16. Grazing Management

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Learning objectives

On completion of this topic you should be able to:

- demonstrate a thorough understanding of grazing management concepts and the science behind grazing management principles
- discuss relevant literature relating to grazing management and sustainability
- access and utilise recent research and extension efforts describing sustainable grazing systems and recognise the difference between anecdotal claims and objective evidence
- Understand some of the important differences in the capacity of different pasture species to support sustainable wool production and the important influences of fertiliser, stocking rate and grazing management

Key terms and concepts

Grazing management terminology (especially continuous, rotational and tactical grazing)
Spatial and temporal changes in grazing behaviour and pasture supply
Sustainability
3-leaf and 4-leaf stage of plant growth
Grazing tolerance
Light interception and pasture growth
Selective grazing
Stocking rate and its interactions with fertiliser and pasture utilisation
Herbage intake
PROGRAZE, herbage mass and digestibility
Rest period
Remote sensing of herbage
Nutrient responses
Animal production per head and per hectare

Introduction to the topic

The issue of what type of grazing management is best has been challenging researchers and graziers for decades. In the booklet "Management of Profitable and Sustainable Pastures - A Field Guide", published by New South Wales Agriculture, Chapter 23 provides a brief summary of Grazing Management Systems (see 16-1-Grazing management systems on your resource CD-ROM).

This book also includes descriptions of other crucial issues related to grazing management such as pasture utilisation and feed supplements, the principles of pasture assessment, assessing livestock, understanding pasture growth of various species and knowing what species one has on a farm and finally, putting it all together. The subtitle of this topic is titled 'Rules for Grazing Management', but one can readily see how vague such rules can be. In fact, that is one of the main conclusions from a vast amount of grazing management research - that it is very difficult to provide any robust rules, especially when the demands for growing pasture in a variable climate and the nutritional demands for raising profitable livestock often conflict. So perhaps one of the rules might be "there are no rules!"
Having said that, there are principles of grazing management and, because grazing management usually has linkages to virtually every aspect of farm management, the inter-relationships are complex. This topic highlights those principles which have been discovered in research and also applied by graziers. There is no absolute answer to questions about grazing management. The central conundrum of grazing management is, “how do you match the conflicting needs of a pasture which grows variably in response to climate with the more or less constant needs of the grazing animal without destroying the natural plant and soil resources which support livestock enterprises”

Definitions of different types of grazing management systems are contained in the document 16-2-Glossary of grazing management terms on the CD-ROM.

As soon as fences withhold animals on less than the whole farm, we are limiting the supply of feed to those animals. In principle, if we were to have a farm with no fences at all then the animals would have absolute choice of what they ate across that whole farm. So, when we restrict animals to less than the whole farm (for any reason), management is limiting, at least to some extent, the ability of the animals to choose their diet.

The manager needs to be confident that his/her decisions to manage grazing will provide benefits to their overall farm operations. You need to know how to resolve the dilemma of looking after the pasture whilst also satisfying the conflicting demands of grazing animals. This is stated succinctly by Willoughby (1970):

"Any ... system of grazing management other than continuous grazing requires that the stock be restricted for a time to less than the whole food supply available and thus introduces the risk of current animal production being depressed. For a management system to be superior to continuous grazing, subsequent access to the previously protected area or material must more than compensate for this prior depression.” (Willoughby, 1970).

This statement clearly shows that any deprivation that causes the animal to restrict its dietary intake must be more than compensated for by the additional growth and/or maintenance of a desirable botanical composition in the pastures that are rested for any period. Of course, when animals first enter a rotationally grazed paddock where a lot of feed is present (say more than 3000 kg DM/ha), they will not initially compete for feed with each other so their intake can be high. But, at high stocking densities, at times as high as several hundred dse/ha, the competition for feed is intense and so they will be competing for feed and thereby reducing their intake within a few days.

16.1 The science behind grazing management

Firstly, let us study some of the fundamentals of science surrounding pastures and animals according to John Hodgson who has worked extensively in the UK and New Zealand.

Grazing management – Science into practice

In his book, Grazing Management – Science into Practice, John Hodgson (1990) describes in great detail the principles of grassland and grazing management and the ecology of grazed pastures. Please read the following synopsis which captures some of the key principles.
Contemplate the interactions between the various components contained in this figure and the “butterfly valves” which moderate rates of flow around the diagram. The processes such as growth, senescence, consumption, digestion and excretion largely govern grazing system productivity. When animals graze pastures, they consume the most digestible green leaf first.

Consider the diagram below and think about how much of the photosynthetic capacity would be removed if most of the leaves were to be eaten. Did you know that Fulkerson, Donaghy, Slack and others have found that ryegrass is best grazed at the 3-leaf stage whereas prairie grass is best grazed at the 4-leaf stage? Why do you think that might be?

**Figure 16.2 Illustration of an established plant of perennial ryegrass with four tillers.**


How many leaves are on each of the ryegrass tillers? Would there be enough for this plant to be grazed without threatening its persistence?
Think about where the energy comes from for regrowth when a plant has all of its leaves defoliated. This energy is built up in the stem bases of grasses when the plant reaches the 3 or 4-leaf per tiller growth stage.

**Figure 16.3** A white clover stolon showing leaf development and stolon branching. Stolons allow plants to avoid grazing and are an important mechanism for white clover survival under grazing. *Source: Hodgson (1990).*

What would happen if stolons didn’t root at the nodes?

Is a plant like white clover tolerant of grazing?

Why is a legume in a pasture so important? Is white clover a perennial? If white clover dies due to extreme drought how can it regenerate in a pasture? Students should have the answers to these questions from prior learning (e.g. Agronomy 211 and Agronomy 321 at UNE).

**Figure 16.4** Cross-section of a mixed sward of grass and clover. *Source: Hodgson (1990).*

The location of green digestible leaf, dead leaves, stem, etc. in the plant canopy is a key to how readily an animal can select a quality diet. There is a very strong interaction between the light interception by a grass sward and therefore its capacity to carry out photosynthesis and its leaf area index (LAI), as shown in the following figure.
Figure 16.5 The relationship between Leaf Area Index (LAI) and light interception by a grass sward. Source: Hodgson (1990).

At a LAI of 4-6, almost all light energy is captured. Thus, an overgrazed sward without much leaf area will not be able to utilise all of the incident light.

The issue of selective grazing is an important one when considering grazing management. Obviously, the greater the opportunity an animal has to select its own diet, the higher the quality diet it is able to eat. In intensive rotational grazing systems where many animals are grazing in one paddock, all animals are competing for a limited resource and hence their capacity to selectively graze and thereby to select a high quality diet is restricted. This is a key issue relating to the productivity of individual animals when grazing swards under rotational management systems. In contrast, when animals have access to large areas, such as when all the gates of a farm are open, they have maximum opportunity for selective grazing and hence choosing the best diet from their perspective. There have been some interesting free choice pen feeding studies in NZ, where sheep given an unrestricted wide selection of feed choices, eat a balance of feeds which meet their protein and energy needs.

