such soil losses are decreased water quality (turbidity, nutrient enrichment and subsequent algal blooms) and siltation of streams and water supplies. Increased community concern over these issues, as expressed for example in the Namoi Regional Catchment Statement 1996, has lead to recent changes in the water use policy in New South Wales.

PASTURES AS PART OF AN ECOSYSTEM - ENERGY FLOWS AND ECONOMICS

A pastoral system is part of a complex and dynamic ecosystem. The problems that face graziers and their probable solutions take on a different perspective when considered from an ecosystem viewpoint rather than considering the individual components. Traditionally, in these systems, graziers have focussed on the grazing animal and its production (Kemp 1994). This has resulted in most graziers having good livestock husbandry skills, but poorly developed pasture and soil health assessment skills. This concentration on animal production to the exclusion of other parts of the ecosystem has been fostered by economics and to some extent by research. Graziers only pay a direct monetary penalty for degrading the animal component of the system, not the plant and soil components. Reviews of grazing management studies in the 1960s and 1970s (Heady 1961; Wheeler 1962; Myers 1972) concluded that, for animal production, there was little or no benefit of using rotational grazing. These studies, however made no mention of the degrading effects of continuous grazing on the plant and animal resource base. Hutchinson (1992), summarised the current situation, suggesting that a policy of continuous grazing to maximise short-term animal production has led to systems that excel at low production costs and efficient management of ruminant livestock, but neglect the regenerative needs of plants, which are often grazed year round. One paradox of grazing is that animals need to be able to maintain daily intake, while their food source (plants) generally need to have periods of rest to replenish reserves, flower and produce seeds. Another is that pasture plants produce more quality and quantity of digestible nutrients when grazed moderately.

The simplified model of Scott et al. (1992), with three ecological layers of soil (and soil biota), pastures (including browse and trees), grazing animals, and an economic layer ($) provides a useful, approach for considering the interaction of these components. Three things become apparent from this simplified model. Firstly, the animal component of the system, which most graziers closely monitor and support (eg dietary supplementation and disease control), is the last and least likely component of the system to suffer long-term degradation. By the time animal production declines on any land unit there have already been losses in plant and soil reserves. Secondly, animal degradation as poorly finished livestock is the only direct short-term price penalty in the system. Up till now, little cost has been attached to the loss of other resources, measured as the cost of restoration or rehabilitation on or off the farm. Thirdly, in terms of the time needed to rehabilitate parts of the system, animal losses are the easiest to fix, then sown pastures, followed by native pasture degradation and tree loss, and finally soil degradation. New animals can be readily purchased and pastures and forage sources re-established in a matter of months. Native pastures and trees can be regenerated over years and decades, but the time-scale for soil replacement by weathering is hundreds to thousands of years. From an ecosystem perspective soil should be considered as a non-renewable resource and the most fundamental component of the system that needs to be protected (Scott and Lovett 1997). The only part of the soil renewal process that may be manipulated in a relatively short time-frame is the accumulation of litter and its breakdown to soil organic matter. Litter acts as both a food supply and a living space for decomposer organisms (King 1997), as well as providing a soil surface mulch that moderates surface soil temperatures and reduces evaporation of soil moisture. Litter and dung are also the main sources of organic residues for soil carbon. The quality of litter and dung fragments entering the soil determines the quality of soil organic matter and is the source of nutrients available for recycling through decomposer activity.

An ecosystem focus on management can be gained by considering the biomass and energy requirements of the simplified ecosystem. Research on the Northern Tablelands of New South Wales showed that, for a phalaris-white clover (Phalaris aquatica - Trifolium repens) pasture grazed at 20 dry sheep equivalents (dse)/
ha, the microbial biomass was equivalent to the mass of 88 sheep/ha (King 1977). In terms of total biomass, the microbial contribution was 17%, compared with only 3.4% for the sheep. Microbial respiration accounted for 73% of the total annual energy expenditure; the sheep flock used 23% (Hutchinson and King 1982). From an ecosystem perspective, managing a pasture for animal production and basing many of the management decisions solely on those animals, makes little sense, since they are not the major components of the system. However, for managers of animal production systems, it makes good sense (at least in the short-term) to manage the herbivores at the expense of others since they generate the income, and there is no immediate price penalty for degrading the resource.

