final report

Project code: B.ERM.0304

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Date published: July 2007

PUBLISHED BY
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Development of a One Day Workshop for Catchment Management Authorities (CMA) Staff

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

This project developed a draft one day workshop for CMA staff in southern Australia, conveying the key messages about the interconnection between producer production issues and NRM. The project produced an outline of a workshop, lesson plans and participant manual. The workshop and participant manual was based on the PROGRAZE training course and highlighted pasture assessment, perennials and water balance, nutrient use, soil stability, weed ingression, grazing management and basic ecology grazing planning, feed budgeting and targeting markets, casestudy of a farmlet to demonstrate grazing impacts of decisions to remove land from grazing, and outline a group exercise, to develop in the participant's minds how to better communicate with the producers on NRM matters in a grazing business context.

Lesson plans for the delivery of the workshop were drafted.

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Objectives
By 20 July 2006:

1. Have developed, piloted and evaluated a one day workshop for CMA staff in southern Australia, that conveys the key messages about the interconnection between producer production issues and NRM

2. Developed and delivered to MLA the lesson plans, participant notes and resource material required for the conduct of workshop

Results
The project successfully developed the project notes, lesson plans and group exercise conveying the key messages about the interconnection between producer production issues and NRM.

The workshop and participant manual was based on the PROGRAZE training course and highlighted pasture assessment, perennials and water balance, nutrient use, soil stability, weed ingression, grazing management and basic ecology grazing planning, feed budgeting and targeting markets, casestudy of a farmlet to demonstrate grazing impacts of decisions to remove land from grazing, and outline a group exercise, to develop in the participant's minds how to better communicate with the producers on NRM matters in a grazing business context.

Lesson plans for the delivery of the workshop were drafted.

The workshop was not evaluated in a pilot.

Further development required a broader interaction strategy (training, engagement in R&D project etc) with catchment management staff which was beyond the scope of this project.

APPENDIX 1

CMA Training Workshop
Managing for Production and NRM/ Environmental Sustainability

Workshop Content

Segment 1 Running a Sustainable Grazing Business

Segment 2 The Water Cycle

Segment 3 Pasture Assessment

Segment 4 Animal Production from Pasture / Meeting your Markets

Segment 5 Feed Budgeting

Segment 6 Principles of Plant Growth

Segment 7 Grazing Management of Pastures / Grazing Systems

Segment 8 Plant Nutrition – Assessment and Monitoring

Appendix
Paddock Monitoring Tools
The Pasture Health Kit (from MLA)
The Sustainability Profile (form MLA)

Workshop length: 5 hours 30 mins

9.30 – 10.45	1 hour 15 mins
10.45- 11.00	morning tea
11.00-12.30	1 hr 30 min
12.30-1.00	lunch 30 mins
1.00-2.00	theory 1 hour
2.00-2.30	practical 30 mins
2.30-2.45	afternoon tea 15 mins
2.45-4.00	1 hour 15 mins

Mixture of theory/classroom and practical

Segment 1 Running a Sustainable Grazing Business

It is often claimed that “it’s hard to be green when you’re in the red”.

This highlights the importance of profitability as a key focus for all grazing operations. Indeed profit is often considered the most common measure of the short term health of a grazing business.

However it is imperative that equal consideration is also given to social and environmental objectives if that profit is to be maintained over the long term. This integrated approach is referred to as the 'Triple Bottom Line' in which all three components must be in balance for long term (farm) sustainability.

A sustainable grazing system on farm has been defined as:

"A process of continuous improvement that balances the following six general requirements and prioritises them for a particular farm situation:

1 Increase productivity and profit from the grazing system
2 Increase water use in the grazing system
3 Protect the on-farm natural resources
4 Create more opportunities for biodiversity
5 Reduce off-site impacts from the grazing system
6 Improve producer satisfaction, motivation and capacity to implement change ".

Farm managers need to determine the appropriate balance between each of these six financial, social and environmental issues.

Figure 1 Intro TSG

The purpose of this Training Course is to provide some practical guidelines for advisors to assist graziers in helping to determine and/or prioritise this balance. Emphasis is placed upon providing greater understanding of the principles involved in addressing this balance but also in describing some simple tests and tools which can be undertaken on-farm to assess the current status and monitor changes over time.

The Sustainable Business Approach

Graziers are under continuing pressure to realize a profit as a consequence of the continuing and escalating cost–price squeeze and high overhead costs. This in turn is making it increasingly difficult to manage their natural resources, placing extra demands upon the environment both on and off farm.

This is reflected in increasing concerns about such factors as erosion, weed incursion, salinity, soil health, chemical residues and biodiversity decline. On top of this, the wider community has growing expectations about the overall health of the rural environment with emphasis upon such things as clean water and a return of native trees and animals to the landscape.

All of this places a further burden upon the social or 'people' aspect of running a farming business.

Key Profit Drivers: Dollars and Sense

The two elements that influence return on investment and determine profit are *income* and *costs*.

Income is determined by the quantity of product and the price received per unit of product. The higher the price received for a commodity, the greater the income – but not necessarily the greater the profit.

While producers can improve the prices they receive by enhancing quality or undertaking better selling/marketing option, they have much greater impact upon profitability by influencing the *quantity* of product produced and *cost* structures. These are referred to as the *major farm profit drivers*.

Fixed costs are those which the landowner is obligated to pay regardless of farm stocking rates and include rates, insurances, loan repayments etc.
Variable costs are those associated with the actual running of the enterprise and will vary according to stock numbers.

The easiest way to reduce costs on-farm is to spread the fixed costs over as much product as possible and in doing so reduce the important *cost of production*. Having a thorough understanding of cost of production is a key indicator of farm profitability.

Farm benchmarking studies have shown that the most financially successful producers do some or all of the following:

- Have higher stocking rates than the district average
- Know their costs of production per kg of product and tend to be in the lowest 20%
- Have a business management focus
- Objectively assess –and usually record – pasture and animal performance
- Are prepared to spend a dollar to make two dollars
- Run many more stock per labour unit than the district average
- Continually benchmark their performance relative to others

Key Social Drivers

A successful grazing enterprise is one which builds “social capital”, that is the enhancement of the personal development of the land manager.

Social capital can be defined by the extent to which producers build up:

- A sense of satisfaction from involvement in the grazing industries
- Pride and a sense of accomplishment in their products and production systems
- Linkages and networks with others who share common values and goals
- Skills and related knowledge in managing grazing systems; and
- Motivation and confidence to continually improve the grazing business

Key Environmental Drivers – Protecting the Farm Engine Room

Historically environmental outcomes have not been recognized as key objectives as in grazing businesses. This has resulted in potential depletion and run-down of the environmental capital in the grazing business.

