GRAZING MANAGEMENT: SOME KEY ISSUES

GRAZING SYSTEMS OVERVIEW - THEORY AND PRACTICE OF GRAZING MANAGEMENT FOR SUSTAINING PRODUCTIVE TEMPERATE PASTURES

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Abstract: There is growing evidence of decline in our temperate, high rainfall pastures. Some of this decline may be associated with reduced fertiliser use and a run of poor seasons, but there is a growing perception among farmers that there would be substantial gains from adopting some form of controlled or rotational grazing. Major findings from defoliation studies (UK and NZ) are reviewed and related to grazing management practice. However, these defoliation concepts have been developed from perennial ryegrass pastures in temperate environments with relatively dependable rainfall. Defoliation frequency, intensity and competition between plant species dominate current thinking on grazing management. Grazing preference, the reproductive potential of grazed plants and stress from lack of water and nutrients must be added before we can optimise grazing management for Australian conditions. Current systems of grazing management are briefly reviewed along with key issues that govern the long-term stability of pastures. Some unresolved issues of grazing management are noted along with advice to farmers to adopt grazing management practices cautiously at this stage of our knowledge.

INTRODUCTION

The improved pastures of the temperate regions of Australia carry 41% of our sheep and cattle. There is growing evidence of decline in production from these resources. The farmer's perception of average gross revenue lost from degradation in temperate grazing lands is approximately $10 000/farm/year (Hall and Hyberg, 1991). Surveys of pasture decline (*eg*. Quigley *et al*., 1992) point to a loss of sown species and their replacement with less desirable annuals. This trend has also been recorded in a 30-year experiment, where the replacement of the sown perennial grass (*Phalaris aquatica*) by inferior annual grasses was related directly to a high rate of set-stocking and drought (Hutchinson, 1992).

The high cost of re-establishing the sown perennial grass ($100-200 per ha) has focussed attention on the potential value of grazing management for sustaining the production of improved pastures (Kemp *et al*, 1992). The major aims of this review are to examine the theory and practice of grazing management, to review current grazing management systems and to outline some concepts that govern the long-term stability of our temperate grazing resource.

GRAZING MANAGEMENT: A BRIEF HISTORY

Grazing management involves the movement of animals around the farm in order to exercise some control on the grazing process (*eg*. rotational grazing). This control is directed primarily at optimising pasture growth rate, pasture rationing and sustaining a desirable botanical composition. In this sense, *set-stocking* represents the zero grazing management option in which plants are exposed to grazing over the entire grazing season with limited control over intake. Set-stocking is widely practised in Australia because our high drought frequency has led to conservative stocking levels, with little recognition of the need for more sophisticated methods. This has provided the environment in which management has been directed at the *grazer* rather than the *grazed*. However, a widely recognised deterioration in our pasture resource has prompted interest in the potential value of grazing management to arrest decline.

The potential of grazing management to alter botanical composition was recognised 60 years ago (Jones, 1933a; 1933b). Grazing management was promoted by Voison (1959; 1960) on two key issues. The *first* issue was that the recovery period, between grazings, should be varied with the objective of optimising pasture growth. Voison claimed that this objective could be realised by grazing rules generated from the S shaped form of pasture regrowth, with the emphasis on maintaining biomass within the steep part (Phase 2) of the curve. The limitations of this claim will be examined later. The *second* was that the period of grazing for any enclosed area should be short enough to avoid the grazing of regrowth within the time period of one rotation; the reason advanced was that repeated grazing of regrowth restricted replenishment of the plant's nutritional reserves.