Similarly, a more ecosystem-orientated approach rather than a short-term animal production focus may have highlighted, for example, the basic chemical processes inherent in soil acidification that result from the long-term use of superphosphate and subterranean clover. It can be argued that the historically high profits from this production system should be offset against the long-term costs of land degradation, lost production and the cost of lime applications as a soil ameliorant. If this were done, would such a production system really be profitable? The misleading conclusion about the validity of continuous grazing at high stocking rates as a sustainable production system, may well be repeated if we do not value the cost of land degradation in the cost of production when assessing the economic benefits of exploitative agricultural practices. Scott et al. (1992) suggested that currently farm management decisions are mainly based on financial criteria. Decisions are therefore dominated by short-term financial profit considerations, without regard for the costs and consequences of degradative processes. These costs are likely to be high. Hall and Hyberg (1991), for example, reported farmer estimates of $10,000/farm/year for land degradation in temperate grazing lands.

THE ROLE OF NATIVE AND SOWN PASTURES

There are approximately 30 million hectares of native grasslands in the temperate, higher rainfall areas of Australia (Young et al. 1986). Only 6% of Australia’s grazing lands have been improved with fertiliser and exotic plants (Hutchinson 1992) and these pastures support 41% of the grazing ruminants, and a high proportion of the meat producing livestock. Approximately 80% of Australia’s sown pastures have been established in temperate areas, from the 1920s until their peak in the 1970s. These pastures are predominantly legume based, with the dominant species sown being subterranean clover (Trifolium subterraneum), white clover, lucerne (Medicago sativa) and barrel medic (Medicago truncatula). Introduced perennial grasses, such as phalaris, ryegrass (Lolium perenne), cocksfoot (Dactylis glomerata) and tall fescue (Fescue arundinacea) can be major contributors to the production of the 14 million hectares of sown pastures in the higher rainfall, temperate regions (Hutchinson 1992).

Traditionally, the approach to native pasture management and improvement has been overshadowed by a species replacement philosophy (Whalley 1970). This philosophy was encapsulated in the statements of Donald (1970) that ‘all the evidence indicates that our native plants have neither actual or potential value as artificially sown species’ and that ‘they are incapable of high production, of responses to high levels of fertility’. While these generalisations are true for many native grasses, two main factors have led to a questioning of the validity of this broad statement. Firstly, the replacement philosophy assumes that the level of land capability can be permanently raised by the use of sown species, fertiliser and herbicides. Increasing costs, declining prices, droughts and the failure of sown species to persist even in the more favourable environments (eg Kemp and Dowling 1991; Schroder et al. 1992) have raised some doubts about the long-term effectiveness of this strategy, particularly for graziers in marginal environments. Secondly, many graziers (eg Fleming 1986; Crofts 1989; Wyndham and Wyndham 1992; Dalglish 1993) have reported long-term (up to 30 years) stocking rates of 8 to 15 dse/ha on native grass-based pastures with minimal inputs of legume, superphosphate and manipulating seasonal grazing pressure.

We need to recognise and understand that both native and sown pastures may have particular management requirements and limitations to their usefulness. Many summer-growing, frost susceptible native perennial grasses have low green leaf production in winter and early spring (Lodge and Whalley 1983), limiting their grazing value at a time when green forage is required. In wetter years, when temperature is not limiting these grasses produce large amounts of material, which is of low forage value when frosted. More needs to be known about the role of supplements in utilising such forage sources for maintenance of stock or for taking the pressure off other pasture resources at strategic times of the year. Other species may be susceptible to competition from clover (eg Davies et al. 1934) or, with overgrazing, are replaced by annual grasses (Moore 1970; Lodge and Whalley 1989). The benefits of existing native pastures are that they are adapted to
droughts, they do not need to be established and in some areas they provide a substantial proportion of the on-farm forage resource. Particular native perennial grasses may also have potential for use in the restoration of lands degraded by cropping, erosion, acidification and salinisation (Lodge 1994).