The accumulation of increasing amounts of herbage over time is well-known in grazed pastures and is depicted below.

You will note the similarity between the above graph and the stages of growth depicted in booklets such as the PROGRAZE literature and in literature relating to cell grazing which refers to three phases (1, 2 and 3) of growth of a pasture (see Figure 16.7). The figure above shows the very steep rise in the net accumulation of live pasture up to a maximum; beyond that point there is a decline of green pasture and an increasing amount of senescent or dead tissue.
Figure 16.6 The time sequences of (a) herbage accumulation and (b) tissue turnover in a cut sward. The cumulative changes in herbage mass (kg DM/ha) in a sward over time during a period of recovery growth after a cut close to ground level and (b) the corresponding changes in net accumulation due to growth and losses due to senescence and decomposition. Source: Hodgson (1990).

Figure 16.7 Simplified growth curve of pastures. Source: “Management of Profitable and Sustainable Pastures - A Field Guide” (NSWA 1997).
Obviously there is a compromise between having sufficient herbage available and its greenness and digestibility and hence the rate of intake with which an animal can eat that pasture. Not only does this affect the intake of a grazing animal, but it also affects the rate of growth of the herbage; this is depicted in figure 16.8 below.

**Figure 16.8** The influence of sward surface height and LAI on rates of herbage growth, senescence and net production on continuously stocked swards. Relationship between sward height, LAI and rates of herbage growth, senescence and net production in swards grazed by ewes and lambs under continuous stocking. Source: Hodgson (1990).

The amount of herbage intake that an animal can eat is closely related to its capacity to grow wool and to gain weight. As described by Hodgson (1990), herbage intake is affected by the digestion rate, which is related to the quality and maturity of the herbage eaten, the physical structure of the sward canopy and the demand for nutrients and digestive capacity of the livestock eating the pasture; this latter factor is determined largely by the age and productive state of the animal. Intake is also affected by the fouling and trampling of pastures brought about by grazing animals having affected the pasture prior to an animal arriving at a particular plant or part of a sward. In general, liveweight gain is almost linearly related to herbage intake. Note the similarity in the figure below between the herbage intake by various classes of animals and their weight gain or milk yield as it is affected by the height of the sward being grazed. This demonstrates that herbage intake is closely related to weight gain or milk yield. Although not shown here, it is also closely related to wool growth, as wool is a product of protein synthesis just as is milk and meat.

In his text, Hodgson (1990) explains that the critical values of the sward height for continuously stocked animals are generally lower than for rotationally grazed animals. The critical value for ewes and lambs is 4-5 cm in spring under continuous stocking and 6-7 cm under rotational grazing. When pastures are rotationally grazed, animals require a taller pasture in order to maintain adequate levels of herbage intake close to the maximum compared to those under continuous stocking. Of course this will very much depend upon the physiological state of the animals and the species and quality of the pasture and its maturity, as well as its leafiness.
Figure 16.9 Relationships between sward surface height and (a) herbage intake or (b) animal performance in grazing animals under continuous stocking management. Intake and performance are expressed in relative terms. Note that the intake of ewes and lambs starts to fall at sward heights below 7 cm. ‘C’ indicates the critical height for different classes of animal. Source: Hodgson (1990).

It is important to attempt to maintain ideal sward conditions to maximise pasture growth but, in the face of variable growth rates, this is extremely difficult to achieve under Australian conditions. Nevertheless, as shown in figure 16.10 below, ideal conditions have been described for sheep as those swards which are 4 to 5 cm tall.

Figure 16.10 Photograph of grazed pasture which is at an optimum height for grazing sheep. Source: Hodgson (1990).
Another dilemma is presented in the figure below, which shows a negative relationship between intake and utilisation. You will note in the MLA book 'Towards Sustainable Grazing', that producers need to increase utilisation of pastures and yet get high per animal performance. This graph points out how difficult this is because, to increase utilisation, one needs to reduce the herbage allowance, which is associated with lower intake. Hence, once again, there is a need for a compromise between intake and utilisation (see 16-3-Grazing management on CD-ROM).

Figure 16.11 Relationships between daily herbage allowance under rotational grazing management, herbage intake per animal and the efficiency of herbage utilisation. Source: Hodgson (1990).

This very much relates to stocking rate and/or carrying capacity of the farm. As is shown in Figure 16.12, as we increase the stocking rate we tend to depress net production, but we also see an associated decline in losses through senescence as we utilise more of the pasture. Obviously, at extreme stocking rates, growth will crash to zero.

Figure 16.12 The influence of stocking rate on rates of herbage growth, senescence and net production. Source: Hodgson (1990).
An idealised diagram showing the relationship between gain per sheep and gain per hectare is shown in figure 16.13 below. This diagram shows a linear decline in gain per sheep as stocking rate increases. This is not strictly true as, at low stocking rates, there is little competition between animals. Nevertheless, as competition occurs, per animal performance will certainly decline.

**Figure 16.13** The relationship between stocking rate and (a) individual performance or (b) animal production per unit area over a grazing season. Source: Hodgson (1990).

Grazing management also has impacts on the survival and death of internal parasites of sheep and there has been much research conducted on how grazing management affects the health of grazing animals. In general, in order to kill the larvae of internal parasitic worms of sheep, it is necessary for an extended rest period to occur if parasite numbers are to decline significantly. However, the better the nutrition of the livestock grazing infected pastures, the better their capacity to tolerate chronic infections of internal parasites.

**Figure 16.14** Methods of grazing management. Diagrammatic depiction of various methods of grazing management from set stocking through to rotational grazing. Source: Hodgson (1990).
16.2 Grazing management systems

Rotational vs continuous grazing
Continuous grazing is where animals graze a particular area over more or less the entire year. It is the least controlled of the grazing systems. Rotational grazing involves moving the stock from paddock to paddock thus permitting each grazed area to recover somewhat before another grazing; it requires a higher investment in fences and watering points than continuous grazing.

Rotational grazing is claimed to improve the botanical composition of a pasture, reduce animal ‘camp’ effects, result in less waste, and create higher quality pastures. Under Australian conditions, the supposed benefits of rotational grazing over continuous grazing have not been proved in practice except where the species are intolerant of continuous grazing (e.g. lucerne) or where stocking rates are very high. This may be due in part to the fact that under continuous grazing systems, animals can be more selective in their grazing whereas, under an intensive rotational grazing system, animals are forced to eat what is on offer. Following rotational grazing, the grazed paddock is shut up and allowed to regrow for 21-90 days depending on the time of year and growth rate. In New Zealand, some sheep graziers have adopted a rotational grazing system where large numbers of stock are moved each day to a rested pasture paddock.

Writing about the management of native pastures in Queensland, Scattini et al. (1988) summarise the words of Wilson et al (1984) thus:

- "rotational grazing systems do not increase short-term animal production"
- "the botanical change brought about by a grazing system must either increase the density of desirable species or replace an undesirable species with a desirable one"
- "grazing systems are more likely to lead to a useful change in botanical composition when the vegetation contains a number of perennial grasses"
- "rotational grazing systems favour perennial species and continuous grazing favours annual species"
- "the advantage of a grazing system requires many years to become evident, and"
- "the adoption of grazing systems requires additional expenditure in fencing, watering and stock movement."

