PASTURES IN THE CROPPING ZONE:

Grazing by numbers makes lucerne last

Rex Williams

NSW Agriculture, Yanco, NSW, 2703

Summary: Lucerne can provide major benefits provided it lasts the duration of the pasture phase. This often depends on the "art of grazing management". This "art" can be simplified by providing an outline for success and some "numbers" to follow to select the best grazing system. The objectives of the farming system can then be balanced with aspects of the pasture, plant, variety, animals, and environment. Simply decide how long the pasture is needed, then consider the size of the paddock and stand age. Critical rest intervals can be determined by flowering stage, and manipulated by grazing height, stock type, stocking rate, and grazing duration. The variety, the weather, plant stress, and/or weeds may also affect the choice of grazing strategy. Outcomes need to be monitored, and grazing strategies changed where necessary. Flexibility is important. Ultimately, lucerne grazing management becomes not an "art", but a "numbers game" based on skill and science.

Lucerne (*Medicago sativa*) provides a reliable, high-yielding, and nutritious source of feed in pastures. It is the most common perennial legume used for grazing by sheep, cattle, and dairy cows. It is also used in crop rotations to fix nitrogen, reduce weeds, and provide a disease break. Lucerne can control salinity by lowering water tables and reducing recharge. During droughts, it provides valuable feed by drawing on deep water with long tap roots or by responding quickly to any rain.

Given these benefits, lucerne is increasingly being used in farming systems throughout Australia. However, its success in these systems often depends on whether an appropriate density of plants can be maintained for the duration of the pasture phase. Studies have shown that with inappropriate grazing, lucerne may only last for six months (Brownlee 1973). Although publications have often addressed this issue, many still regard lucerne grazing management as an "art". The simplest form of art is a "paint by numbers" kit where an overall outline is provided and numbers are used as a guide to completing the picture. In the following paper, the aim is to outline the "art of grazing management" of lucerne, and discuss the main "numbers" required to complete the picture of the most appropriate grazing system.

The target

The choice of grazing system for any lucerne pasture must provide a balance between the requirements of plants, animals, the environment, and the viability and sustainability of the farming system. Targets must be determined before selecting an appropriate grazing system or even deciding whether a grazing system is required (Lodge 1995). For example, grazing pastures in response to rainfall or feed shortages may penalise the long-term survival or persistence of lucerne (Lodge 1991). However, this may keep stock alive during drought. Grazing strategies will therefore depend on the overall targets of the enterprise. One of the first "numbers" required to aid the choice of grazing strategy is the desired duration of the pasture phase.

The duration of the pasture phase

Some lucerne plants can survive for 20 to 25 years (Leach 1978). However, the density of plants in a pasture over time is far from stable and resilient (Gramshaw 1978). The longer a lucerne pasture is required, the more important the choice of grazing management becomes. For example, rotational grazing has been recommended since the 1940's to maximise the life of lucerne stands for livestock production (Moore *et al.* 1946). In contrast, such highly-managed systems of grazing may be less important in crop rotations where stands are required for only 2-3 years.

The pasture

Seedling regeneration in lucerne is rare and the productive life of a lucerne pasture depends on the

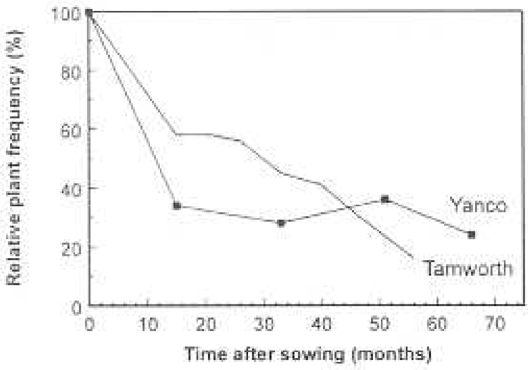


Figure 1. The decline in the average persistence of lucerne varieties as measured by relative plant frequencies for dryland trials sown at Yanco (open squares) and Tamworth (closed squares) during 1988.

survival of original plants (Leach 1978). The density of these original plants declines with time, although the rate and degree of the decline may vary across environments and management systems. For example, a continuous decline in density (relative plant frequency) was measured over time in a dryland trial at Tamworth (Figure 1). The same lines at Yanco crashed initially, but then maintained density for the duration of the trial.