Sown pastures are often perceived by graziers as having a high risk of establishment failure in many environments and are costly to establish and maintain. These perceptions may have contributed to resowing rates of introduced species of less than 2%, even in more favoured areas (Quigley et al. 1992). Lees and Reeve (1995), in a survey of graziers in the high rainfall (>600 mm) temperate pasture zone of south-east Australia, found that, on average, 82% of respondents indicated that pastures weakened and disappeared within 10 years of sowing. Gross margin budgets (eg Vere et al. 1997) showed that for sown pastures the time required for returns to exceed costs was a minimum of 3 to 4 years in most environments. However, these figures were calculated on high stocking rates (up to 15 dse/ha) being achieved and maintained throughout the life of the pasture. In reality, either poor establishment, droughts, overgrazing or weed invasion make achieving these stocking rates difficult, particularly in more marginal environments. The benefit of sown pastures is that they have the potential to produce substantial quantities of high quality green leaf, supporting high rates of stocking and animal growth. Increasingly, producers are becoming aware that the profitability of these pastures is linked to their persistence (Scott 1995; Scott et al. 1998); the longer a pasture persists and is productive the more likely it is to be profitable.

The major factor limiting animal production is the quantity of green leaf available to the grazing animal (Willoughby 1959). Some short term-studies, comparing native and sown perennial grasses (eg Simpson 1994; Jones 1996) concluded that they have similar potential for livestock production based on forage quality (crude protein, digestibility, metabolisable energy). Few studies (eg Lodge and Whalley 1985; Robinson and Archer 1988) take into account differences in the amount of green material (not total forage) when comparing species and species groups. It is only when the availability of green forage and, in particular, green leaf does not restrict intake that differences in quality will have a major influence on animal production. It is also difficult to attribute animal performance to particular components of pastures with a complex botanical composition.

Increasingly, low input native perennial grass-based pastures and the use of trees in the landscape are being proposed as solutions to the problems of land degradation (eg dryland salinity and recharge), particularly by conservation groups. While there are several native grass domestication programs in Australia (Lodge 1996a), few species are available in commercial quantities and some species will not be suitable for some environments. The widespread encouragement of producers to harvest and sow their own native grass seed may also have limited success, since seed quality will be variable (Loch et al. 1996) and many grasses have specific germination (eg Hagon 1976; Lodge and Whalley 1981) and establishment requirements (Hagon and Groves 1977; Lodge 1981; Lodge and Schipp 1993). The comparative role and economics of planting trees versus deep rooted perennials such as lucerne also needs to be carefully considered. A recent report to the Murray Darling Basin Commission suggested that to reduce saline base flow, one third to one half of the Basin upland areas would need to have the minimal recharge associated with treed landscapes. In central Victoria (Heislers and Reid 1996), southern (McKellar 1996) and northern (R. Young, pers. comm.) New South Wales, lucerne has been shown to dry the soil profile to depths of 3-6 m, and so may have a more practical role than trees in preventing recharge in some cropping and pasture situations.

The corollary to an increased interest in native pastures and trees by conservation groups is that many traditional agricultural practices, such as fertiliser and herbicide use are considered as undesirable. This view may not be justified. In a recent review, King (1997) reported that in general soil microbes are tolerant to herbicides commonly used in pastures and that fertilised improved pastures produce high quality organic matter in the form of both plant litter and dung (King 1993). Recent studies (King 1997) clearly show the benefits of fertiliser application on microbial activity with biomass increasing by 78% and 60% at two sites, compared with unfertilised soils. It may well be that in low litter and organic matter situations, which occur in many native pastures, fertiliser application may be required to stimulate microbial activity by promoting legume growth and providing high quality litter as well as nutrients to increase microbial biomass.