Environmental capital can be defined by the extent to which producers build up:

- The onn which the production system directly depends – soils and pastures
- The farm’s natural resources, such as native vegetation, riparian zones, and waterways
- Practices that minimize impacts from the grazing business on the off-farm environment

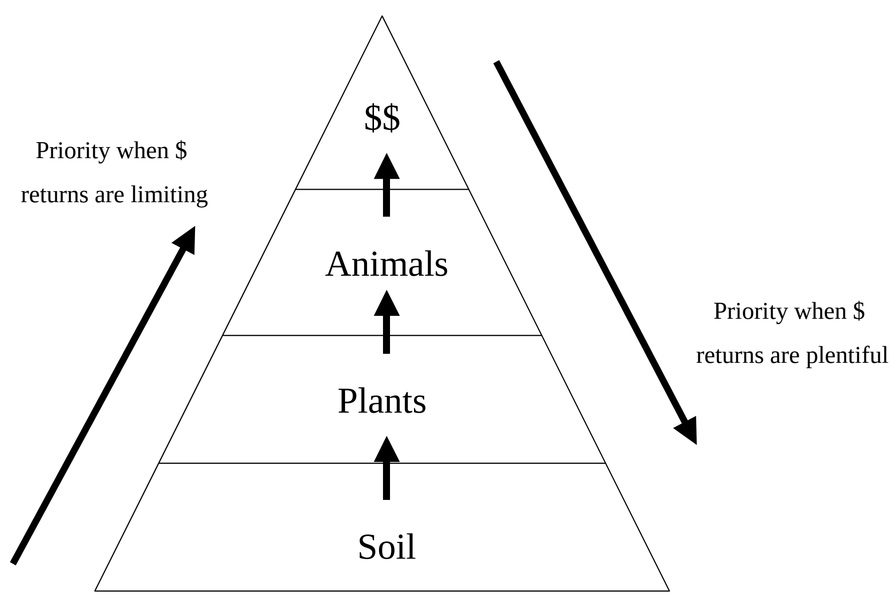
- Knowledge and awareness of the key environmental issues for their property, catchment and region and how to manage these within a productive and profitable grazing business; and
- An ability to understand and manage the interactions between water, soils, nutrients, trees and biodiversity in grazing systems

What drives your 'on farm' decision-making – animals or pasture?

Making money from grazing is dependent on good soil, quality pastures and quality livestock.

Paying greater attention to the 'grass roots' levels of the farming system is essential to build a solid foundation for animal production and financial return. However, historically most graziers' priorities are dominated by cash flow, hence the expression "It's hard to be green when you're in the red". The essential inter-relationship between the different components of a grazing system and their impact upon profitability is demonstrated in the "profit pyramid" below.

The steps to profit



Farmers should always consider what they are trying to achieve with their animals and pastures. The aims of pasture production should be consistent with the aims of the animal enterprise and the farm as a whole.
For instance the aim might be to achieve above average prices by producing a quality product that the market needs.

Other examples:
• By producing cattle to market specifications for sale by a specified time.
• By producing a target quantity of wool of specific quality, and/or producing sheep of a specific liveweight.

Examples of aims for pasture production are:
• To maximise pasture production during winter.
• To match pasture production to animal requirements throughout the season.
• To provide the quantity and quality of pasture to achieve required animal growth rates.
• To minimise supplementary feeding.

The farm manager's job is to achieve pasture and animal aims in a profitable system that can cope with seasonal variation, changing markets, and economic and human constraints. The system should be sustainable in the long-term, and not cause a run-down of soil, water or other resources, or be overly stressful to the operator.

Profit, production and sustainability – a management partnership
Sustainable grazing systems have two key roles. They must be productive and profitable, and they must contribute to the sustainability of the farm and the environment for future generations.

Production, profitability and sustainability depends on understanding the water cycle. When rain falls, it can either drive pasture growth, animal performance and profit, or it can be wasted and contribute to the sustainability problems of dryland salinity, soil acidity, soil erosion and declining water quality in dams, rivers and streams. 'Sustainability' actually depends on vigorous, well managed, productive pastures using as much of the rainfall as possible, leaving little left over to cause the sustainability problems.

The profitability of livestock enterprises is influenced by the following factors:
• Productivity per livestock unit (eg kg wool/sheep, carcase weight/animal sold).
• Market returns for produce sold (price/kg).
• Production costs per livestock unit (variable costs/DSE).
• Pasture production and utilisation.
• Number of livestock per unit area (stocking rate).

The producer has some control over each of the above factors. They may be in turn influenced by a range of *secondary* factors over which the producer also has some control.

These factors include:
• The *grazing system* used; that is, rotational grazing or set stocking.
• *Livestock requirements;* that is, livestock feed requirements vary according to liveweight, rate of growth and reproductive state. Livestock requirements need to be matched with pasture availability.
• *The choice of calving and lambing time is a key decision* that has a large influence on how well livestock requirements match pasture availability. The aim of the manager may be to ensure a minimum of supplementary feeding by matching peak feed requirements to peak feed production. This will vary with different enterprises. For example, spring calving is more suitable for weaner cattle production in high rainfall areas with substantial early summer growth of pastures, or areas with very harsh winters. Autumn calving may be preferred for vealer production in areas with a reliable autumn and winter rainfall, and a substantial period of summer drought. The calving/lambing time decision will also influence the potential stocking rate of the property.
• *Pasture production and utilisation*. The potential production from most livestock enterprises depends primarily on the pastures and the amount of rainfall.

Three major factors interact to determine the *potential productivity* of a pasture:
• species selection;
• soil fertility and structure; and

• grazing management and utilisation.

Understanding the options available in each area and the way they interact will make day-to-day decision-making more effective. The management of grazing animals has a profound impact on the growth and vigour of pastures. The timing and intensity of grazing and the recovery periods between grazing influences the quantity and quality of feed available to animals.

This leads us to the question of : **What is a Successful Pasture Manager?**
A successful pasture manager is one who:

- Has an inventory of their farm's physical resources and understanding of its environmental and climatic parameters
- Grows productive pastures and utilises those pastures to the optimum
- Has an understanding of the growth characteristics of pastures(including both quantity and quality) and how these affect animal performance. Most importantly has skills in assessing these
- Is able to match as closely as possible feed demand and feed supply through adjusting the annual calendar of operations, taking into account market requirements and specifications
- Has implemented a grazing management regime which contributes to the achievement of many of the above factors
- Uses feed budgeting as a regular part of management to assist in decision making with regard to stocking rate, marketing and supplementary feed requirements
- Understands the environmental consequences of his/her decision making

All of these different characteristics will be described more fully throughout this Manual.

Segment 2 The Water Cycle – Converting rainfall into dollars

One of the key indicators efficiency of any farming enterprise is Water Use Efficiency. Within the context of a grazing operation this relates to the efficiency of conversion of each mm of rainfall to kg of dry matter of pasture growth. Similarly grain growers talk in terms of kg or tonnes of grain per mm or 100 mm rainfall.

A similar and comparable yardstick of pasture sustainability is the proportion of days in the year that a pasture possesses green leaf.

Both of these indicators are related to water which is the key to any successful agricultural enterprise as well as the health of our ecosystems.

In order to fully maximize the potential of rainfall in a grazing system it is necessary to understand the water cycle ie what happens to rain after it falls. This best described in Fig X see p9 TSG

Understanding the water cycle

When rain falls on a pasture paddock (see Figure 1), it either:

- Moves across the soil surface (ie as run-off);
- Is caught on bare soil, litter or plants and evaporates (evaporation);
- Infiltrates into the soil and is used by plants (plant water use, or transpiration); or
- Infiltrates into the soil, drains below the roots and joins the water table (deep drainage).

Managing the elements of the water cycle for profitability and sustainability

Run-off

Water moves across the soil surface when soils are fully wet, or when a hard soil surface slows down the infiltration of water into the soil. Although some run-off is required to fill dams and enter streams and rivers, it has to be managed because excessive run-off means less water is available for pasture growth, and soil and nutrients can be carried in the run-off leading to erosion and increased silting of dams. Excess run-off also lowers water quality entering dams, streams and rivers and increases costs through the need to replace lost nutrients and repair erosion damage. Run-off is increased by low plant density, compacted soil surfaces, low litter level, and saturated soils. It is decreased when the soil surface is protected by litter and high plant density.

Water used by plants

Water use by plants has to be maximised because it drives pasture production and therefore the productivity of the whole grazing system.
Plant water use is decreased if groundcover is low, if annual species dominate and if pasture management does not assist growth (ie overgrazing, set stocking, inadequate fertility).
Plant water use is increased if perennial pasture species dominate, high groundcover is available and pastures are managed to assist pasture growth.