Even under correct management and without diseases or pests, lucerne swards will "self-thin" to an equilibrium plant density consistent with the environment (Palmer and Wynn-Williams 1976). Unfortunately, we do not know equilibrium popul-ations for each environment and assessing the compounding effects of different systems of grazing management on lucerne persistence is difficult stock production, N_2 fixation, and land-use stability. We may address these questions in future research.

What we do know is that grazing management can play a major role in determining the rate of decline in lucerne persistence (Lodge 1991). Continuous grazing at medium to high stocking rates leads to rapid declines (McKinney 1974), whereas rotational grazing can provide long-term productivity (Leach 1968). Resting or spelling pastures or even individual lucerne plants can be achieved by subdividing large paddocks, reducing the stocking rate and/or by providing alternative feed sources. The strategy chosen is best related to another key "number", the initial size of the paddock.

The size of the paddock

Large paddocks of lucerne are best subdivided to maximise stock productivity and pasture longevity. Although central watering points and electric fencing offer cheap and effective methods of subdivision, the extra management involved in shifting stock and monitoring pasture growth may not be practical (Lodge 1991). The need and degree of subdivision are greatest when seeking maximum use of feed, long lucerne life, high stocking rates, and/or where rainfall is limited (McDonald *et al.* 1995). Alternatively, stocking rates on large cropping paddocks may be reduced below carrying capacity and animals set-stocked. Although further research is needed, this could alleviate the need for a grazing system altogether. Animal productivity and lucerne persistence will not be optimised, but these penalties may be small given the reduced infrastructure and management costs. Even in these types of paddocks, lucerne plants could be rested by providing alternative feed sources either within the paddock as part of the pasture mix or as supplements. Separate paddocks based on other species such as sub-clover or oats could be used to fill feed gaps or to rest the lucerne. On the other end of the scale, Kemister (1995) suggested the use of oat self-feeders in a small paddock of high quality lucerne to boost feed quantity for finishing stock. Lloyd-Davies (1994) suggested a sporadic system of one day of lucerne, five days of dry pasture to maintain weight of weaner sheep in summer where only a small area of lucerne could be established.

The stand age at grazing

Seedlings stands of lucerne are more easily damaged by grazing than established stands. McDonald *et al.* (1995) provided specific guidelines for graz-ing and to prevent early lodging of the crop. A brief grazing after crop harvest will disperse stubble, promote lucerne growth, and better use any grain lost from the header. Rotational grazing in newly-established stands should commence once the lucerne has fully flowered. Lucerne sown without a cover crop should be first grazed only in full flower, unless weed competition is severe.

The plant

A rest interval between successive grazings helps sustain the productivity of a lucerne plant. The duration of this rest interval is a key "number" in determining the optimum grazing strategy.

The duration of the rest interval

The minimum recommended rest interval between grazings is about 35 days (Moore *et al.* 1946; McKinney 1974; Leach 1979). This replenishes essential root reserves of energy to ensure rapid regrowth and plant survival after grazing (McDonald *et al.* 1995). More than 90% of these energy reserves are stored as starch (Heichel *et al.*, 1988). We measured starch levels in a range of 20 varieties to find the optimum resting interval (Williams 1995*a*). Starch levels declined for 13 days during regrowth as reserves were mobilised to support the growth of new stems and leaves (Figure 2*a*). After 13 days, starch levels increased as photo-synthesis in the tops produced more carbohydrates than needed for shoot growth. These results were consistent with limited studies under different conditions (Hodgkinson 1969). In common with the recommended rest interval, 35 days were required after cutting before starch concentrations returned to their initial levels (Figure 2*a*). However, in this study, root systems also gained weight during regrowth