Voison's ideas were most influential in the northeast of the US and in New Zealand. For the year-long grazing systems of New Zealand, the application has been modified by the need to match animal demand with seasonal pasture supply and by reducing grazing intake at times when the animal's metabolic status is relatively low (demand-side modification). The latter is a feature of NZ "controlled grazing", which is being used now in Tasmania and Victoria (Cook, 1992). In the US, Voison's "rational grazing" has been fitted to dairy enterprises by adding the practices of silage and haymaking to redistribute spring and summer surpluses (supply-side modification). In southern Africa, Voison's ideas were fused with an ecological ethos (Savory, 1988), promoted for use in rangelands and extended to include economic gross margins. During the 1980's, Savory's "cell-grazing" has been marketed in the North American rangelands by Parsons' ("Ranching for Profit") package, a mix of motivation and education. Parsons has visited Australia in recent years and has a consulting service here.

EFFECTS OF GRAZING ON SWARD STRUCTURE AND FUNCTION

Under so-called set stocking and continuous grazing the individual plant is grazed rotationally. Research on the effects of grazing on the structure of set-stocked swards provides baseline information for grazing management. Under set-stocking, the average time interval between defoliation of the individual perennial ryegrass tiller declined from 25 days in a

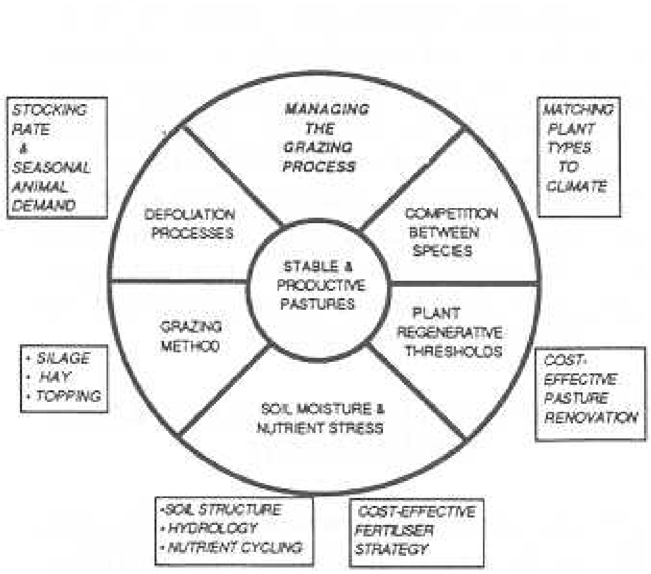

Figure 1: Achievement of the aim of stable and productive pastures requires an understanding of five key sectors for managing the grazing process. The boxes surrounding these sectors enclose some wider issues and management supports for sustaining productive temperate pastures.

lightly grazed pasture (5 sheep/ha) to 10 days at 40 sheep/ha (Hodgson, 1966; Hodgson and Ollerenshaw 1969). As the frequency of defoliation of tillers increases with stocking rate so does the severity of defoliation with older leaves being defoliated less frequently than younger leaves. Frequency, along with age preference and severity of defoliation are important components of defoliation; a fourth important process is the preference for particular species. Grazing management can exercise important control on defoliation as a key process (Figure 1).

Parsons *et al.* (1983a) showed that, under "hard" grazing (47 sheep/ha), young ryegrass leaves provided 77% of the growth provided by net photosynthesis while contributing only 43% of the total photosynthetic area of the green sward, measured as the leaf area index (LAI[1] = 1.0). Surprisingly, under hard grazing, 51% of the shoot growth senesced, died and entered the litter cycle. Under "lax" grazing (24 sheep/ha with a LAI of 3.0), 71% of the leaf growth senesced. Grazing intake of the sheep flock was higher under hard grazing and this was attributed to a higher harvesting rate of the shoot produced and a smaller proportion of shoot that was subject to senes-

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Footnote 1: Leaf Area Index provides an estimate of the ability of the sward to intercept light radiation required for photosynthesis. LAI is the ratio of leaf area (one side) to ground area.

cence and death (Parsons *et al.*, 1983b). In a mixed sward, the net production of herbage (growth minus senescence) remained virtually constant over a wide range of both herbage mass (850 - 1850 kg organic matter/ha) and LAI values (2.3 - 4.7) and there was a compensatory increase in tillers and stolon growing points under hard grazing (Bircham and Hodgson, 1983). These studies have provided important support for grazing management systems and particularly for New Zealand controlled grazing.