Deep drainage

Deep drainage has to be minimised because the water which drains past the root zone of plants and into the water table is not only lost for pasture production but is the major cause of dryland salinity, soil acidity and contamination of ground water with nutrients.

Deep drainage is determined by how much water the vegetation uses. Annual pastures and crops use the least water, perennial pastures use much more, and trees use much more again. In a 600mm rainfall area in southern Australia, annual crops and pastures allow about 100mm deep drainage, perennial pastures about 50mm and trees about 5mm of deep drainage per year.

Deep drainage is increased when water is not used by vegetation or stored in the soil and it is decreased when actively growing vegetation (pasture, crops and trees) remove water from the soil profile. Soil acidity and dryland salinity are problems relating to excessive deep drainage but are not always obvious until the problems are serious.

In the context of increasing pasture production the aim is to increase the amount of rainfall that the pasture uses. This can be achieved by:

- Maximising the amount of rainfall that enters and is stored in the soil for the pasture to use
- Minimising the amount of rainfall that is lost from evaporation at the soil surface by increasing ground cover
- Moderating the losses to deep drainage by having deep rooted perennials that can extend the growing season into summer and encourage deep, active root systems through grazing and fertilizer management
- Managing the surface runoff to ensure dam-fill and stream flow, but with minimal loss of soil or nutrients in that runoff

This is referred to as the 4M approach to water management.
Insert diagram on page 13 on the 4M Approach

1 Maximize Plant Water Use
A plant only uses water when it has green leaves, so maximizing plant water use is about maximizing the amount of green leaf throughout the year.
Plant water use efficiency is influenced by:

- Species composition
- Fertility
- Grazing Management
- Pasture and Soil Management (ie organic matter, litter)

Efficiency of Rainfall – Conversion of rainfall to dry matter
The variation in water use efficiency is evident from the following comparisons

- Highly productive sown perennial pasture: 26 kg DM/ha/mm (range 23-28)
- well managed fertilized native pasture: 17 kg/ha/mm (range 14-23)
- Unfertilised native and poor quality pastures: <17 kg/ha/mm (range 2-17)

2 Minimise Soil Evaporation
Rainfall 'lost" from the soil surface by evaporation is not harmful but may be regarded 'wasteful' from an agricultural perspective. Management should therefore aim to reduce the amount of bare soil exposed to the atmosphere.
Aim to maintain ground cover above 70%. This can be comprised of green or dead material and either attached to the live plant or present as detached litter on the soil surface.

3 Manage Surface Runoff
Again maintain at least 70 % ground cover and up to 100 % on steeper slopes which are more erosion prone.
While run off is essential to fill farm dams it also represents a major productive loss of water to the plant and poses a major risk in terms of nutrient and soil removal by erosion.

4 Moderate Deep Drainage
Deep drainage is the most difficult component of the water cycle to understand and manage with both positive and negative aspects. While it contributes to the catchment's water supply "losses" of water through deep drainage pose potential problems both agriculturally as well as environmentally ie as a consequence of salinity down stream.
Maximising plant water use either through pasture growth and/or encouraging the growth of trees and shrubs provides the best way to moderate deep drainage.

Segment 3 Pasture Assessment

Why assess pasture?

- To better match animal requirements and pasture production.
- To know how much feed you have on hand in the paddock, how different classes of livestock will perform if grazed on that paddock, and therefore, the most appropriate allocation of stock to paddocks.
- To achieve more precise supplementary feeding.
- To enable accurate feed budgeting for livestock production targets.
- To Ensure ground cover is sufficient to protect soil from rain and run-off; to encourage infiltration and to reduce the risk from weed invasion

Assessment of pasture involves being able to estimate the quantity of pasture, predict the quality of what is available, and determine the percentage groundcover.

Quantity of pasture

This is referred to as herbage mass or sometimes feed on offer (FOO), and it is measured in kilograms of dry matter per hectare (kg DM/ha).
Herbage mass is described in terms of dry matter. This is due to the considerable variation in water content of pastures between species, at different times of the day and at differing growth stages. For example young leafy rapidly growing pasture in autumn may contain 85 % water (15 % dry matter) while dead pasture during summer may be 90 % dry matter (only 10% water).

Herbage mass is influenced by pasture height, density and dry matter.
Sometimes the term herbage mass is used to describe the total pasture available. Alternatively, it might be used to describe a component of the pasture, for example, the green portion only. With pasture assessment it is important to recognise the proportion of green and dead material in the pasture mix.

Table Q estimates green pasture dry matter in kg/ha from pasture height for a range of pasture types. The table demonstrates the differences between a dense, grazed pasture and an open pasture. This relationship may change with different species and pasture density, and may require local calibration.

Table below from Vic Prograze Manual Alternatively use that form MLA Pasture Ruler

Table 1 – Approximate relationship between pasture height and kg green DM/ha

Height (cm)	**Lightly grazed 50% green**	**Mod. grazed l00% green**	**Dense 100% green**
1	250	400	500
2	500	700	800
3	600	1000	1100
4	800	1200	1400
5	1000	1400	1700
6	1150	1600	2000
7	1300	1750	2300
8	1450	1900	2600
9	1600	2000	2800
10	1700	2100	3000

Quality of pasture available

The most useful measure of pasture quality is digestibility.
Digestibility is the proportion of pasture or feed which, once consumed, is retained and used by the grazing animal. It is expressed as a percentage.
For example, if pasture has a digestibility of 70%, it means that 70% of the pasture eaten will be used by the animal and 30% will pass out as faeces. A highly digestible feed will usually be digested and pass through the animal more quickly allowing for greater intake and hence increased animal production.
Digestibility may refer to the total pasture, but often a more useful measure is the digestibility of pasture components, for instance, the green or dead component.

Digestibility is a useful measure of quality because:
-It is directly and positively related to the energy content of the pasture; and
-It is positively related to the protein content

Important factors which influence quality include:

Proportion of Legume
Legumes usually have higher digestibility than grasses. Also, at the same digestibility the intake of legumes is greater than that of grasses.

Stage of growth.
The stage of growth has a major influence on digestibility which declines as plants mature. This is shown in Figure X Figure from Prograze Manual
Green pasture will always be of higher quality (55-85% digestibility) than dead herbage (35-65% digestibility) of the same species. Pasture is of highest quality early in the vegetative stage. Quality gradually declines as the pasture ages and goes from the vegetative to reproductive state as shown in Figure X. Pastures also decline in quality as stock selectively graze the green component and as soluble carbohydrates are leached out by rain.

Parts of the plant.
In most plants, leaf material is of higher digestibility than stem. The difference in quality between the stem and leaf can be judged by how 'woody' the stem is. For example, there is a large difference (10-15%) in the quality of lucerne stem and leaf. In contrast, there is little or no difference in the digestibility of subterranean and white clover leaves and stems.
Maintaining grasses in a vegetative state rather than allowing tall rank growth to develop increases the digestibility of pastures.

Grass Species / Annual v Perennial Grasses
There is often little difference in the digestibility of annual and perennial grasses early in the growing season. However, towards the end of the growing season, annuals quickly decline in quality when they produce seed heads and die.
Perennial grasses maintain higher quality longer and usually have some green material present, particularly if out of season rain occurs.

Percentage groundcover
The proportion of the soil surface covered by pasture (both green and dead) is referred to as groundcover. Groundcover provides an indication of soil protection to minimise erosion and run-off as well as an indication of pasture sustainability.
Ground cover may be estimated visually or determined using the simple end-point method.

Include more on assessing pasture composition

Practical demo of pasture assessment techniques

Segment 4 Animal Production from Pasture /Targeting Markets

Interaction of Herbage Mass and Digestibility

From an animal production perspective there is an interrelationship between herbage mass and digestibility.
At low levels of herbage mass but where digestibility is high animal production may be restricted because intake is limited ie small bite size means the animal simply cannot eat enough per day. Conversely at the other extreme where herbage mass is high but digestibility is low' intake is limited by the slow movement of feed through the animal.