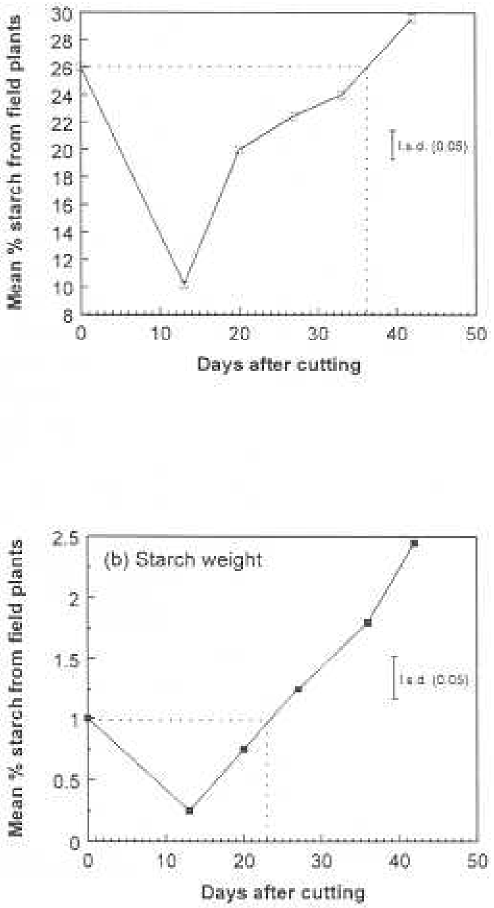


Figure 2. Mean effect of the duration of regrowth on (a) the concentration of starch and (b) the weight of starch in roots of twenty different varieties of lucerne.

and this diluted the concentration of starch. Only 23 days were required before the total weight of starch in roots was renewed (Figure 2*b*). This suggests that for established plants with root systems that change little in weight during regrowth, rest periods shorter than 35 days may be possible. Investigations are continuing.

However, any calendar-based system of grazing management ignores the basic biology of the lucerne plant and its response to grazing and stress. Therefore, alternative systems of determining rest intervals in lucerne have been suggested. The most widely used "number" is the percent flower

The percent flower at grazing

About two thousand years ago, Pliny suggested that lucerne should be cut at the beginning of flowering (Bolton 1962). Many authors in Australia have since promoted the management of lucerne based on flowering stage (Lodge 1991). Common practice relies on the 10% flowering stage as an indication of when to graze lucerne. The reason this technique is often successful is the association between flowering stage and the accumulation of energy reserves in the roots and crowns. Maximum accumulation of root reserves occurs at full bloom (Reynolds and Smith 1962), not at 10% flowering when these reserves may only be 40-60% of maximum. However, forage value and animal productivity may be reduced in later stages of flowering. The 10% flower stage provides the best compromise of quality, forage yield, and persistence (Lodge 1991). Given that grazing only at 10% flowering will still reduce reserves, letting lucerne fully flower whenever possible is probably useful (such as during winter when alternative feeds are plentiful) and/or immediately before and after periods of plant stress.

The use of flowering stage to time the rest interval is complicated by the effects of temperature, daylength, and water availability on the flowering response. Under particular combinations of these variables, it is possible that there may be no association between flowering and root reserves. Graber (1935) also suggested that there are occasions when flowering in lucerne is not necessarily a prerequisite to obtaining high levels of energy reserves in roots.

The length of basal buds (and grazing height)

When daylength is inadequate to promote flowering, or when flowering is sporadic or affected by insect damage, some researchers have suggested that the development of crown buds may provide a better guide to when lucerne is ready to cut (Sheaffer *et al.* 1988). The existence of new shoots below cutting height at the time of cutting increased the that the development of crown buds may provide a better guide to when lucerne is ready to cut (Sheaffer *et al.* 1988). The existence of new shoots below cutting height at the time of cutting increased the rate of regrowth (Smith 1972). However, variation in crown bud appearance and elongation across varieties and growing conditions makes this trait unreliable for determining time of cutting or grazing (McDonald 1995). With respect to grazing management, the aim is to reduce damage to these crown buds. Grazing should be timed to occur before bud elongation. Another option may be to manipulate grazing pressure or duration so that taller stubbles may be left and buds remain undamaged. Tall stubbles (5 cm) can also prevent declines in root weights during regrowth (Hodgkinson *et al.* 1972). Leach (1968) showed that tall stubbles provided more sites for regrowth and led to the highest yields. However, large amounts of ungrazed stubble may also reduce the rate of regrowth (Leach 1979). The value of old basal leaves has also been questioned (Brown *et al.* 1966), especially if they photosynthesise slowly, shade the crown, and prevent the development of new shoots. Generally, tall stubbles appear to have value where close grazing will damage crown buds or where root energy reserves are depleted.