GATHERING THE REQUIRED SKILLS

Until recently the primary focus on pasture management has been on single issue topics such as selection of species, establishment, fertiliser application, weed control, fodder conservation etc. Often this has meant that graziers were not guided sufficiently towards obtaining and developing skills for monitoring soil condi-
tion or assessing pasture and so gaining an integrated understanding of the relationship between pasture quantity and quality, animal requirements and production. Increasingly, through courses such as Prograze (Bell and Allan 1998) graziers are learning the skills required for them to assess the productive capability and sustainability of their grazing systems. The challenge for researchers and advisers is to develop simple, ‘feet-in-the-paddock’ rules so that graziers can easily assess where a pasture is on the production/sustainability scale and whether or not some remedial action is required.

For assessing economic sustainability, Scott et al. (1998) have developed an easy-to-use computerised spreadsheet model that allows graziers to input their own figures for establishment, production costs and prices and projected stocking rates. Allowance can be made for establishment failure and the need to resow, or the pasture failing after establishment and being grazed at a lower stocking rate or requiring resowing. Inputs such as stock purchase, fertiliser rates, herbicide application, use of supplements and stocking rate can be varied in any one year. Cash flow budgets over a 15 year period allow the pasture improvement scenario to be compared with an unimproved or existing pasture. From these figures graziers can assess the likely impact of any proposed pasture development on their cash flow. Such tools are an essential prerequisite to convincing graziers of the economic benefits from adopting stocking rates and grazing strategies which can provide long-term persistence of sown pastures. For assessing profitability of both production and sustainability timeframes of 10-15 years are essential (Scott and Lovett 1997), since the long-term cost of producing pasture feed declines markedly if pastures can be managed to persist beyond three years (Scott 1995). Importantly, this point is often overlooked when many short-term studies, with valid results and conclusions are extrapolated to the longer term.

As graziers become more skilled in pasture management and models or “tools” such as those above become commonly used, then our use of terminology needs to be more precise. For example, the terms “stocking rate” and “carrying capacity” are often interchanged by graziers, advisers and researchers, but they have two quite distinct meanings. Stocking rate is the number of animals on a unit of land and is a management decision. By contrast, carrying capacity is the inherent productivity of the land: it is influenced by weather, soil type, topography, aspect, tree cover, pasture composition (or its successional level or transitional state) and the management imposed including choice of enterprises. It is only when stocking rate exceeds carrying capacity for significant periods that pasture degradation is likely to occur as a result of overgrazing (Lodge 1995). Long-term studies of native pastures on the North West Slopes of New South Wales (Lodge and Roberts 1979; Lodge and Whalley 1985; Lodge et al. 1998) clearly indicate that the carrying capacity of these pastures grazed by merino wethers is 5 sheep/ha, 40% higher than the average stocking rate of 3 dse/ha (Lodge et al. 1991). This has implications when comparing pasture development budgets. Assessment of the economic viability of using fertiliser and legumes to increase stocking rate from 3 to 8 sheep/ha, has a markedly different interpretation if the pasture was initially understocked and the real rise in stocking rate is only from 5 to 8 sheep/ha. While climatic variability and aversion to risk may prevent some producers from increasing their stocking rates to those that are biologically feasible, the economic consequences of these decisions needs to be acknowledged.