The interrelationship between herbage mass and digestibility for a number of livestock classes is shown in Table Y Prograze Manual

Pasture benchmarks for sheep and cattle

Pasture benchmarks have been developed which provide a 'ballpark' estimate of the minimum herbage mass needed to satisfy/maintain the nutritional requirements of various categories of livestock. They are presented for both sheep in Table Y.

Three different pasture qualities are presented in Table Y to highlight the importance of quality on minimum pasture mass. It should be noted that at times, it may not be possible or desirable for animals to maintain weight. For example, after joining it would be acceptable for fat ewes to lose some weight. At other times, if pastures are below the benchmarks the effects may be severe. For example production losses will occur if lactating ewes are not supplemented to make up the shortfall in pasture mass.

Determining Farm Stocking Rates

An essential prerequisite of all graziers should be a determination of the potential stocking rate which a farm or paddock is capable of supporting. This is because *stocking rate is the basis of farm profitability.*

What is the potential/target stocking rate for farms?

In much of southern Australia this is primarily influenced by:
- Rainfall
- Length of the growing season
- Paddock size

Rainfall
A number of predictive equations have been developed based upon the results of experiments as well as on-farm demonstrations.
Of these probably the most accurate and meaningful is that derived from the Triple P Program (below) which was conducted throughout much of south-eastern Australia. This involved in excess of 300 paired paddock comparisons whose purpose was to determine optimum stocking rates

across a broad cross section of environments and soils. Analysis of the results suggests that a target stocking rate can be based on the following formula:

1 dse/ha per 25 mm rainfall in excess of 250 mm

<u>Length of Growing Season</u>
Further analysis of the Triple P data indicates that length of growing season is also a useful and perhaps more accurate indicator of potential farm stocking rate. This refers to the period between the date of the opening autumn break and when moisture cuts out in spring. This relationship also highlights the importance of perennials which are able to extend the growing season further into spring compared with annuals (include Prime Time 2005 graphs as well as Grassgro Model for S.A in Prime Time 2005)

<u>Paddock Size</u>

The Triple P program also suggested that paddock size can also influence stocking rate. Paddocks less than 20 ha (50 acres) support in the order of 2 dse's per ha more than those above 20 ha. This is related to the improved utilisation of feed available in smaller paddocks. This improvement may be even more pronounced in undulating paddocks of variable slope and aspect where variability in grazing pressure is more marked.

Taking length of growing season and paddock size into consideration it is possible to determine a target stocking rate for farms in the winter rainfall environments of southern Australia include Prime Time 2005 slide

Pasture Utilisation
Implicit in the goal of targeting maximum farm stocking rates is the need to optimise the utilisation of feed grown.
Utilisation is a key driver of productivity and profitability
Under-utilisation is common in Australian grazing systems. As an example surveys undertaken by MLA indicate that a level of utilisation of 20-30 % is common.
A target of 40-50% is realistic for most producers while those with more advanced management skills and in more reliable and predictable rainfall environments may aim for a ceiling of 60-70%.
Note: Levels of utilisation in excess of these represent a significant risk especially in terms of environmental sustainability.

After determining what is a (theoretical) target stocking rate for a particular paddock or farm, how do we go about realising that target? What factors must be considered for optimising stocking rate and moving towards that potential?

This has two aspects:
1 Maximising pasture growth rates and water use efficiency
2 Optimising the number of breeding units ie through best matching need with feed

1 Maximising pasture growth rates **and** ***Water Use Efficiency***

Pasture growth rates are measures in terms of kg of Dry Matter per kg per day and will vary throughout the year as influenced primarily by temperature and moisture availability. During winter growth rates in the range of 5 -15 kg DM/ha/day are the norm while in spring under optimum growing conditions rates of up to 100 kg DM/ha /day are achieved.

As discussed previously Water Use efficiency or the efficiency of conversion of rainfall into plant (in this case pasture) growth is one of the key indicators of production efficiency for any farming enterprise.

Even in the same environment there exist considerable differences between farms in the conversion or efficiency of conversion of rainfall into kilograms of dry matter or pasture growth (rates).
As rainfall is regarded by most farmers as their most precious but limiting component then any means of increasing its efficiency should be addressed.

Both pasture growth rates and Water Use Efficiency are largely governed be three aspects of management over which farmers have direct control. These are:

- Soil Fertility
- Grazing Management
- Pasture Species selection

<u>Soil Fertility</u>
During the implementation of the Triple P program two adjacent (paired) paddocks are compared for differences in stocking rate and animal performance. Both paddocks are managed similarly, the only difference or variable being fertility with optimum fertility applied to one paddock compared with normal practice on the other.
All sites therefore were addressing fertility.
Stocking rates were adjusted in accordance with feed budgets taking into consideration the importance of utilisation.
Results from the Southern Tablelands of NSW are presented in the Table V (Prime Time 2005) and demonstrate the importance of fertility in raising pasture productivity, stocking rate and profitability.

<u>Grazing Management</u>

Benefits of Rotational grazing:

- Increase in pasture growth rates - solar panels
- Increase in pasture utilisation
- Improved persistence of perennial grasses
- Improved Nutrient distribution

Integrate slides from Prime time 2005, incl Lewis Kahn’s Forbes talk
Refer to SGS Vasey results as well as Lisa Warne’s

<u>Species Selection/Pasture Composition</u>

Focus on the need to use appropriate species for the environment – consider persistence and production; seasonality of growth; species that complement each other and respond to rainfall throughout the year.
Perennials v annuals: little difference in winter production but perennials extend growing season – this has benefits for later lambing/calving and better match of supply with demand. See Graph X (Prime Time 2005 from Grassgro).
Also perennials provide for reliability of growth and increased efficiency of water uptake due to their deep rootedness compared with annuals.

Highlight the importance of legumes especially in terms of feed quality and N fixation.
Prime Time 2005 slide on quality
5% increase in digestibility leads to a 10% increase in intake and hence a 25% increase in animal growth rate

2 Optimising the Number of Breeding Units per hectare ie Match Feed with Need
Nutritional management is really all about matching feed with need - that is, matching the annual calendar of operations to best fit the annual feed supply.
This highlights the following:
-Time of lambing and calving
-The need to focus on per ha production and not per head
-Feed budgeting to assist in the decision making process
-Need also to meet market specifications

Include slides from Prime time 2004 incl generic growth curve as well as S.A annual v perennial

Segment 5 Feed Budgeting / Meeting Production Targets

Slides in Prime Time 2004

Undertaking a feed budget is akin to the budget submitted to the bank manager which reconciles forecasts of expenditure versus income. With pastures however it relates to the balance between predictions of animal intake against pasture growth or feed demand and feed supply.

Feed Budgets can be used for short term and long term decision making.

Fodder budgeting involves assessing current pasture mass or supply, adding predicted or potential pasture growth and subtracting livestock requirements (animal intake per head times stocking rate). Consideration is also given to potential losses in system ie from trampling, spoilage decay etc

(Available Pasture + growth) – Livestock requirements (intake per head times stocking rate)

A feed budget is used to predict:

-Potential stocking rate?
-Grazing days or how long feed in a paddock will last?
-How many livestock will this paddock support?
-Area of paddock required?

A feed budget is useful for predicting whether a feed surplus or deficit is likely. In doing so it enables producers to plan ahead and take appropriate measures to address the situation. Where a surplus is likely there is a potential to purchase livestock, make hay/silage or increase target marketing weights of existing stock. Conversely, and most importantly from an environmental perspective, where the budget indicates a feed deficit land owners can sell livestock –usually when the market is stronger and before animals lose weight; or purchase supplementary feed.