Cell grazing
Cell grazing is a particular form of intensive rotational grazing. It involves a farm being divided into many paddocks which then allows each paddock to be intensively grazed followed by an extended period of rest. Claims made for such systems include the importance of hoof action in restoring hydraulic function, the importance of plant succession and the redistribution of nutrients – all of which are claimed to allow higher stocking rates. There is much debate about such systems and there is little scientific evidence to support these claims.

Ultimately, it should be remembered that when one forces paddocks to be rotationally grazed, one forces the animals to eat a restricted diet compared to continuous grazing where animals theoretically have greater choice of diet. This can have impacts on productivity per head and per hectare. Ideally, one wants good per animal productivity without compromising overall per hectare performance.

Most farmers practising intensive rotational grazing with long rest periods would rarely have a rest period any longer than 100 days. However, in some situations rest periods can extend as long as 200 days (e.g. if the graze period is 3 days followed by a 100 day rest then that ‘cell’ will require about 33 paddocks). Whilst it may seem from the pastures point of view desirable to have such a long rest period, one has to acknowledge that, whenever grazing animals are not grazing a paddock, then that part of that farm is not being utilised on any of those days by a livestock enterprise which generates money for that farm.
The profitability of grazing systems is more likely to be affected by the species sown, the fertiliser used and the stocking rate than by the grazing system used. These aspects are covered in much greater detail in the attached readings (see especially Chapman et al (2003) in 16-9-Effects of grazing method and fertiliser ... who discusses the interaction of grazing management with species and fertiliser inputs.

Also, see the sections below titled “Are fertiliser inputs really necessary in sustainable systems?”, “Stocking rate” and “Effects of grazing management on different species”.

**Negative effects of grazing**

Treading injury has a cumulative effect during the grazing. Damage is greatest under wet conditions. In a study of the impacts of treading, reductions of pasture yield were by 6, 9, and 12% in years 2, 3, and 4 respectively compared to year 1 when the pasture was newly sown. The zone of compaction is about the top 15 cm. However, stocking rate doesn’t appear to have a large effect. It is possible for vigorous pasture growth to rehabilitate compacted soil but this can take some years, depending on growing conditions (K. Greenwood, pers. comm.)

**Table 16.1 Influence of sheep treading on the regrowth (kg/ha) of a mixed sward at Mount Cotton, Queensland. Source: Humphreys (1981).**

<table>
<thead>
<tr>
<th>Stocking rate (sheep/ha)</th>
<th><em>Lotononi s bainesii</em></th>
<th><em>Digitaria decumbens</em></th>
<th>Other species</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>440</td>
<td>430</td>
<td>20</td>
<td>890</td>
</tr>
<tr>
<td>7</td>
<td>310</td>
<td>420</td>
<td>30</td>
<td>750</td>
</tr>
<tr>
<td>14</td>
<td>150</td>
<td>430</td>
<td>30</td>
<td>610</td>
</tr>
<tr>
<td>21</td>
<td>40</td>
<td>470</td>
<td>20</td>
<td>520</td>
</tr>
<tr>
<td>28</td>
<td>10</td>
<td>490</td>
<td>10</td>
<td>510</td>
</tr>
<tr>
<td>Significance, P&lt;</td>
<td>0.001</td>
<td>N.S.</td>
<td>N.S.</td>
<td>0.001</td>
</tr>
</tbody>
</table>

The table above demonstrates the principle that, in general, grasses are far more tolerant of treading injury than legumes.
16.3 Use of pasture assessment/feed budgeting

This subject is covered in detail in a practical way in PROGRAZE courses run by accredited staff in most States. It is an essential skill that graziers need to acquire so that they can objectively assess the herbage mass and quality of their pastures as well as the condition (or fat score) of their livestock. In this way, graziers are better equipped to manage their grazing systems regardless of their approach to grazing management.

Prograize - extension for grazing management

The focus of this extension package (over 10,000 farmers have now been trained in Prograize across southern Australia) is on assessing pastures and animals in order to determine the optimum grazing management.

The two most critical assessments are herbage mass and digestibility. See the Prograzier article on assessing herbage mass (16-4-How Much Feed Do You Have) on your CD-ROM. Note that the chart in this article relates pasture height to kg GREEN Dry Matter/hectare – not TOTAL.

Also, have a look at the page on your CD-ROM titled 16-5-How much green pasture ... which shows in colour a range of herbage masses for a phalaris-based pasture.

There is a need to focus on animal and pasture benchmarks which are shown below.

Figure 16.16 below shows, for example, that a dry sheep can get equivalent nutrition from 3000 kg DM/ha of 55% digestibility as it can from a pasture with 600 kg DM/ha of 70% digestibility.

Figure 16.16 The relationship between herbage mass and digestibility in providing an equivalent diet for different classes of livestock. Source: PROGRAZE manual (undated).
Plant growth stage is also important for livestock production. Grazing ruminants require at least 7% crude protein and 55% digestibility for maintenance. For growth they need substantially higher levels. A difference of just 5% in digestibility may not seem much but it has a large impact on sheep productivity, including on wool growth. You can check this out when using the GrazFeed software. Thus, it is important wherever possible, to graze pastures that are vegetative, not senesced.

**Pasture benchmarks for sheep**

The minimum pasture herbage mass levels for the various classes of sheep (and cattle for comparison) are shown in Table 16.2. Note that the benchmark is for green herbage mass – not total.

**Table 16.2 Green pasture mass requirements. Source: PROGRAZE manual.**

<table>
<thead>
<tr>
<th>Sheep category</th>
<th>Growth stage</th>
<th>Minimum pasture (kg green DM/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry sheep</td>
<td></td>
<td>400-500</td>
</tr>
<tr>
<td>Pregnant ewes</td>
<td>mid pregnancy</td>
<td>500-600</td>
</tr>
<tr>
<td></td>
<td>Last month</td>
<td>800-1000</td>
</tr>
<tr>
<td>Lactating ewes</td>
<td>Singles</td>
<td>1000-1200</td>
</tr>
<tr>
<td></td>
<td>Twins</td>
<td>1400-1600</td>
</tr>
<tr>
<td>Growing stock*</td>
<td>30% (90 g/day)</td>
<td>500-600</td>
</tr>
<tr>
<td></td>
<td>50% (150 g/day)</td>
<td>700-800</td>
</tr>
<tr>
<td></td>
<td>70% (190 g/day)</td>
<td>900-1000</td>
</tr>
<tr>
<td></td>
<td>90% (250 g/day)</td>
<td>1500-1600</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cattle category</th>
<th>Growth stage</th>
<th>Minimum pasture (kg green DM/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry cow</td>
<td></td>
<td>700-900</td>
</tr>
<tr>
<td>Pregnant cow</td>
<td>7-8 months</td>
<td>900-1200</td>
</tr>
<tr>
<td>Lactating cow</td>
<td>(calf 1-2 months old)</td>
<td>1500-2300</td>
</tr>
<tr>
<td>Growing stock*</td>
<td>30% (0.44 kg/day)</td>
<td>700-900</td>
</tr>
<tr>
<td></td>
<td>50% (0.71 kg/day)</td>
<td>1000-1100</td>
</tr>
<tr>
<td></td>
<td>70% (0.95 kg/day)</td>
<td>1300-1500</td>
</tr>
<tr>
<td></td>
<td>90% (1.20 kg/day)</td>
<td>2200-2300</td>
</tr>
</tbody>
</table>

*Growing stock percentage refers to percentage of maximum growth rate of the animal.*
Calculation of stocking rate based on pasture supply and demand

When one knows the herbage mass and growth rate, one can calculate the likely stocking rate which that pasture can support. An example calculation is shown below for a situation where ewes are about to lamb.