MEETING THE CHALLENGE - GRAZING MANAGEMENT

The role of grazing management in meeting the challenge of halting the decline in pasture production and improving the persistence of perennial grass-based pastures has been discussed previously (Lodge and Whalley 1989; Hutchinson 1992; Hutchinson 1993, Kemp 1993; Kemp 1994; Lodge 1995). Surprisingly, until recently little was documented about the grazing management requirements of many of native and sown perennial grasses used by Australian producers. Grazing guidelines based on strategic seasonal resting and grazing of pasture have the potential to significantly increase plant persistence and stand life, thereby maintaining production for longer periods and so avoiding costly resowing. Determining these guidelines was the focus of experimental studies in the Temperate Pasture Sustainability Key Program (Lodge 1996b), which was conducted at 22 sites throughout the high rainfall temperate pasture zone of south-eastern Australia. Importantly, these experiments were the first series of coordinated studies which conclusively demonstrated, over a range of environments, that strategic grazing could markedly affect the persistence of perennial grasses. From these studies preliminary, practical guidelines for strategies leading to increased persistence, which producers can readily implement have been prepared (FitzGerald and Lodge 1997) for phalaris, fescue, perennial ryegrass, cocksfoot and some native grasses. Other guidelines are available for specific management strategies, such as wiregrass (Aristida ramosa) control (Lodge and Whalley 1985; Dadd et al. 1989; Lodge et al. 1997).
However, grazing management on its own does not supply all of the answers and so it should be used in conjunction with other appropriate management inputs, such as choice of species, fertiliser strategy, weed control, and fodder conservation (Scott 1996). In the Victorian Grassland Productivity Project, de Fegely (1997) reported that although the responses to superphosphate had been dramatic there was a need to consider using grazing management strategies to maintain the perennial grass component of the pasture.

The role of pasture fertilisers

Fertiliser is one of the most expensive on-farm inputs and the cost-effectiveness of plant nutrients and their retention on-farm are major issues, both for the producer and for a community concerned about water quality in rivers. Farmers appear divided on the question of pasture fertiliser use. A small sector remains unnecessarily concerned about use of acidulated fertilisers, which they equate with adding damaging ‘acid’ to the soil. However, the majority of producers recognise the value of traditional superphosphate or new high analysis fertilisers, which can also provide a choice of elemental ratios and release rates. Given continuing low commodity prices, these producers are more likely to ask ‘How long can I afford to leave fertiliser off without losing production and risking decline in my pastures?’ A third group could be attracted to a high fertiliser input strategy, with the benefits demonstrated by Wolfe and Lazenby (1973) for newly established pastures later extended to mature sown pastures; such systems can be productive (Saul and Cayley 1992), where the liveweight of spring-lambing ewes increased linearly with fertiliser phosphorus applied up to 32.1 kg P/ha.year, at a stocking rate of 22.5 ewes/ha. However, the benefits from this approach must be evaluated for risk, including factors such as low commodity prices, rainfall variability and differences in the capability of the land and pasture resource to respond to fertiliser and to retain high levels of nutrient input.

There are useful and generally accepted methods for evaluating fertiliser status on-farm. Soil testing for available nutrients is still widely used for paddock scale assessments. Development of the colour coded SatMap technology (Taylor 1997), based on remote sensing research by Peter Vickery and his colleagues at CSIRO Armidale, provides a useful and cost-effective starting point for assessing fertiliser priorities at the farm scale. Finally, testing based on response of pasture strips to a range of fertiliser applications, provides a reliable and under-used method which can be largely under the farmer’s control.

Knowledge of the dissolution rates of fertiliser nutrients, their reactions with soil, uptake by biota, redistribution by grazing animals, biological recycling and overall retention are understood sufficiently well to enable the development of computer models to aid fertiliser decisions. A series of models has been developed starting with the simple, three-parameter ‘Decide’ model for predicting superphosphate response (Bowden and Bennett 1974), which gave way to process-based, single element models such as ‘Pmod’ (Blair et al. 1976), and currently to the incorporation of multi-element models into whole farm management packages. However, there remain important research areas that need to be addressed. They include the following:

- quantifying the inter-relationships between strategic fertiliser use and changes in the presence, composition and response of plants and soil biota;
- seeking an understanding of the pervasive influence of a legume-based nitrogen economy on soils, plants and animals, and
- measuring the effects of rainfall events, surface cover, soil profile and topography on nutrient transfers and losses.