In order to undertake a feed budget accurately it is important to have access to:
-pasture growth rates
-predicted daily livestock intakes
These are provided in the accompanying Tables
Include average pasture growth rate Table from Vic Prograze; also Intake Tables from Prograze

Include slide from Prime Time 2004
Include feed budget examples from Prograze
INCLUDE FEED BUDGETS SHEETS FROM TRIPLE P
INCLUDE SUMMER FEED BUDGET SHEETS FROM TRIPLE P MANUAL
INCLUDE INTAKE SHEETS FROM PROGRAZE MANUAL AND TRIPLE P

(One DSE consumes around 400 kg DM/year - allowing for 30% wastage).

Apart from undertaking feed budgets for the strategic production purposes mentioned above, another feed budget which plays an essential role in overall farm management decision making is the summer feed budget. This helps in determining the sustainability of the grazing operation.
The summer feed budget is undertaken at the end of the growing season to determine how long the (dry) paddock feed will last relative to the current stocking rate. If there is insufficient feed then consideration can be made to selling surplus stock – usually when they are in good condition – or the purchase of appropriate supplements such as hay or grain. In doing so measures can be implemented to protect the pasture resource from overgrazing and environmental degradation ie erosion caused by excessive bare ground.

Planning to Achieve Production Targets

Feed planning or budgeting is a procedure by which projected feed availability is compared to estimated feed requirements in order to determine potential feed surplus or deficit, how many days feed will last or how many stock can be put in a paddock.
If a feed deficit is predicted you can calculate the most economic option to meet it.
Options to address a feed deficit include:
Selling stock. Good planning may enable you to achieve better prices than those who leave the decision until the last minute.
Rationing feed. Knowing the feed requirements of your stock may enable you to restrict intake at times of the year when they will eat more than they need to conserve feed for critical periods.
Applying nitrogen. Applied to a responsive pasture at the right time of the year nitrogen can produce about 10kgs of feed for each kg of nitrogen used. It may be economical when applied say, six weeks prior to spring lambing.
Rotational grazing. A simple four paddock rotation, or even an occasional spell over winter, can grow 20 to 30% more feed for an August lambing.
Special pastures or fodder crops. Species such as Sirosa phalaris can be twice as productive as other pastures over winter if managed correctly. Oats, annual ryegrasses or other fodder crop options can address a predicted shortfall.
Supplementary feed. Understanding your animal requirements, being able to buy before prices rise and being able to calculate the most cost-effective ration gives you the edge – all part of feed planning.

If pasture growth is in excess of animal requirements then you may consider conserving feed as silage or hay in spring, buying in more stock or taking on some short term agistment.

Feed budgeting over the whole of a large property is difficult. Errors associated with the assessment of pasture quantity, quality and growth, as well as changes in animal fat scores are likely to make the budget inaccurate. A better approach is to budget for a particular mob or area of the farm.

Production targeting

The process of targeting in grazing management is not just aimed at defining markets, although that is one component. Targeting is about setting short-term goals or targets which may be pasture or animal based. For example, I am aiming to have my sheep in fat score 3 at lambing with the lambing paddocks having 1200kg green DM/ha or; I need my steers to grow at 1.3kg /day to have them sold by October. Pasture and animal assessment skills form the basis for monitoring pasture and animal production.

When overall targets are set, a plan needs to be developed which may have a number of steps or sub-targets, which can be used to assess likely success of achieving the primary target. When you reach these sub-target times, assess how you are going. Are the animals on track to meet the final liveweight or fat score? Do they need supplementary feeding because growth is slow? Do I need to ration pasture because animal growth is too fast? Should I sell now rather than taking them through to the targeted market?

Setting targets

Targets can relate to any activity you undertake – markets, reproductive rates, VM (vegetable matter) in wool, growth in weaners and so on. The key to setting targets is based on four factors:

1. Specification – what you want to achieve.

2. Budget – to achieve the target. (For example, limit input costs such as supplements and herbicides).

3. Time frame – over what period do you want to achieve the target.

4. Soil management – checking if the grazing targets will compromise soil protection at any stage.

Following is a general outline of the thought processes involved in targeting.

Step 1 – Primary target

Define and write down the target. What you want to achieve, how much financial input you will allow, and when you want to achieve the target by.

Step 2 – Sub-targets and strategies

Establish sub-targets in terms of livestock and pasture needs that are required to reach the next sub-target. Assess and monitor the production cycle. For example, check progress at key times (see Figure 10).

Reassess targets in light of how you are going at key times. Are you still within time and cost constraints? Will the specifications required for the primary target be obtained?

Modify your future action to achieve the next sub-target based on how well you did or did not achieve the target.

A) Measure liveweight and fat score, then compare this to the target.

If they are outside the range, consider if you can still achieve the final target.

Options:

• Supplements, changing targets and management such as splitting animals for preferential feeding or shearing.

• If you are within the range, define feed required (quantity and quality of pasture and supplements) to achieve the next target.

B) Use pasture assessment benchmarks and weighing to monitor the required growth rates.

C) Repeat actions from ‘A’ at this next target.

D) Use pasture assessment benchmarks and weighing to monitor the required growth rates. Start considering marketing issues such as selling options, breakeven price, transport costs and market intelligence.
E) Carry out your marketing plan.

Insert Figure 10 – Production targeting page 30 S.A Prograze
Set targets and consider options at each stage.
At the end point reassess the target process using market feedback and highlight parts of the cycle that need attention. Change from production to marketing issues as you near the end of the chain.

Step 3 – Review
Reassess the original target using feedback information for future planning. Write down what was done right and wrong. If the target was not achieved, why? Was it due to genetics, paddock feed, supplements used, cost of supplements, joining time, season, market issues, animal health or poor assessment of pasture? Note any changes that you may be able to implement next time.

Meat production example
Step 1
The primary target is for male drop, 46kg lambs at eight months of age. That is, they must average 110grams/day growth between weaning and eight months. Pasture has been assessed and paddocks identified which have the feed available.
Step 2
Establish sub-targets, key times, target weights and acceptable range and the pasture needed to get the liveweight at the next sub-target.
At three months, weigh. If the average is between 28 and 32kg the stock are on target. If the average is below 28kg, ask: ‘Do I supplement?’, ‘Do I move to better pastures?’.
If above the target ask: ‘Do I sell early as trade lambs?,’ ‘Is the market suitable?’.
Repeat the cycle at the next key time.
Continue using pasture assessment and fat scoring to monitor growth rates.
As you approach the final key point consider market issues such as selling options, breakeven price, transport, using market intelligence and feedback.
Step 3
Assess strategies as you go along, to assist you in overall decision making.
After going through a cycle, identify any limiting areas.
This may be the period between five and eight months for spring lambs. Growth was low, supplements costly. Should you consider putting in a fodder crop, improved pastures, irrigation, or lucerne?
Use the process to identify problems in the cycle and then look atyour options.
InsertTable 5 page 31 S.A Prograze – Summary of example targets for sheep meat production

Segment 6 Principles of Plant Growth

Plants grow by absorbing carbon dioxide from the air and water from the soil and in the presence of sunlight, converting them into carbohydrates. These carbohydrates are used immediately for growth or stored as water soluble carbohydrates (energy reserves) in the base of the stem and roots. The rate of growth is therefore largely determined by the size of the leaf area (to access sunlight). The rate of regrowth after grazing is strongly influenced by the leaf area left after grazing and the size of the energy reserves (which are affected by the length of the previous spell period).

After hard grazing, plants call on these energy reserves for regrowth and stored energy will decline quite rapidly over the next 10 days or so as the plant uses it to rebuild its leaf area. Energy reserves will remain stable for roughly another 10 days until manufacture exceeds current growth demand and then gradually increases over the next 10 to 20 days (depending on the season). It will take about a month until they will be back to pre-grazing levels.