NB. If a pasture is not actively growing, it can only support livestock grazing until the existing herbage is depleted.

<table>
<thead>
<tr>
<th>Supply</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Present pasture mass</td>
<td>1500 kg green DM/ha</td>
</tr>
<tr>
<td>Less required minimum pasture mass</td>
<td>1200</td>
</tr>
<tr>
<td>Available pasture</td>
<td>300</td>
</tr>
<tr>
<td>Plus pasture growth (42 lambing days X 20 kg DM/ha/day)</td>
<td>840</td>
</tr>
<tr>
<td>Total available pasture</td>
<td>1140</td>
</tr>
<tr>
<td>Less 30% wastage for trampling/fouling</td>
<td>342</td>
</tr>
<tr>
<td>Balance available</td>
<td>798</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demand</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement 2.3 kg green DM/hd/day for 42 days</td>
<td>96 kg green DM/hd</td>
</tr>
</tbody>
</table>

No. of ewes = Total available/livestock demand = 798/96

Stocking rate = 8.3 ewes/ha

16.4 Native vs improved pastures

In the recently completed key MLA program, Sustainable Grazing Systems, researchers investigated a wide range of pasture types, inputs and managements. In summing up the pasture findings over 8 sites and 4 years, Sanford (2003) stated:

“Based on the results from the SGS NE (National Experiment), pastures in the HRZ (high rainfall zone) were unlikely to exceed a water-use efficiency (WUE) of 18 kg DM/ha.m. Native and naturalised pastures, by comparison, at best achieved a WUE of about 10 kg DM/ha.mm”.

This means that for a rainfall of say 800 mm, the best sown pastures (with fertiliser) could produce 14.4 tonnes DM/ha/year (18 X 800) whereas native and naturalised pastures (with fertiliser) could produce about 8.0 tonnes DM/ha/year (10 X 800). Of course, the cost of sowing pastures in order to get higher yields needs to be balanced against the fact that most native pastures cost relatively little.

The productivity of both native and sown pastures subjected to either continuous or tactical grazing (with and without fertiliser) is shown in Figure 16.18 below. Tactical grazing tends to result in higher levels of perennial herbage.
Figure 16.18 Total, green and perennial herbage mass over a number of years for a range of pasture types and grazing management systems implemented at Carcoar, New South Wales. Source: Michalk et al. (2003).

Table 16.3 shows the economic and resource impact ratings for the systems tested.

Table 16.3 Economic evaluation and resource impact ratings for the seven treatments tested at Carcoar (Central Tablelands of NSW). Source: Michalk (2003).

<table>
<thead>
<tr>
<th>Pasture type</th>
<th>Grazing management</th>
<th>Rating of resource impacts</th>
<th>EANR(^\text{A}) ($)/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfertilised naturalised</td>
<td>Continuous</td>
<td>-5</td>
<td>179</td>
</tr>
<tr>
<td>Unfertilised naturalised</td>
<td>Tactical</td>
<td>+1</td>
<td>166</td>
</tr>
<tr>
<td>Fertilised naturalised</td>
<td>Continuous</td>
<td>-2</td>
<td>218</td>
</tr>
<tr>
<td>Fertilised naturalised</td>
<td>Tactical</td>
<td>+3</td>
<td>199</td>
</tr>
<tr>
<td>Sown perennial grass</td>
<td>Continuous</td>
<td>+3</td>
<td>250</td>
</tr>
<tr>
<td>Sown perennial grass</td>
<td>Tactical</td>
<td>+4</td>
<td>194</td>
</tr>
<tr>
<td>Chicory</td>
<td>Rotational</td>
<td>+3</td>
<td>235</td>
</tr>
</tbody>
</table>

\(^{A}\text{Equivalent annual net return (annualised over 10 years).}\)
It is clear from the above table that the rating of resource impact (the higher the better) and the annualised net economic return was higher on pastures where fertiliser had been added and higher still where sown pastures were used. However, the economic ratings tended to be higher with continuous grazing than tactical in contrast to the resource ratings which showed quite marked improvements due to tactical grazing.

**Effects of grazing management on different species**

What species is by far the most well known with regards to requirement of careful grazing management? Any search of the literature or textbook will tell you it is lucerne. Why is that? Well, if one thinks about it … lucerne is a plant which provides an upright living haystack of highly digestible nutrients. Being upright means that the grazing animal can bite off all leaves and stems except for the woody crown. And as it is so high in quality, animals have rapid intake and hence will repeatedly eat any new regrowth from the crown if given a chance. This leads quickly to the depletion of the energy reserves in the plant and ultimately to the plants dying.

What about pasture plants at the other extreme? Do they get grazed out readily? Consider, for example, tussocky poa (*Poa sieberiana*). It is relatively low in digestibility and usually has a lot of senesced leaves of particularly low digestibility. It is difficult to remove through grazing and commonly persists very well in continuously grazed paddocks.

In between, we have many plants that range from very tolerant of grazing (e.g. kikuyu) through to others which can disappear if grazed continuously (e.g. perennial ryegrass).

In the case of the paper by Chapman *et al* (2003) the focus is largely on phalaris (a perennial grass) and subterranean clover (an annual legume). Both these species are relatively tolerant of continuous grazing because they are well adapted to withstanding animals with their prostrate habit under grazing.

The results of this study could well have been quite different if the species under study were different. In general, the more digestible the pasture plant, the more important it is that the plant is rested in between grazings.

### 16.5 Decision support tools

Models of grazed pastures will ultimately be put into decision support systems which will be capable of making sophisticated predictions to aid graziers to manage risk better. During residential school students will experience the use of decision support systems and especially the use of GrassGro and GrazFeed so that you can gain an appreciation of the linkages between various parts of the grazed ecosystem.

**GrazFeed**

One of the best tools for assessing the consequences of varying amounts of herbage mass and quality on livestock production is that provided by the Decision Support Tool GrazFeed. GrazFeed predicts animal growth and reproduction based on intake which is linked to herbage mass and quality. This is a computer-based version of the Australian Feeding Standards for Ruminant Livestock. During the residential school you may be given an opportunity to use this Decision Support Tool to evaluate the consequences of varying supplies of herbage mass and quality and legume percentage on liveweight gain and wool growth.