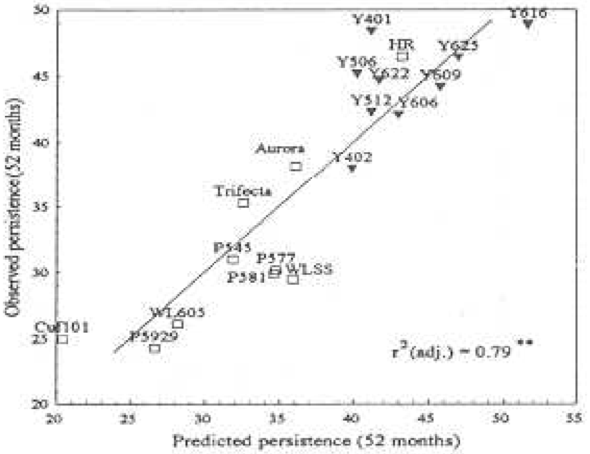
The variety

Lucerne varieties differ in growth pattern and in their response to challenges from pests and disease, drought, waterlogging, grazing, *etc.* A variety should be chosen that will produce sufficient yields when needed and maintain this productivity as required. Different types of varieties may require different grazing strategies to optimise their performance. Again, certain "numbers" are important.

The winter-dormancy rating

All lucernes grow best from late spring until early autumn, but differ in their relative growth during late autumn/winter (McDonald *et al.* 1995). This difference in "winter-dormancy" (or "winter-activity") is associated with other important differences among varieties (Williams 1995*b*). The best balance of traits depends on the target and the location. For example, the autumn/winter production from highly winter-active varieties can provide great benefits to livestock productivity. However, highly winter-active varieties have a higher crown structure (Williams 1995*a*) and harsh grazing may more easily damage them. Even at low plant densities, highly winter-active varieties generally out-yield dormant varieties (Lodge 1985 *a*). However, they can lose quality quickly if grazing is delayed (McDonald 1995).

Many studies have sought an association between winter-dormancy and performance under grazing. Under rotational grazing, there were generally few differences among varieties or among dormancy groups in persistence (*e.g.* Leach 1969; Brownlee *et al.* 1984; Lodge 1985 *a,b*). However, survival varied among varieties following heavy (Leach 1970) or continuous (Kaehne 1979) grazing. Where disease incidence was low, Lodge (1991) concluded that grazing may cause different varieties to decline at different rates, but that they eventually decline to similar levels. Therefore, at specific times during the life of a pasture, varieties may differ in density and this must be considered relative to the desired stand life. Recently we measured large differences in density among varieties in grazed trials at both Yanco and Tamworth (Williams and Boschma 1996). These differences could be predicted, not by differences in winter dormancy alone, but by combining this trait with measures of stem length in summer. The observed and predicted densities for varieties at Yanco are illustrated in Figure 3. This study also identified differences among varieties in their use of starch reserves during regrowth (Figure 4). Root reserves were better maintained during regrowth for the persistent variety Aurora (winter-active) than for the less persistent varieties, P545 and Cuf101. The dormant variety P545 recovered quickly, but the highly winter-active variety Cuf101 did not. Additional data for 20 varieties showed a similar pattern. This may be related to differences in regrowth rates. Nevertheless it suggests that highly winter-active lucernes may be more susceptible to damage from grazing earlier in the regrowth cycle than dormant types. This would also make them unsuitable for use under extensive or prolonged heavy grazing.



Fgure 3. Persistence of lines (closed triangles) and varieties (open squares) of lucerne after 52 months in a dryland trial at Yanco as predicted from stem lengths in summer and winter compared with that observed.