After grazing the first priority for the plant is to re-establish leaf area and to do this root growth and tillering will virtually cease.
Consequently a balance rapidly develops between the root mass of a plant and the stem/leaf mass. Plants which are constantly grazed to a low level (phase 1) will have a small root system, small energy reserves, access less water and nutrients, capture less light and grow slowly, whereas plants which have been spelled will have larger energy reserves and greater access to water, nutrients and light.

How plants grow

- Plants absorb carbon dioxide from the air & water from the soil and convert them to carbohydrates
- Carbohydrates are used immediately for growth or stored as root reserves

But the rate of regrowth after grazing is largely determined by:

- The intensity of grazing (ie the leaf area left to capture light to produce carbohydrates)
- The frequency of grazing (ie the root reserves of carbohydrates)

Plants are made of carbohydrates

There are two sources:

- Direct from photosynthesis (sunlight, carbon dioxide & water)
- From root reserves

Grazing too low will reduce leaf area & photosynthesis
Grazing for too long will reduce root reserves
Both will reduce the rate of regrowth after grazing

Plants are solar factories

✡The bigger the solar panel (leaf area) the more energy (carbohydrates) is generated and the faster they grow (particularly in winter)

Root reserves

Include here picture of plants and roots –see Tim Prance's powerpoint
After grazing to the ground

✡The plant uses root reserves to grow
✡they are reduced by 50% over the next week
✡It takes 4 - 6 weeks to replenish them
✡Unless replenished roots will shrink & plants eventually die

Include the 2 pictures of the W.A plant growth/root growth expt

How do pasture plants grow?

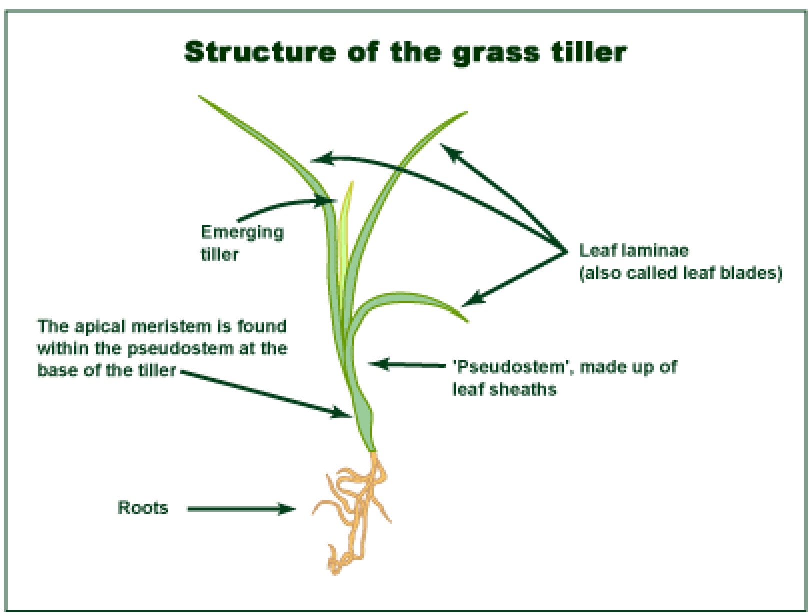
Plant growth comes from photosynthesis, the process whereby solar radiation, intercepted by green leaves, provides the energy to convert CO_2 and water into simple sugars. These simple sugars are then converted into organic compounds that make up 90% of plant dry weight.

The Growth of Grasses

Tillers

The basic unit of growth in grass plants is the tiller. The structure of the tiller is generated from a chain of segments, called phytomers, that are laid down by the apical meristem of the tiller.

The apical meristem is usually found at or below ground level, and so is protected from removal by grazing animals or damage by other factors such as fire. This is the key adaptive feature of the grasses that allows them to survive in the presence of grazing animals.



The growth and spread of an individual plant depends on the number and size of tillers connected to that plant. Ultimately, a pasture comprises plants of all shapes and sizes, and populations are typically made up of a high proportion of small plants and a low proportion of large plants. The large plants account for most of the pasture dry weight, but the small plants are important for population expansion when conditions are favourable. Alternatively when a pasture has been degraded with a consequent loss of plant population then this capacity for the remaining plants for expansion is equally important.

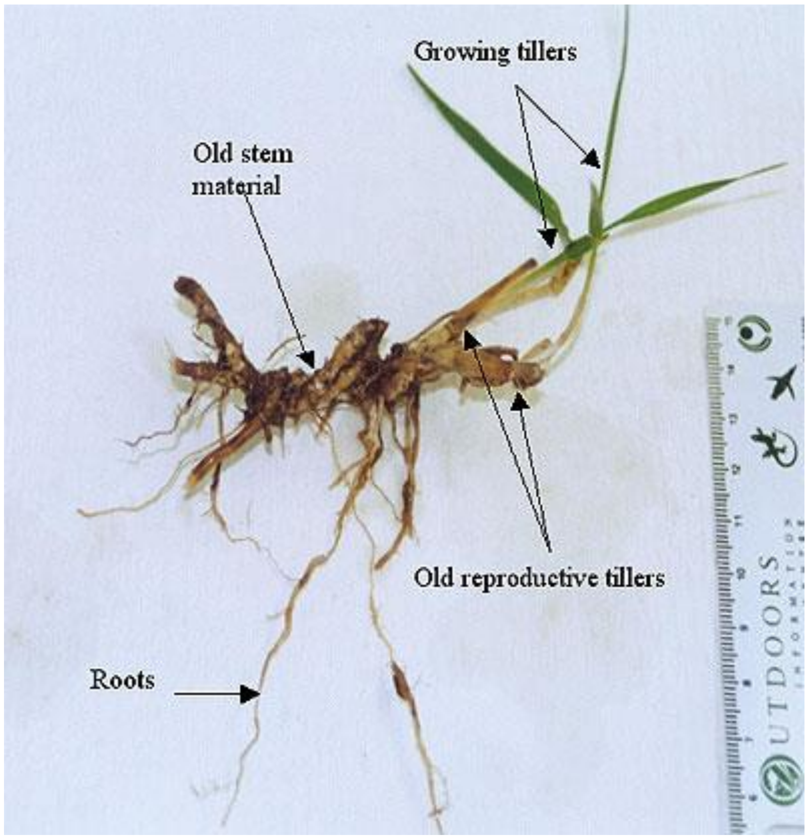


Photo of a phalaris plant extracted from a pasture. Growing tillers can be connected to older plant material in all sorts of arrangements giving a wide variety of plant structures within a population.

While the grass plant is still young (that is, soon after a new pasture is sown and established), it is relatively easy to identify individual plants and even to count the number of tillers that make up a plant. However, as the plants grow and become larger, they eventually break up into smaller plants which become entangled with each other.

The population of plants in a pasture varies enormously in size and structure when the pasture is beyond 1 - 2 years old. Furthermore, it is impossible to distinguish individual plants from one another when looking at the pasture. To get an idea of the structure of the grass population in a pasture, the measure that is commonly used is the tiller density, which is the number of tillers per unit area of ground. Each tiller represents a site for new leaf production, and each leaf that is produced also creates a site for the production of a new tiller (via the tiller bud on the phytomer). For example, an intensively managed ryegrass pasture may contain around 5,000 ryegrass tillers per m2 while a phalaris pasture grazed more extensively by sheep may have around 2,000 phalaris tillers per m2. Each of these tillers must produce only one established daughter tiller per year in order for the grass population to remain stable.