While current models represent a substantial technical achievement, their low levels of use by the farming community suggests that they may need to be modified to make them more acceptable. Mills (1991) assessed the nature of the communication gap between computer software developers and farmers, by contrasting the programmers delight in mathematical puzzle, measure and method with the farmers intuitive and heuristic approach to solving problems. There may be at least one further generational gap before farmers widely accept solutions based on mechanistic computer models. Until then there is probably a strong case for using models in the background as a means rather than an end to produce different scenarios and outcomes. Another possibility is the establishment of mutually agreed decision rules involving farmer input at every stage. Such rules can be computerised at a later stage using ‘expert system’ shells (eg Lodge and Frecker 1990) or simple spreadsheet models (eg Scott et al. 1998).
Grazing strategies

Lodge (1995) devised a series of rules for graziers to assess whether or not grazing management should be used to manipulate species composition and so improve long-term animal production. Unfortunately, there is no single grazing management system that can be applied in all environments and to different species to achieve the same result. While there are general benefits of resting pastures, grazing strategies need to be applied on a seasonal basis so that they have a relationship to plant phenology. For example, resting in spring to allow stem elongation, flowering and an increase in carbohydrate reserves; resting in autumn after rain to allow for tiller development from basal buds. While grazing systems such as time control grazing (TCG), eg McCosker (1993; 1994) and holistic resource management (HRM), eg Savory (1988) take an ecosystem type approach, they rely solely on the grazing method to affect changes in plant succession and water, nutrient and carbon cycling. However, any grazing method potentially restricts the dietary choice or intake of grazing animals and any benefits of using these systems must more than compensate for the likely loss of individual animal performance.

The principles and practices of both TCG and HRM have been widely debated (Jones 1993; Hacker 1993; Hutchinson 1993; Lodge 1995). These grazing methods are ‘hybrids’ of both forage budgeting and fodder conservation systems and those designed to implement change in species composition by matching grazing and resting periods to species phenology (Lodge 1983). The major benefit of both methods is claimed to be in increasing stock density to achieve a ‘herd effect’ of hoof action on the soil surface to assist litter breakdown and form favourable micro-environments for seedling establishment. The risk is that increasing stock numbers to levels sufficient to achieve this effect within a confined time period (generally from less than 1 and up to 3 days), will result in a lowering of intake (Willoughby 1959). Restricting intake, particularly of green forage will reduce individual animal performance and is probably one of the reasons that Waugh (1997) reported declining animal performance with TCG.

In periods of drought and feed shortage, there could well be some advantage in having large numbers of small paddocks to forward plan feed availability and clearly see how much feed there is in reserve. However, with adverse environmental conditions it should be remembered that much of the available feed will be of low quality and so may require the use of supplements to maintain or increase liveweight.

Much has been made of the supposed effects of both TCG and HRM grazing methods on plant succession and species composition. The reality is that compared with continuous grazing, any rest is beneficial to plants. Many of the claimed anecdotal changes in species composition in the short-term (less than 1 year) merely reflect these benefits for existing plants, rather than the recruitment of new plants. The process of plant recruitment in both native (eg Lodge 1981) and sown pastures (FitzGerald and Lodge 1977) occurs over a much longer timeframe and is an episodic event, more dependant on favourable seasonal conditions than grazing method. Earl and Jones (1996) reported substantive benefits of TCG compared with continuous grazing for pastures studied during and immediately after the worst drought this century on the Northern Tablelands of New South Wales. Clearly, what they were observing was the benefits of resting the pasture compared with continuous defoliation in drought. Indeed, it would have been surprising if there were no differential responses in pastures which had received markedly different patterns of grazing and resting. Such benefits would probably have occurred in any comparison of rested and continuously grazed pasture, and so care needs to be taken in attributing their cause to a particular management method. Similar ‘changes’ in species composition were observed in a native redgrass (Bothriochloa macra) pasture on the North West Slopes of New South Wales (Lodge, unpublished data), excluded from grazing for 100 days in the dry winter of 1997. These ‘changes’ occurred solely as a result of resting the pasture, rather than any grazing method. No new plants were recruited into the population; the differences merely reflected the fact that excluding grazing allowed plants which were normally heavily grazed and so not apparent in the pasture (such as the winter-green wallaby grass (Danthonia spp.) to be recorded. Long-term monitoring of pasture composition on two commercial properties undertaking either TCG (Randall et al. 1995) or HRM (Lodge, unpublished data) indicated that in native pasture there was an increase in the undesirable corkscrew grass (Stipa scabra) at one site from 1990-97 and no change in species composition of both sown and native species at the other site, from 1995-97. On the merits of TCG or HRM few could argue with the conclusion of Waugh (1997) that ‘no system is suitable for all areas and you must work out your grazing system to suit your goals, soil, water cycle, climate, grasses, stock and enterprise’.
GRAZING MANAGEMENT FOR DROUGHT CONDITIONS