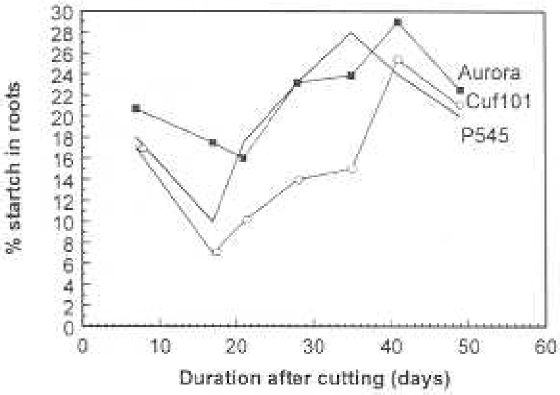


Figure 4. The percent starch in roots during regrowth for seedlings of Aurora (solid squares), Cuf101 (open diamonds), and P545 (open circles) grown in pots in the greenhouse.

the proportion of plants resistant to various pests and diseases. Interaction between varietal resistance to disease and persistence in haycutting stands has been shown (*e.g.* Gramshaw *et al.* 1985). The weakening of a plant due to pests or disease may predispose it further to damage under harsh grazing. Therefore, the choice of variety may be critical for stand survival under grazing in areas where diseases and pests are known to occur. Similarly, varietal differences in tolerance of other challenges, such as drought, have been recorded (Sheaffer *et al.* 1988).

The animals

Pastures are usually grown for livestock production. Decisions on how best to manage grazing in lucerne pastures need to consider "numbers" for both the size (*i.e.* type) of stock and the stocking rate.

The size/type of stock

Continuous grazing, even at low stocking rates, may increase selective grazing pressure on individual plants (Leach 1978). However, cattle graze less selectively than sheep and extensive periods of set stocking with cattle may not affect stand density (Wolfe *et al.* 1980). An aim of good management is also to preserve basal buds and retain stubble. Lodge (1991) suggested that cattle may be more effective than sheep in this regard as they do not graze as closely to the plant crown. However, cattle are susceptible to bloat. This risk can be managed by using anti-bloat agents, careful grazing, and by increasing the grass component of the pasture. Sheep do not bloat, but red gut can occur when no other feed available except lush pure lucerne. Roughage as hay or grass will overcome this problem. Lambs can scour and lose weight from changes in feed quality during rotational grazing. Moving lambs before they have eaten all the leaf will overcome this problem (Kemister 1995). Dry ewes can then complete the grazing. If lambing must occur on lucerne, continuous grazing at low stocking rates will reduce mismothering and reduce damage to the lucerne. To avoid reductions in twinning rates, remove breeding animals four weeks before and during joining if leaf disease is evident (McDonald *et al.* 1995).

The stocking rate

The optimum stocking rate will vary depending on the enterprise target, the environment, and the system of grazing management. Successful systems of rotational grazing have involved rates per hectare from 12.5 wethers at Trangie, to 15 dry sheep at Wagga and Tamworth, to 20 breeding ewes at Canberra (McDonald *et al.* 1995).

The grazing interval

Decisions regarding the duration of grazing may be less important for stand survival than the length of the rest interval. For example, grazing periods of up to 21 days did not affect subsequent persistence in studies reviewed by Lodge (1991). However, stock may have to be shifted earlier to prevent reductions in weight gain or even considerable weight loss (Kemister 1995).

The environment

The final set of "numbers" that should be considered in designing an effective grazing management system concern aspects of the environment in which the lucerne is grown.

The weather

Grazing treatments applied in a wet year reduced lucerne vigour more than in a dry year (Whitear *et al.* 1962). Wilman (1977) showed that wetter seasons favoured grass-dominated pastures when lucerne was frequently grazed, but this effect disappeared in drier years. Therefore, the optimum grazing regime for maintaining lucerne in a mixed pasture may vary across years and weather conditions. Lucerne can also quickly die if cut or grazed before heavy rain or irrigation under hot conditions, especially where soils are poorly drained (Donovan and Meek 1983). Where night temperat-ures are high, root energy reserves can suffer a net decline from respiration (Feltner *et al.* 1965) and this may reduce tolerance to grazing. Many studies have shown that energy reserves also decline during harsh winters in America and that lenient grazing in autumn and spring is recommended for plant surthis may reduce tolerance to grazing. Many studies have shown that energy reserves also decline during harsh winters in America and that lenient grazing in autumn and spring is recommended for plant survival (Smith 1972). Limited studies in Australia suggest that grazing in autumn and winter can affect subsequent productivity and persistence if other stresses occur concurrently (Lodge 1991).