Individual tillers on a perennial ryegrass plant are marked with a yellow tag

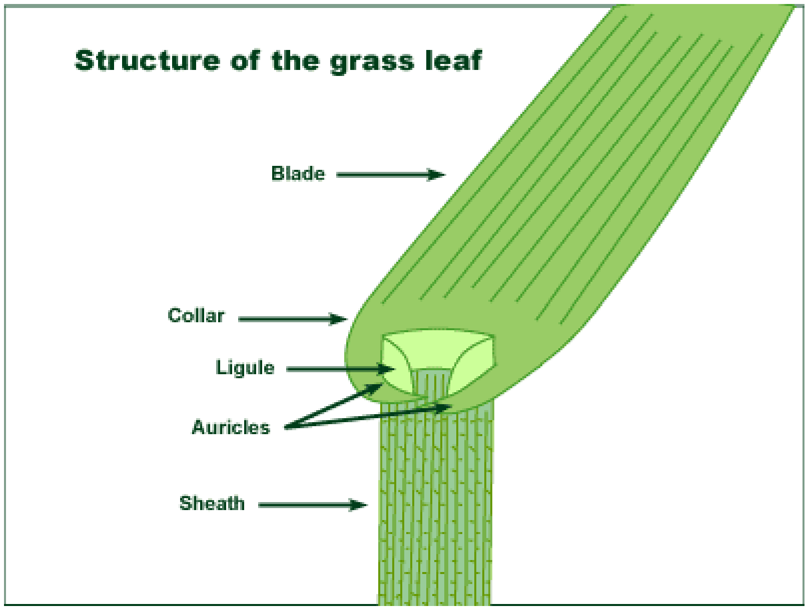
Leaves

Information on tiller density does not indicate how much dry matter a pasture will grow, or how best to manage the pasture to maximize yield. In practice, the density of tillers does not limit or control the growth of the pasture unless tiller numbers have been depleted by some event such as a drought severe enough to kill plants. In those situations, re-establishment of a tiller population is necessary before the pasture can recover. This can be achieved by spelling a pasture from grazing and is one simple but effective technique for restoring a degraded pasture.

When looking for management rules to optimize pasture yield, it is more important to consider the dynamics of leaf growth.

Leaves grow by cell division from the base of the grass plant, through the tube (or 'psuedostem') created by the leaves that have been produced previously. The leaf emerges into light, and continues to grow through cell expansion to reach a mature size which is determined by the environment in which the plant is growing.

The point at which the leaf emerges from the surrounding psuedostem and is first visible is called leaf emergence or leaf appearance. The rate of leaf appearance is an important driver of the growth of the whole pasture. It is usually expressed as the leaf appearance interval, in units of days - this is the time taken for successive leaves to appear on the same tiller.



The sheaths of successive leaves accumulate to form the pseudostem, a hollow tube through which new leaves emerge.

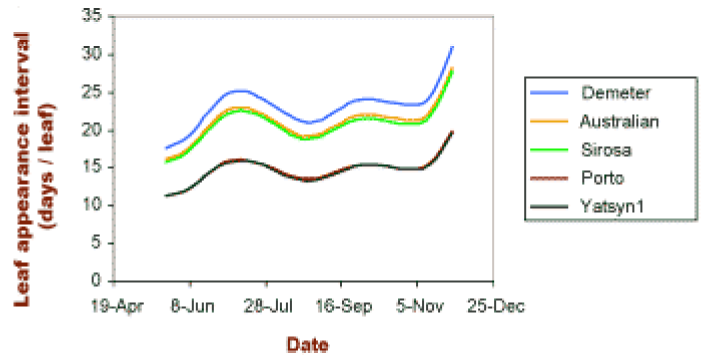
Photo of a tall fescue tiller, showing an emerging leaf plus older leaves, including a dead leaf.

The rate at which leaves are produced, their rate of expansion, and their final size are all influenced by the environment for plant growth.

In temperate climates, there is a characteristic seasonal pattern of leaf appearance. For example, in cool temperate regions, new leaves appear every 10 - 12 days in spring and autumn, and 20 - 30 days in mid-winter In summer-dry environments, leaf appearance interval increases in summer as dry soil conditions start to limit growth. Leaf appearance eventually stops altogether when conditions get very dry and plants either enter dormancy or are unable to keep growing under the water stress.

Leaf appearance rate is more-or-less linear over the range 5 - 20^{o}C for temperate grass species when growth is not limited by other factors like water or nutrient availability. Note the differences between species shown in the bottom graph on this page. All show a similar seasonal pattern, but ryegrass and cocksfoot have the shortest leaf appearance intervals, and tall fescue the longest, throughout the growing season.

Leaf appearance intervals in grazed pasture:
Perennial grass species in a summer-dry environment

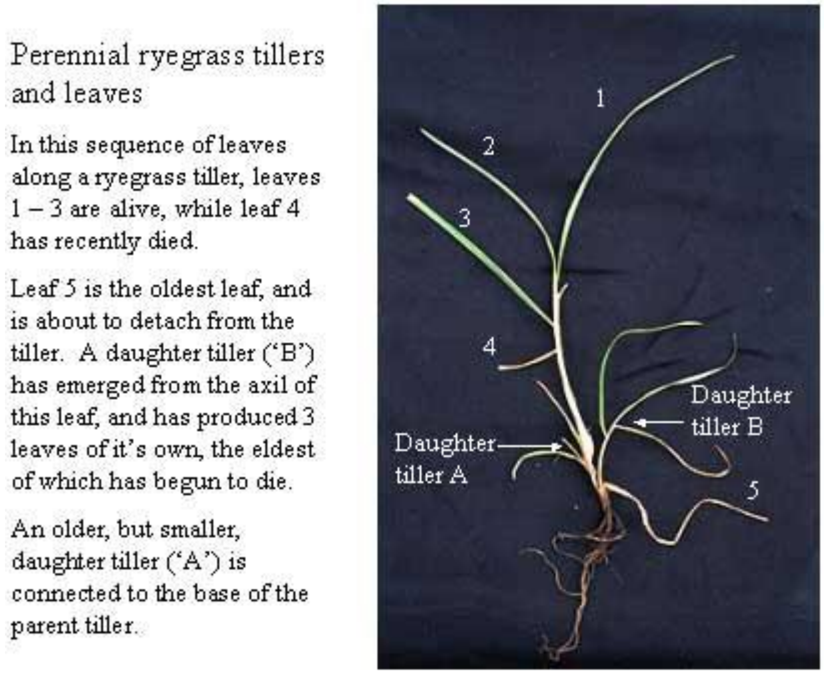


'Demeter' is a tall fescue cultivar; 'Australian' and 'Sirosa' are both phalaris cultivars; 'Porto' is a cocksfoot cultivar; and 'Yatsyn 1' is a perennial ryegrass cultivar. The Porto and Yatsyn lines follow each other almost exactly.
Source: B. R. Cullen.

Plant death

No part of the grass plant lives for very long in a pasture.

Tillers generally live for only 12 months maximum (the average age of tillers at death is generally much less than 12 months), and leaves die, or 'turn over', even more rapidly. 'Winter' leaves in a species like ryegrass might live for, on average, about 70 days, whereas 'spring' leaves may live for only around 25 - 30 days. It is noteworthy that leaf death rates are greatest when leaf appearance rates are also greatest. This process, whereby leaves are produced and then die in a regular sequence, is called 'tissue turnover'.