PRODUCTION BENEFITS FROM GRAZING MANAGEMENT

Voison's *first* contention needs further examination. This suggested that there would be substantial production benefits from planning pasture recovery periods to maintain pasture on the steep part of the S shaped plant growth curve. However, this is an oversimplification and researchers have put forward a number of mechanisms that could modify the compensatory growth response that follows grazing. Briefly these mechanisms are :-

- Removal of apical dominance, resulting in increased tillering.
- A rapid allocation of plant reserves to produce new leaf which is highly efficient for photosynthesis.
- Improved light penetration into the sward.
- An increased supply of mineralised nutrients from the return of dung and urine.

The operation of such mechanisms may not always be sufficient to compensate rapidly for the loss or damage of leaf area that follows grazing. For the Australian environment there is also the critical question of the extent to which regrowth may be limited by lack of moisture and the impact of this stress on premature senescence. Also, an old sward may contain more than 100 species, each with a different potential growth rate and often with different strategies for responding to defoliation or even for avoiding it. Selectivity by the grazing animal for particular species and parts adds further to the uncertainty of predicting gains based on the S shaped pasture response; any claim for a 2 to 3 fold increase in production overall is certainly inflated. It must be agreed, however that unstressed pasture growth does have some Sigmoid form which give growth benefits by avoiding the extremities of the curve, where there is low herbage cover under close grazing or where there is a high mass of mature standing pasture.

In the field, where management demands an economic level of pasture utilisation, the respective mixes of compensatory responses that operate under set-stocking and under rotational grazing tend to maintain an equilibrium in leaf growth, which is the key to photosynthesis and pasture growth. The balance of these compensations was illustrated clearly when set stocking (SS) was compared with rotational grazing (RG) in the hill country of New Zealand (Chapman and Clark, 1984). Comparisons between RG and SS for the components of pasture growth and defoliation were:-

Growth components:	
Leaf appearance rate;	RG>SS
Tiller density;	SS>RG
Total leaf growth:	SS=RG
Defoliation components:	
Defoliation frequency;	SS>RG
Defoliation severity;	RG>SS
Leaf removed;	RG=SS

These outcomes for SS and RG outcomes occurred across a wide range of pasture mass and this gives little support to Voison's *first* contention that there would be substantial pasture production benefits from rotational grazing.

GRAZING MANAGEMENT TO SUSTAIN VALUABLE SPECIES

Voison's *second* contention that rotational grazing allows the grazed plant to replenish its reserves, could confer a benefit that is more substantial than the claim for increased plant production. Rotational grazing could conserve the more nutritious species which face the greatest grazing intensity by "levelling the playing field" for all species during the grazing period and by allowing the sown species, which are usually more competitive, to replenish their nutritional reserves during the rest period. Grazing could also be planned to remove grazers at times which are critical for replenishing the sexual (seedbank) and asexual (budbank) reproductive reserves.

Where growth and reproductive rhythms are asynchronous, then the reverse rotational strategy can be used to reduce undesirable species. Species have their weakpoints in the course of their growth and reproduction (phenology) and the crash grazing of weed species can be very effective provided that the preferred species have a different flowering time. The success of the wire grass (*Aristida ramosa*) control program provides an example (Lodge and Whalley, 1985). The wiregrass is a low-value, warm season, perennial flowering between January and March, while wallaby grass (*Danthonia linkii*) is a valuable, year-long green, perennial flowering in spring and in autumn where seedling establishment follows. Heavy grazing over summer and autumn, with or without burning, reduces *Aristida* and promotes the valuable *Danthonia*.