Australia is one of the driest continents, with a long history of periodic droughts. Yet managing for drought is not generally a well-developed concept and each new drought is treated as an unexpected national disaster. Current government policies of feed and livestock transport subsidies in drought declared areas encourage producers to maintain livestock numbers well into drought. Anecdotal observations in the severe droughts of the 1980s and 1990s indicate that those producers who de-stocked early were able to maintain the persistence of their sown species, particularly the perennial grass component, and maintain high ground cover thus reducing erosion risks. These observations were confirmed in the Temperate Pasture Sustainability Key Program studies, where continuous grazing even at low stocking rates of 1-2 dse/ha resulted in the failure of sown species to persist. In these situations, any resting from grazing was beneficial, with long rest periods of up to 6 months maintaining swards in good condition. Long-term (30 year) data of grazed phalaris pastures on the Northern Tablelands of New South Wales (Hutchinson 1991) also indicated that when severe droughts were developing, decisions on when to discontinue grazing based solely on animal production criteria accelerated the loss of sown species, particularly at high stocking rates.

From specific drought studies within the above program at Armidale, New South Wales (eg Scott et al. 1997), the following guidelines have arisen:

- perennial grasses can survive droughts, provided that they are not intensively grazed during the drought.
- more plants die in moderate rather than severe drought conditions as they attempt to regrow after grazing.
- de-stocking pasture when its herbage mass declines below 1200-1000 kg/ha of dry matter is important during dry periods, particularly in spring and/or summer when plants are accumulating internal energy reserves. While early destocking may have an animal production penalty, higher pasture persistence will ultimately lead to lower feed costs in the long-term (Scott 1995).

A VIEW OF A PRODUCTIVE SUSTAINABLE PASTURE

Before graziers can manage for productive and sustainable pastures, they need to have a mental picture of what a good pasture looks like, so that when they stand in a paddock they can make a rapid assessment about where that particular pasture is on the sustainability/production scale. Once they have made a judgement about a pasture, it will then be evident as to whether or not some sort of restorative action or grazing management is required.

There are many different ways of assessing the productivity of a paddock such as using past stocking rates and $ returns and there are also a large number of sustainability indicators (eg Pankhurst et al. 1995; King and Pankhurst 1996). However, as a practical ‘in the paddock’ guide for graziers there are probably five critical factors to consider that can be readily visualised over a year:

- the proportion of desirable perennial grasses;
- the amount of green leaf;
- the proportion of legume;
- the amount of litter on the soil surface, and
- the level of ground cover.

If all of these are rated as high then the pasture is in good condition and probably needs little additional management inputs. A low or declining proportion of either desirable sown or native perennial grasses may indicate that a grazing management strategy is required to increase their contribution to the pasture. If the proportion of green leaf and legume are low, then plants may be growing poorly and so animal productivity is likely to be low. If soil moisture has been adequate for an extended period and yet legume content is low then nutritional limitations are likely to be constraining the legume; soil strip test and legume resowing may be desirable strategies. Low levels of litter and ground cover would indicate that soil biota activity is likely to be sub-optimal, plant growth low, water infiltration low, run-off high and the risk of erosion high. Having made these assessments graziers can then decide on a positive course of action to restore the productivity of the pasture and increase its sustainability.
REFERENCES