The degree of plant stress

Grazing during drought (Brownlee 1973) or under waterlogging (Gramshaw *et al.* 1982) can quickly lead to major declines in lucerne density. Plants weakened by disease may also be less tolerant of grazing pressures that compound plant stress. However, grazing may also be used as a tool to reduce and control insect populations or to stop transpiration by plant tops during periods of water deficit.

The weed burden

Grazing management can play a significant role in regulating species composition in pastures (Lodge 1995). Rotational grazing can be used to favour perennial components of the pasture (Wilson 1986), such as lucerne, and reduce competition from annual weeds.

A "graze by numbers" scheme

This paper has outlined various systems of lucerne grazing management. The most successful and productive system involves rotational grazing where stock are introduced into a lucerne paddock at 10% flower to full flower, allowed to graze to a stubble height of 5 cm, then removed from the paddock for at least 35 days. However, implementing such a strict system can be difficult, costly, and limit the use of lucerne in areas where it is most needed (*i.e.* wheat-sheep belt). In contrast, a "lenient" system of management involving set stocking at low stocking rates is cheap and easy. Although animal productivity will not be optimised, in some situations, lucerne density may still be maintained for the duration of the pasture. In other situations, strict rotational grazing is needed for lucerne survival. Key "numbers" can be used to decide a practical balance between the use of "strict" or "lenient" grazing management (Figure 5). As shown in Figure 5, if long-term pastures are needed, and/or when root energy reserves are low, and/or during periods of plant stress, for example, the balance tips in favour of strict rotational grazing to maintain lucerne density. In contrast, when only short-term pastures are required, and/or root reserves are high, and/or plants are generally unstressed, a more lenient system of grazing may be more practical.

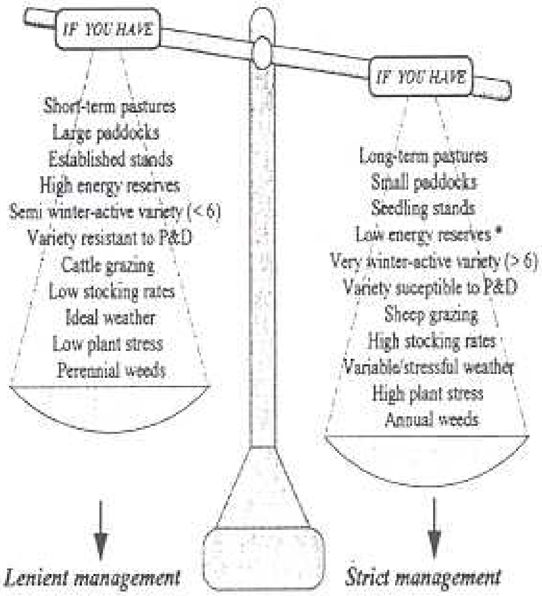


Figure 5. Factors affecting the balance between strict rotations or lenient set stocking as choices for a practical grazing system to maintain lucerne density.

(* Low energy reserves in roots can be produced by rest intervals less than 35 days, grazing prior to 10% flowering, and/or low grazing heights).

Ultimately, a successful grazing system should balance the goals of the farming enterprise with the characteristics of the pasture, individual plants, the type of lucerne variety, the animal production system and the environment. This requires more than just knowledge. It also requires understanding and monitoring of the grazing system and its effects to see if targets are being met. A flexible approach to grazing management may be required to "weigh-up" the options after any change in key "numbers". For example, if a lenient management system is adopted and root energy reserves become depleted or plants become stressed by drought, a change to a strict management system may be required for stand survival. Alternatively, if cattle replace sheep on an established stand of semi-dormant lucerne, changing to a lenient system of management will save on management costs without major reductions in stand longevity. Such decisions can be based on the balance between the key "numbers" presented in Figure 5. In this way, lucerne grazing management will become no longer an "art", but a "numbers game" based on skill and science.

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