SEASONAL GUIDELINES AND OPPORTUNITIES FOR GRAZING MANAGEMENT

Autumn

The regeneration of perennial grasses is based on the emergence of new leaves from the stem bases of previous tillers, or stolons for white clover. Germination and establishment from seed is an important long-term regenerative strategy for white clover but contributes very little to production in the first year. It is important that perennial grass crowns and clover stolons are not damaged by hard grazing during autumn moisture stress, which is common in temperate Australia. Overgrazed perennials might provide the opportunity for inferior annuals to compete with greater success when the season breaks. It is also good management to allow new perennial leaves to develop quickly, both to support autumn grazing and to accumulate sufficient biomass to sustain winter pasture growth.

The recovery of autumn tiller density depends on light penetration into the base of the sward (Korte *et al.*, 1982) and this is helped by the rapid decomposition of dead plant material. Autumn is the main season for the decomposition of surface litter and its incorporation into the soil. This process is governed by the quantity of litter formed (related to spring and summer grazing control), its quality (grass leaf and legume litter quality is high), and the level of biological nutrient cycling activity that the management system can support. Recycled nutrients represent more than 80% of the nutrient economy of pastures and with the effective retention, spatial distribution and replacement of nutrients provide key elements in system stability (Figure 1).

Winter

This is the season with the lowest probability of encountering moisture stress. Average winter growth rate of a well-developed, unstressed, sown pasture is about 8 kg Dm/ha/day, which will provide the winter intake required by 5 pregnant ewes/ha due to lamb in early spring. Under the NZ controlled grazing system a higher growth rate is claimed and the stocking level applied may be twice this. The ewes are rationed to 1.0 to 1.3 kg DM/day and managed in a rapid rotational sequence of 60-100 days with the major goal of entering spring with a pasture mass of at least 1000 kg DM/ha to meet the high demands of the lactating ewe.

Winter rests from grazing in *perennial* pastures favour perennial grasses over annual grasses, but legumes may be reduced; winter rests in *annual* pastures favour legumes (Kemp *et al.*, 1992).

Spring

Hard grazing, before flowering, favours stolon based growth in white clover but later in spring, overgrazing damages seed set particularly under moisture stress.The key to spring *production* is grazing control. Either set-stocking or fast rotations can be practised (Chapman and Clark, 1984) but neither will give complete control from the production viewpoint. Fodder conservation (Figure 1) can control the quality problem of rank herbage growth and the earlier cutting for silage will allow some regrowth.

Management for botanical *stability* can be the reverse. In late spring, the shoot apices of perennial grasses can be elevated and vulnerable when subjected to hard grazing. In late spring some spelling of perennial grasses favours reproductive and crown bud development, particularly in marginal areas (Hill and Watson, 1989). To quote a successful pasture seed grower - "Let the perennial grasses go through their full act occasionally and don't always bring the curtain down in mid-performance" (Friday, 1992).

Summer

Latitudinal differences in the moisture status of Australian temperate pastures range from substantial summer rain in the north to dry summers in the south. Breaking summer dormancy of perennial grasses in the north can provide growth but may reduce long-term stability. These northern zones are closer to NZ conditions where white clover stolons can survive well under lax grazing and achieve better production in the following autumn and winter (Korte *et al.*, 1982).

Patchy grazing can become evident under summer set-stocking; in theory, this could reduce pasture growth and intake rates (Clark, 1992). From an agronomic view point, senescent pasture is wasted and reflects a lack of grazing control; however during senescence, perennial plants exercise their *internal* nutrient cycling strategy which is important for the early nutrition of buds and shoots. The production aim of maintaining leafy pastures in summer can be in conflict with the long-term aim of stabilising the sown perennial species. Stability is basically concerned with sustaining the regenerative capabilities of species (buds and seeds) above threshold values, which unfortunately are poorly defined. Hard grazing in summer, compared with no grazing, can reduce viable seed densities in ryegrass resulting in negligible seedling re-establishment in the following July (L'Huillier and Aislabie, 1988). The importance of plant residues in *external* nutrient cycling has already been raised. New Zealand pasture and soil ecologists have recorded significant benefits from an annual spell for pastures (September to April) showing improved seed set, carbon and nitrogen status, root mass and its depth distribution (Mackay *et al.*, 1991). These authors suggest that a "sabbatical" for pastures could be part of a strategy to resolve any conflict between short-term production and long-term sustainability.