**GrassGro**

GrassGro is a comprehensive decision support tool, based upon systems science, which provides a powerful tool for understanding complex ecosystems. GrassGro uses daily climate data to drive a soil water and pasture growth model which then interacts with GrazFeed on a daily basis to predict animal growth. Management rules are provided in GrassGro to allow for various joining, shearing dates, stocking rates, etc.
It allows the calculation of plant and animal responses to a wide range of soil and daily weather conditions. It is capable of being adapted for any pasture species in any region of the world although, to date, it has been most thoroughly tested in the high rainfall temperate zone of Australia.

16.6 Remote sensing of feed on offer

Over recent years the technology for measuring pastures from space has improved dramatically with trials extending from Western Australia through to Victoria and now into Queensland.

The CD-ROM contains an article by David Henry, titled Managing Cows from Space (16-6-Managing cows from space). Another article from the Spring 2001 issue of Prograzier (16-7-Satellites Now Measure Pastures) describes the technology in a little more detail and shows an example of a false colour image displaying varying amounts of feed on offer.

This technology involves satellites being able to scan parts of the earth’s surface with light reflectance detectors measuring various parts of the spectrum, both visible and invisible, including the infrared and near infrared wavelengths. You may be aware that it is common practice these days in laboratories to measure pasture quality using near infrared spectrometers (NIR). These detectors mounted on satellites are basically a flying NIR reporting back to earth with data, which is transformed by computers and can be made available for particular farm areas. This technology is very suitable for measuring paddocks greater than six hectares and is the only way – apart from data captured by flying aircraft – that one can get an integrated assessment of the whole farm’s herbage mass at a particular time.

As this technology improves, not only will herbage mass be measured, but so will herbage quality. These are the two guiding principles influencing animal growth described in the PROGRAZE extension package that has been used so successfully around the various states of Australia. An additional factor that can be measured by remote sensing is an estimate of pasture growth rate; this is one of the key factors governing the stocking density that can be supported by a pasture at any one time.

Thus, ultimately we will have increasingly valuable assessments from space of herbage mass, herbage quality and growth rate and, in time, the pixel size (or resolution) of these images will improve as satellite technology improves. In spite of this technology, you still need to be well equipped yourself with some skills in assessing the herbage mass and quality of pasture and have an appreciation of the likely growth rate of pastures. You would no doubt benefit from taking a PROGRAZE course if you want to improve your pasture assessment skills.

16.7 Sustainability of grazed pastures

Think about the term ‘sustainability’. What does it mean to you?.

One useful view is to consider a pasture or a farming system as one comprised of layers. In order for the system to function properly over time, all its parts need to function well. That is, a whole farm needs to be sustainable. A farm is comprised of its paddocks, soils, pastures and crops, animals, financial viability, human capital, etc; all of these components need to be cared for if sustainability is to be an achievable goal.
$u$tainability is a question of balance

Figure 16.19 showing layers supporting a $u$tainable system. Note the differences in farmer priorities to biophysical importance. Source: Scott et al. (2000).

According to Scott et al. (2000), measures of ‘sustainability’ should include:

• biophysical and
• economic components
• trends over time of natural capital status, and
• assessments of any off-site effects.

Measuring sustainability
Ultimately a complex matrix of sustainability indicators and production benchmarks will need to be met in order to be deemed ‘sustainable’. This is an important current issue for much of Australia’s livestock production areas.

The question of quantifying sustainability has been tackled for grazed pastures by Scott et al. (2000) where the authors compiled data and trends over time for a number of soil, pasture, animal, production and economic parameters. Some of these measurements are summarised here for three different pasture types, all on similar soil and fertilized at the same rate. The pastures were all based on the same original phalaris/white clover pasture sown in 1966. Over time some paddocks had become ‘degraded’ by losing most of the phalaris and white clover. Other paddocks (‘phalaris’) had lost the clover component. The third treatment was also phalaris dominant but had white clover re-established in autumn 1994. These pastures were found to have quite different sustainability characteristics (see Table 16.4).

The combination of a deep rooted perennial grass (phalaris) with a persistent legume (white clover) resulted in more water extracted in autumn (thus a bigger ‘bucket’ to fill up when it rains), least runoff during a storm, more nitrogen at the surface (thus more productive) and yet less at depth (less leaching of nitrate), more wool growth and liveweight gain per head and per hectare and more financial returns. Thus, it was assessed as the most ‘sustainable’ pasture of the 3 compared.
Table 16.4 Some measurements of soil sustainability and livestock production factors in an experiment comparing the sustainability of three different pasture types.

Source: Scott et al. (2000).

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Units</th>
<th>Degraded pasture</th>
<th>Phalaris pasture</th>
<th>Phalaris/white clover pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water extracted in 4 week drought in autumn</td>
<td>mm</td>
<td>28.0</td>
<td>38.0</td>
<td>51.0</td>
</tr>
<tr>
<td>Run-off following a 106 mm rainfall event</td>
<td>mm</td>
<td>3.0</td>
<td>24.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Mineral N (0-5cm) at Feb-97</td>
<td>µg N/g soil</td>
<td>13.5</td>
<td>13.0</td>
<td>29.0</td>
</tr>
<tr>
<td>Mineral N (40-60cm) at Feb-97</td>
<td>µg N/g soil</td>
<td>1.6</td>
<td>3.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Wool growth</td>
<td>kg/hd/yr</td>
<td>3.0</td>
<td>3.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Liveweight gain</td>
<td>kg/hd/yr</td>
<td>5.5</td>
<td>10.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Stocking rate</td>
<td>dse/ha</td>
<td>9.9</td>
<td>14.0</td>
<td>14.8</td>
</tr>
<tr>
<td>Liveweight gain/ha</td>
<td>kg/ha/yr</td>
<td>54.5</td>
<td>140.0</td>
<td>222.0</td>
</tr>
<tr>
<td>Wool produced/ha</td>
<td>kg/ha/yr</td>
<td>29.7</td>
<td>47.6</td>
<td>68.1</td>
</tr>
<tr>
<td>Gross return/ha (@$1.00/kg LW and $6.00/kg wool)</td>
<td>$/ha/yr</td>
<td>$233</td>
<td>$426</td>
<td>$631</td>
</tr>
</tbody>
</table>

Conclusions on a ‘sustainable’ grazing enterprise:

These authors found that a sustainable enterprise is:
• based on partnership between a nutrient responsive grass and an active legume
• is profitable over the long-term, and
• causes no significant detriment to the plant and soil resources.

A further important principle in sustainability is that it is necessary to survive bad seasons with the farm’s natural capital in good condition.

Ultimately, a sustainable system is one where the farmer lives off his/her ‘interest’ rather than their ‘capital’.

Sustainable grazing enterprises are built on inter-related layers, each supporting the next - with long-term profit being the ultimate aim.