CURRENT GRAZING MANAGEMENT SYSTEMS

Fixed interval rotational grazing

These systems, which are based on fixed intervals between grazings, can provide a basis for objective comparisons with set-stocking systems but they fail to accommodate the flexibility that is needed to cope with important interactions between seasonal droughts, plant performance, grazing intake and nutritional demand (Cook, 1992). Australian experiments based on fixed rotational regimes have shown little advantage over set-stocking (Moore *et al.*, 1946; Morley *et al.*, 1969) although the stocking levels may not have been high enough to show benefits. However, the results serve as a warning to producers to proceed carefully before making a large investment in subdivisional fencing.

Flexible rotational grazing

Characteristically these systems have a very substantially reduced grazing period (1 - 3 days) and increased period of spelling. Time controlled grazing (or cell grazing) comes under this category and its origin has been noted. Stock can be aggregated into large mobs, depending on species, physiological status or productive purpose. The rest period (RP) is determined by plant growth rate which in turn defines the graze period (GP) and can be calculated as the ratio of RP to the number of paddocks resting. In periods of fast pasture growth the GP can be as short as 1 to 3 days. Twenty paddocks may be recommended per cell which is allocated to a particular group or mob; however, the assignment of paddocks to any cell is flexible to allow for seasonal and marketing demands. Long-term advantages expected by advocates for time controlled grazing include better weed control, improved pasture utilisation, increased root development and soil biological activity, breaking sheep camping behaviour and improving nutrient redistribution, easier stock handling and earlier recognition of stock health problems.

NZ controlled grazing

This combines rotational grazing for part of the year with set-stocking for the remainder. The central idea is to lamb in early spring and to ration pasture from April to September using high stocking densities and long rest periods, *eg.* 100 days. The system is driven by the nutritional needs of the animal with a target ewe liveweight set for ewes early in winter and rationing to ensure that the high demands of lactation can be fully met by spring pasture growth. Ewes are set-stocked at lambing and for the rest of the year unless surplus fodder is conserved to cushion the impact of dry periods. The system has a long history of use in the NZ hill country (Smith and Dawson, 1977) with production advantages claimed through higher stocking and pasture utilisation. Controlled grazing is being used in eastern Australia (Gippsland, Tasmania and southern NSW). Experience gained with this system may increase production indirectly by giving farmers the confidence needed to run more sheep.

The pasture management envelope

This system was first proposed for tropical pastures (Spain *et al.*, 1985) and has been developed for temperate pastures by Kemp (1991). Recognising the substantial variation between paddocks at the whole farm level, the system focuses on optimising the management of individual paddocks. The aim is to stabilise the presence of desirable species within an envelope'' that is bordered by legume presence, green forage on offer (FOO) and a daily forage allowance (Figure 2). The target ranges for the envelope are 1200 to 2500 kg DM/ha for FOO, providing a forage allowance from 1 to 4 kg DM/ewe/day with a legume presence from 15 to 50%.

Grazing pressure may be increased by changing the overall stocking rate, mob-stocking practice or by taking a conservation cut in spring. At the upper limit of FOO, increased grazing pressure is used to control grass dominance and to conserve legume presence. The forage allowance is sustained at the lower level of FOO by reducing grazing pressure to increase herbage accumulation and manage the grass/clover balance. Grazing pressure (GP) is the preferred as a reference point because it accommodates the current

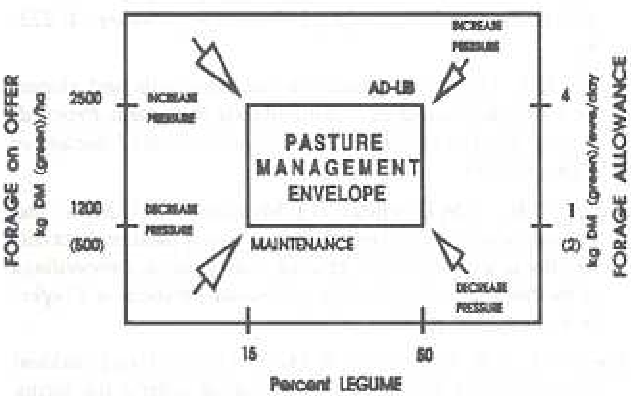

Figure 2: The pasture management envelope formed by the percent legume, forage on offer and forage allowance for ewes. The aim is maintain pastures within such an envelope by manipulating grazing pressure in order to achieve productivity and persistence (Kemp 1991). Further details are given in the text.

net growth rate; GP is defined as the ratio of consumption rate to net growth rate and is achieved by varying animal numbers per paddock.

FOUR UNTESTED GRAZING MANAGEMENT ASSUMPTIONS

(1) *That grazing management can increase animal production*:

Objective evidence is lacking. On farms, grazing management is usually applied as a package along with other inputs so that any response cannot be readily apportioned.

(2) *That "putting and taking" animals to optimise the utilisation, production and botanical composition of a paddock cannot be extrapolated to the farming enterprise as a whole.*

This old debate remains largely unresolved (*eg.* Willoughby *versus* Mott). On the one hand, there must be some upper limit to the relevance of 'put and take' management where the land area of a farming enterprise is finite and provides the total support for its grazing animals year-long. The practical issue is whether or not there is a sufficient range of land capability and pasture type to accommodate 'put and take' that is beneficial for individual paddocks without flow-on penalties to other areas of the farm and its livestock.

(3) *That long-term, desirable botanical change can be predicted from short-term trends.*

Studies of grazing management have indicated both the potential and the direction of botanical change but the studies have been relatively short-term. Grazing resources are intrinsically dynamic, moving between "equilibrial states" with intervening transitions governed by a combination of management and unplanned events (Holling, 1973; Westoby *et al.*, 1989; Hutchinson, 1992). Grazing method can exercise important control on the outcomes of competition and defoliation; however grazing regimes can exercise very little control over moisture and nutrient stress and on the "hidden" items of declining soil structure, hydrology and nutrient cycling (Figure 1). Major interactions must be expected with long-term trends being complex. The key to grazing management for stable and productive pastures will be to define critical thresholds for desirable species and to manage the grazing process accordingly.

4. *That grazing management is good from the ecological viewpoint.*

This claim was advanced by Savory (1988) to support cell grazing. Concepts and ideas invoked included the vegetational climax, energy capture, the water cycle, the different mechanisms of photochemical and biological decomposition of organic residues and nature's benefits from migratory grazing (wildebeest). Some of these concepts are either dated or "draw a long bow", others are important for the stability of systems but there is little evidence yet that they have a particular attachment to grazing management.

CONCLUSIONS

The thresholds for sustained plant regeneration under selective defoliation, unavoidable grazing pressure and environmental stress have yet to be defined.There may also be important physical, chemical and biological constraints, arising from a balance of mechanisms in pasture soils, and which can result in long-term decline. All the factors contributing to management of the grazing process appear to have importance (see Figure 1), with a number acting jointly and possibly interactively.

It must be acknowledged that Australian research has a long way to go before presenting comprehensive guidelines for sustainable and productive pastures. Fortunately, grazing industry research funding bodies are setting the agenda by focussing attention on the need for more information on the role of cost-effective grazing management to achieve productive and sustainable temperate pastures (*eg.* Meat Research Corporation, 1992). Grazing management strategies will be tested on 18 sites in the high rainfall zone of eastern Australia and on other sites there will be ecological studies on particular sustainability issues. Managers should take the opportunities to inspect these sites and discuss progress over the next three years (1993-6).

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