They require sufficient green digestible leaf to be produced by persistent plants. Quality pasture depends on:
• climatic constraints
• pasture species present
• productive capacity of the soil, and
• grazing management.

The last 3 of these can all be managed by the farmer.
Looking after natural capital
In many parts of high rainfall Australia (and in many parts of the world) over clearing for grazing has led to problems for the landscape. Ultimately we must have systems in hydrologic balance. Some state that we need 30% of the landscape under trees as they act as effective ‘water pumps’. However, so do productive deep-rooted pastures. For example, this is being achieved in south-western Australia using kikuyu as a productive pasture which is capable of effectively tapping into ground water supplies.

Soil is the fundamental productive resource of our farms - we need to build productive pasture systems on a sound foundation by having healthy soils:

A well aggregated soil will allow water to enter readily (infiltrate) and be released easily to plants. This is influenced also by the degree of compaction - measured by soil strength and bulk density. These soil properties can be affected by grazing animals. On the negative side, animals can compact the soil. However, through applying nutrients as dung and urine, they help the surface soil to contain active micro-organisms and plants which in turn help soil structure. Also some grazing increases net plant growth from a pasture and so animals can increase overall production. The nutrient capital of a soil greatly affects the productivity and persistence of plants growing on that land.

Microbial activity is crucial for healthy soil processes. These depend particularly on labile soil carbon (i.e. the fraction which is readily broken down by microbial action – not lignified tissue) being available as an energy substrate for microbial function. Microbial organisms turn over nutrients and exude polysaccharides which help ‘glue’ soil particles together, giving soil its structure.

Pasture sustainability
Ideally, we want pastures to last for decades without a need to re-plant them. This means that management of pastures over the long term is crucial. Keeping a desirable pasture composition will greatly assist a farmer to remain financially viable and minimise problems such as weeds, vegetable fault, etc. Pastures can last for decades provided that management (i.e. grazing management and maintenance of adequate nutrition) is good.

The crucial elements for productive animal enterprises are the quantity and quality of the feed available. Managing for high levels of green, digestible leaf is an important objective. Animal production is driven by the availability of green digestible leaf.

Animal sustainability
Weight losses need to be avoided - both for animal welfare and for production aims. Reproductive performance is also dependent on good nutrition. Good pastures also help animals resist internal parasites. Animal productivity depends largely on the feed available. Quality products (tender meat and fine wool with sufficient strength) are increasingly being sought to satisfy demanding markets. In future, desired growth rates will need to be attained from pastures if graziers are to get top prices for their products. As meat, milk and wool are all protein-rich products, we need pastures that supply sufficient energy and protein – hence the need for high protein (highly digestible) pastures.

Is biodiversity important in grazed pastures?
The term ‘Biodiversity’ is commonly used to refer only to native plant species. We contend that it should include all plant species and associated biota. A clear link has not been reported between plant biodiversity and livestock productivity. The major published claims for biodiversity function are based on undisturbed communities - not grazed pastures. Hence I suggest that biodiversity is not important for productive livestock enterprises.

That is not to say that biodiversity per se is not important from the point of view of preservation of diversity in natural ecosystems. But pastures managed for livestock production are not intended to be suited to the preservation of rare and endangered species. Even though they may not be ‘biodiverse’, there are examples of sown perennial pastures that are still productive some 80 years after being sown (R. White, pers. comm.).
It is difficult to manage pastures to retain a suitable balance between 2 or 4 species, let alone attempt to manage for 40 species. In productive livestock systems, we need as many of the plants producing digestible green leaf as possible, hence the need for relatively simple and manageable botanical compositions.

In the recent Sustainable Grazing Systems Key Program, herbage accumulation was less and growth more variable in pastures high in biodiversity.

In a paper summarising the biodiversity theme across this research program, Kemp et al (2003) stated:

“Total diversity and productivity

Across sites there was a small tendency for net annual herbage accumulation to be less on the more diverse treatments (see Figure 16-21 below) as indicated in the regression modelling …. No site showed any apparent increase in species number with increasing productivity”.

That is, the highest annual growth was observed in pastures comprising about 10 species while annual growth tended to decline as the number of plant species increased to 40 or more (Figure 16.21).

Figure 16.21 Mean relationship between total species richness (ie biodiversity) and total annual herbage accumulation in grazed pastures across 6 sites.

Are fertiliser inputs really necessary in sustainable systems?

There is ample evidence that low fertility constrains the productivity of Australia’s pastures – remember that Australia’s soils are some of the oldest and most leached in the world. Fertiliser inputs are therefore necessary to relieve this constraint. There is a commonly held perception that fertilisers cause soil acidity. We know that acidity is linked largely to leaching events (especially of nitrate) and is a common natural occurrence. We can manage our soils to minimise leaching of nitrate and thereby minimise soil acidification. Remember also that product removal means nutrient depletion. We cannot have sustainable systems if nutrients are not replenished. We can get N and C fixed from the atmosphere but P, K and S exported from the system have to be replenished by using fertilisers.

We need to recognise the nutrient cycles which flow from the soil to the plant to the animal and then, through dung and urine, back to the soil again.

Figure 16.22 was constructed based on 4 experiments conducted in different regions across Australia to explore the interaction between fertiliser inputs and stocking rate on wool production. We propose that the data suggest a region of sustainability shown as the optimum range below.

Figure 16.22 Combined data from 4 experiments across southern Australia suggesting an optimum balance between fertiliser inputs and stocking rate.

Source: Scott et al. (2000).

The combined data suggest a boundary region defining sustainable grazing systems. This boundary region is associated with:

- sufficient nutrients
- little supplementary feeding
- little loss of desirable plants and
- utilisation of feed grown using sufficient stock.
**Stocking rate**

Stocking rate is one of the most important determinants of the profitability of a livestock enterprise.

**Figure 16.23** Stocking rate affects different components of the system and different enterprises in a range of ways. Source: Andrews (1997).

![Diagram showing the effects of stocking rate on different components of the system](image)

At high stocking rates, wastage of pasture is reduced - hence more of the plant production is utilised by the animals. At very high stocking rates, the pasture fails to support the animals and deaths can occur.

In Australia, year-round stocking rates on highly improved pasture can be as high as 15 sheep/ha and sometimes even more. The more productive a pasture is, the more complicated the management needs to be.

Any stocking of newly sown pastures should be lenient until the pasture plants are well established with a strong root system. With surface sown pastures, the pasture may need to be left ungrazed for a year or more.

There is an interaction between the stocking rate and gain per head and per hectare and the types of pastures which the animals are grazing, as well as the nutrient inputs into those pastures. It is the type of pastures and the nutrition of those pastures that largely determines their potential for growth, particularly in producing highly digestible green leaf. This is one of the key principles of this whole section on livestock production that ruminant livestock production depends on the availability of digestible green leaf.

Think about the types of pastures that your animals graze. How often are they green? When they are green, what is their digestibility? When they are dead, what is their digestibility? How easy are the pastures for the animals to bite, chew and digest? Do they have any anti-nutritional components in the forage that might limit animal production? Of course species vary enormously in these attributes and hence it is crucial that you understand for your area and your situation those species which have the capacity to produce the most digestible green leaf over the long term.

There is little point in producing masses of high quality feed that only lasts for a few weeks when it may be possible to have other species grow over a more extended period with perhaps a somewhat lesser peak level of quality feed available. Thus grazing management decisions necessarily involve compromise.
At low stocking rates, grasses are favoured in mixed pastures whereas at high stocking rates, clovers and other broadleaf plants tend to predominate.

The plant species can determine the profitability of an enterprise at stocking rates near the optimum. For example, phalaris persists better under grazing than cocksfoot and tall fescue which are better than ryegrass.

The choice of stocking rate for a particular area should be made with whole-farm profitability in mind as stocking rate affects many things including the survival of perennial pastures, the amount of fodder conserved or purchased, the amount of stock trading, the degree of risk, etc.

The most important determinant of stocking rate is the growth rate of the pasture. Stocking rates affect production per head and per hectare and optimum rates will vary with time and level of inputs. Thus an ‘optimum’ stocking rate is an elusive goal.

Readings

1. 16.1 – Grazing management systems.
5. 16.5 – How much green pasture is available in your paddocks?
6. 16.6 – Managing cows from space.

Your reading materials include 6 publications. However, before embarking on these readings, you might like to contemplate the following appropriate quote which demonstrates how difficult it is to manage grazing enterprises.
"In some utopian grazing world, pasture would be produced in constant amounts for animals whose appetites never varied. The feedlot best represents this ideal situation, particularly for the raising and fattening of beef cattle and milking cows for urban supplies... This type of farm enterprise has only limited application in Australia, where ruminant animal nutrition is geared almost entirely to the pasture feed cycle, for economic as well as climatic reasons" (Christian, 1987).

Towards Sustainable Grazing (16-3-Grazing management)

In the book 'Towards Sustainable Grazing – The Professional Producers Guide', published by Meat and Livestock Australia, Chapter 8 concerns grazing management. It also includes descriptions of the key principles for optimising pasture growth and composition, utilising that feed and yet achieving desired growth pathways for livestock whilst looking after the environment. Although these factors are described in some detail, achieving the correct balance on real farms remains a very challenging task. Nevertheless, you’ll find in this chapter some very current and interesting information about the consequences of different types of rotational grazing or set stocking on animal production and on resource sustainability.

A useful classification used in this chapter of rotational grazing systems puts them into three groups, namely:

- time-based
- plant growth-based, and
- animal intake-based.

This chapter goes on to describe several critical management factors determined from this research such as the stocking rate, the livestock enterprise type and the time of lambing or calving and the degree of subdivision and grazing method. When it comes to ‘The Great Grazing Method Debate’ in this chapter you will find discussion there in brief, that is expanded upon in another article contained in one of the Prograiser magazine articles (see 16-12-Great Grazing Debate ... document).

You will note that this chapter concludes that successful practices include ‘tactical grazing’ which, in reality, is ‘having a bet both ways’. That is not to say it is wrong – the authors suggest that at times, it is valid to continuously graze certain pastures and at other times it makes sense to rotationally graze pastures. It is understanding under which conditions one does either that you will need to read more literature in order to understand this.

Article by Norton (16-8-The application of grazing management ...)

An interesting analysis of the science behind grazing management has been published by Dr Ben Norton of Utah State University. He presented this analysis in the McClymont lecture at the Australian Society of Animal Production Conference held in 1998. In this paper he thoroughly investigates the different opinions of rotational grazing formed by scientists investigating the phenomena they have observed and the great conflicts of opinion that have occurred between the scientists and some proponents of rotational grazing and also some graziers who have used rotational grazing systems at times to great effect.

This paper outlines the reasons behind some of the different opinions that occur in the popular press and the scientific literature concerning the pros and cons of grazing management in any system. In particular, he addresses the spatial dimension and the tendency for researchers to have used small paddock studies, often using fixed rotational times, in their investigations compared to farmers who are working at a very different scale and who also are likely to use quite flexible rest periods in any rotational grazing that they implement. The consequences of these two differences of space and of flexibility in rest period are the key, I believe, to why there are differences between the scientific literature and practical experience.

Chapman et al (16-9-Effects of grazing method and fertiliser ...)

One of the key papers attached to your notes is a scientific paper by Chapman et al 2003, titled ‘Effects of Grazing Management and Fertiliser Inputs on the Productivity and Sustainability of Phalaris-based Pastures in Western Victoria’.

This is a well written and thorough analysis of the dual effects of fertiliser and grazing management on productivity and sustainability. Scott 2003 (16-10-Measuring whole-farm sustainability ...)

Scott (2003) describes how attempts are being made to measure profitability and sustainability at a credible scale - that is, credible to farmers and to researchers.
Only through objectively measuring whole-farm systems can we determine the facts of such complex practices and their implications – not only for profits over the long term – but also for maintaining the natural resources upon which our sustainable grazing enterprises depend.

Scott et al. 2000 (16-11-Quantifying the sustainability of grazed...)

This paper is that referred to above under the sustainability discussion. It describes how an experiment was conducted to measure the sustainability of 3 quite different pastures. Many factors were measured over time in all important layers (soil, pasture, animal, production, economic) to produce a matrix of sustainability measurements. By reading this paper, you will come to understand more about how we might be able to assess ‘sustainability’.

The Great Grazing Debate article (Prograzier magazine of winter 2003) (16-12-Great Grazing Debate ...)

This article settles on tactical grazing as the best option. It provides a brief summary of the evidence from the research as well as the information coming from farmer testimonials and feedback. There are also a useful set of guidelines about improving the persistence of certain species, increasing growth rates, increasing utilisation of pasture and improving environmental sustainability.

Compromise (16-13-Compromise Needed Between ...)

The attached article written by Geoff Saul titled ‘Compromise Needed between Production and Protection’ describes how a balanced approach is needed. All this talk about compromise ultimately means that we need to be able to determine optimal solutions when we are deciding on grazing management, i.e., optimal solutions between what is good for the feed base or the pasture and for the consumer of the feed base, the animal. It is not appropriate to talk about maximum pasture growth and maximum animal growth as an optimal solution demands compromise between these two parameters.

I have become increasingly interested over recent years, as I have worked with a local grazier group called The Cicerone Project (http://www.cicerone.org.au), in whole-farmlet studies which examine the sustainability and profitability of entire systems.

Rotational Grazing

There is an interesting article in the autumn 2000 edition of Prograzier titled “Rotational Grazing: Going Around in Circles” (16-14-Rotational Grazing...) in which David Chapman describes how they went about investigating rotational grazing and some comments from graziers practising these methods of grazing management.

Drought management

When managing pastures in drought, special attention needs to be paid to the viability and persistence of desirable species. If this does not occur, these valuable species will be lost from a pasture causing degradation, weed invasion, possible soil erosion and great cost in bringing desirable pastures back into the system. See a link here to the two page tips and tools titled, Looking after Your Pastures in Drought (16-15-Looking After Your Pastures...).

Profit drivers of grazing systems (16-16-Key drivers of profitability ...)

A paper by Phil Holmes (1999), an experienced consultant with Holmes Sackett and Associates from Wagga Wagga in New South Wales, talks about some of the key profit drivers of grazing systems. He particularly stresses the need for any agricultural system to focus on (i) how much product is produced per hectare, (ii) how much it costs to produce and (iii) the price received.

Of course today we are also very much concerned with production and profitability over the long term whilst sustaining our natural capital that enables us to earn income at future times (by future generations). Thus there are a number of other factors to consider on top of those three key profit drivers identified by Holmes. He talks about lowering the cost of production and one must be aware that for ruminant animals this often comes down to feeding animals for a minimum cost. Whilst this can happen by putting the chequebook away and not spending any money, ultimately, if one is to carry sufficient stock to allow reasonable production per hectare, then inputs are certainly necessary and it is the cost per kilogram of digestible nutrients that is the key profit driver.

Pastures are by far the cheapest form of nutrition for grazing ruminants, as they can produce one tonne of feed for as little as $10 to $30 per tonne (dry matter) per year (Scott, 1996). When one contrasts this with prices for hay of $180 per tonne through to grain of up to $500 per tonne (and more during drought) it is easy to see the relative costs of pasture being much lower than...
purchasing grain for supplementary feeding for example. Even with irrigated pastures for dairy production, the cost per tonne of the grain may rise but rarely above $60 per tonne of dry matter produced. Of course, the nutritional value of 1 tonne of pasture is usually lower than that of grain but the difference may be only 30% which is much less than the price differential of up to 2000%!

Another vital point made by Phil Holmes in this paper is that, “Compound interest is the eighth wonder of the world and the great tragedy is that few people generally realise this and even fewer put it to work on their behalf”. You will note in many of my publications about sustainability that I talk about profitability and sustainability over the long term. It is this capacity to have a surplus, build upon a surplus, build upon a surplus, etc. that allows successful and profitable grazing enterprises to be built over periods of decades. Thus, building a successful grazing enterprise requires a long-term policy in much the same way as relying on compound interest over long periods of time for superannuation.

Obviously this is impossible to achieve during extreme drought periods, but good managers control their losses during severe drought seasons and limit the degradation of their natural resources and yet put themselves in a position to capitalise on the good times, which do occur at irregular intervals over periods of decades. Thus, it is vital that producers have pasture species on their farms which have the potential to grow rapidly producing quality feed over long periods of time when favourable climatic conditions occur. Those who, for example, have significant nutrient constraints on their farms or who have species that are relatively unresponsive to favourable conditions will not benefit nearly as much from favourable seasons as those who maintain their properties in a productive condition.

In Australia, we have a highly variable feed supply, both between years and within years. This makes the management of grazing animals on pasture resources particularly difficult. Again this requires significant compromise.

The seasonal variation in the herbage supply (growth) is often extreme compared to the gradual changes in requirements of various grazing animals over the grazing year (as the animals grow, reproduce, etc.).

Activities

Available on WebCT

Multi-Choice Questions

Submit answers via WebCT

Useful Web Links

Available on WebCT

Assignment Questions

Choose ONE question from ONE of the topics as your assignment. Short answer questions appear on WebCT. Submit your answer via WebCT

Summary

Summary Slides are available on CD

Grazing management aims to match the needs of a pasture with the needs of a grazing animal (both of which vary considerably) and plays a critical role in determining the profitability and sustainability of farming enterprises. The best grazing management system has long been discussed and is essentially unresolved. Given this, it can be said that there are principles behind grazing management that will apply in some but not all situations and it is up to the farmer to decide what works best for their production enterprise. There are a number of decision support tools available to assist farmers in developing grazing management systems.
References


New South Wales Agriculture, 1997 'Management of profitable and sustainable pastures' - a field guide (NSW Department of Primary Industries).


N.S.W. Prograze Manual (undated), N.S.W. Department of Primary Industries.


Tips and tools
You will find on your CD a pdf brochure titled SGS Tips and Tools for Making Change. In this booklet you will find useful summaries of practical tips and tactics that can be used in implementing either continuous grazing or time-based rotational grazing, intensive rotational grazing, the maintenance of perennial-based pastures, grazing of native pastures and getting the most out of phosphorus fertiliser applied to soils. There are also tips on managing soil biology and minimising the loss of water either as run off or as deep drainage. These latter points relate very much to the sustainability of our grazing systems.

Glossary of terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell grazing</td>
<td>grazing animals within a &quot;cell&quot; consisting of a large number of paddocks of a size which permits a high stocking density to be applied to each paddock for a suitably short period. Grazing and rest periods are determined according to available herbage and estimated rate of recovery of desired pasture species</td>
</tr>
<tr>
<td>Continuous grazing</td>
<td>similar to set stocking but it is a less confused term describing a more common situation</td>
</tr>
<tr>
<td>Dry sheep equivalent (dse)</td>
<td>the dry sheep equivalent of a livestock class is defined in the PROGRAZE manual as the feed requirement of that livestock class relative to the feed requirement of a two-year old 50 kg Merino wether</td>
</tr>
<tr>
<td>Intensive rotational grazing</td>
<td>stock moved to a fresh pasture regularly (up to twice a day). The pasture rest period is long compared to the grazing period</td>
</tr>
<tr>
<td>Leaf area index (LAI)</td>
<td>the ratio of the sum of the area of all the plant leaves divided by the surface area of the ground on which those plants are growing. A dense pasture can have a LAI of 5 or more</td>
</tr>
<tr>
<td>Rotational grazing</td>
<td>rotating stock around a number of paddocks. Movement can be based on fixed time period, plant regrowth or animal intake</td>
</tr>
<tr>
<td>Rotational grazing types:</td>
<td></td>
</tr>
<tr>
<td>Rotational grazing</td>
<td>Time (calendar) based uses fixed time intervals for stock movement</td>
</tr>
<tr>
<td>Rotational grazing types:</td>
<td>Pasture growth based aims to keep pastures in their most active growth stage (represented by feed-on-offer [kg DM/ha], pasture re-growth phase or leaf stage)</td>
</tr>
<tr>
<td>Rotational grazing types:</td>
<td>Animal intake based provides a calculated amount of feed per animal per day</td>
</tr>
<tr>
<td>Set stocking</td>
<td>animals grazing a paddock for an extended period, at the most extreme, for the full year. Animals are usually only moved for husbandry activities or if paddock feed runs out. In practice it is an ambiguous term with a range of meanings and we recommend that the term be no longer used (see Continuous grazing)</td>
</tr>
<tr>
<td>Stock density</td>
<td>the number of dry sheep equivalents/ha in a paddock at any one instant</td>
</tr>
<tr>
<td>Stocking rate</td>
<td>the total number of dry sheep equivalents/ha on a farm/paddock averaged over a calendar year = total dses carried over the year/area/365</td>
</tr>
</tbody>
</table>