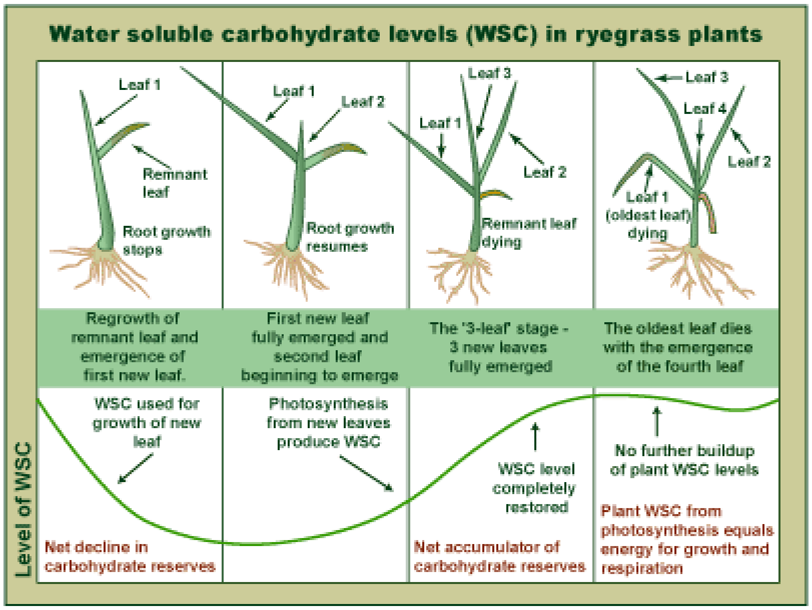


Storage of reserves

Not all of the energy and nitrogen acquired by plants is used immediately for growth or respiration. Some is stored, mostly in the sheath bases and some in the roots, and can be re-mobilized later to support respiration and/or new growth.

.A stylized depiction of how reserves may be drawn down and replenished during regrowth after severe defoliation is shown in the diagram below. The example is for perennial ryegrass. Most of the stored energy is used within the first leaf appearance interval after defoliation, and reserves are usually fully replenished after three leaf appearance intervals.

In environments that are marginal for ryegrass growth, maintaining a good level of energy reserves in the plant is considered important for continued plant survival under intensive grazing.



The cycle of soluble carbohydrate depletion and replenishment in ryegrass following grazing. Source: D. Donaghy

Flowering

Flowering in the grass species can have a major effect on the physiology, growth and utilization of pastures.

Annual species flower in spring every year, and their growth then ceases until seed germinates in response to autumn rains and a population of new plants is established. Their flowering is under strong genetic control - every tiller present in the pasture will produce a seedhead. The annual grasses are very closely related to the major cereal species (wheat, barley), and their flowering behaviour is controlled in much the same way.

Perennial grass species also flower, though not all tillers present in a pasture will be induced to do so. Most temperate perennial grasses must pass through winter conditions of low temperatures and/or short day lengths if they are to flower. This is called the vernalization requirement.

Tillers produced in spring generally will not be vernalized, and therefore will remain vegetative. Some over-wintering tillers may also escape vernalization depending on the conditions of the microsite in which they are growing. Further, fewer tillers undergo reproductive development in frequently grazed pastures (perhaps 15 - 20% of tillers) compared to infrequently grazed pastures (60 - 80% of tillers).

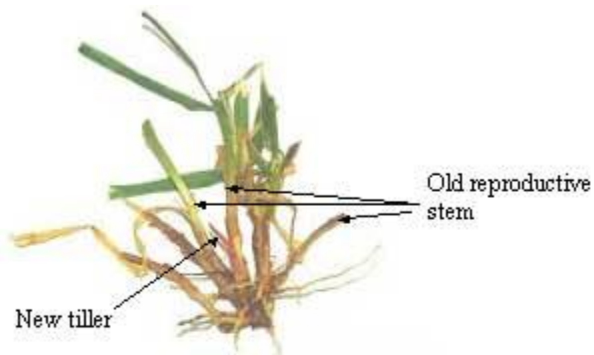
A cocksfoot plant, in full flower with multiple seedheads.

Flowering of perennial grasses has several effects on pasture structure and growth.

First, elongation of the true stem and formation of the seedhead requires significant amounts of energy for structural purposes. The plant meets this energy demand by shutting down Carbon supply to the roots, increasing the rate of photosynthesis in the leaves, and mobilizing energy reserves. The production of this structural material with high dry matter content contributes to the sharp increase in pasture growth rates often seen in spring.

Second, the regular sequence of leaf appearance and senescence is interrupted. Leaf appearance ceases with the emergence of the flag leaf, and older leaves tend to stay alive for longer in order to support the energy requirements of the seedhead and developing seeds.

Finally, tillering also ceases as energy is re-allocated to the stem and seedhead. The reproductive tiller will eventually die, just as the tiller of an annual grass will die after flowering. New tillers develop from the base of the old reproductive tiller to re-establish vegetative tiller density and ensure the survival of the species. The photo shows a new tiller forming on the base of an old phalaris reproductive stem in summer.



A phalaris plant extracted from a pasture in late summer, showing the stubs of reproductive stems formed in the previous spring (these are left after the rest of the stem is grazed), and a new tiller forming at the base of one of them.

Flowering poses some problems for the management of perennial pastures in spring.

While it generally increases dry matter production, the quality (nutritive value) of the dry matter produced is low because of the high content of fibre in the seedhead. Also, there is often a surplus of pasture growth in spring anyway, so extra fibrous material does not necessarily improve productivity. Excess pasture can be conserved as silage or hay to retain control of pasture mass and, in turn, pasture composition and quality. Reproductive development can also be controlled to some extent by frequent or severe grazing. However, this can be difficult to implement in spring when pasture supply is well in excess of animal feed requirements and requires high stocking density.

Alternatively this bulk of dry material provides a valuable source of organic matter which may be beneficial for soil structural improvements.

A regrass pasture which has been allowed to run to 'head'. Sheep will avoid grazing the stem, and selectively graze leaf from the base of the pasture.

Perennials or annuals
Pastures contain perennial and annual species. Perennial species live for more than two years whilst annual species die each year. Where the summers are too hot and dry for perennial species to survive, pastures are mainly annual.

Perennial plants maintain year-round cover and so reduce erosion.
Their established root system can make rapid use of autumn rainfall when it occurs. Perennial grasses, due to their deeper more permanent root system, use more water and nutrients and therefore have the potential to reduce the rate of soil salinisation and acidification. Perennial plants however require some moisture to survive over summer.
Annual plants such as subterranean clover, annual ryegrass, barley grass, Vulpia, serradella and balansa clover, survive the summer dry period as seeds produced in spring before the plant dies. These seeds germinate with the autumn rains and frequently have to compete with established perennial plants for light, moisture and nutrients.

The Growth of Legumes

Growth habit

Growth habit refers to the form that plants take and the way in which they spread into and occupy horizontal and vertical space.

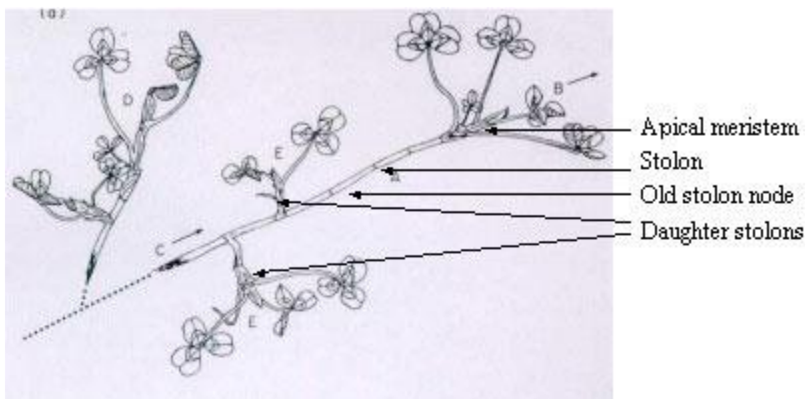
Of the three most common legumes, white clover and subterranean clover are prostrate, spreading plants growing mainly in the horizontal plane close to the soil surface, whereas lucerne is generally an erect plant growing from a crown with minimal lateral spread.

The growth habits of white clover (top-left), sub clover (top-right), and lucerne (bottom).

Prostrate species

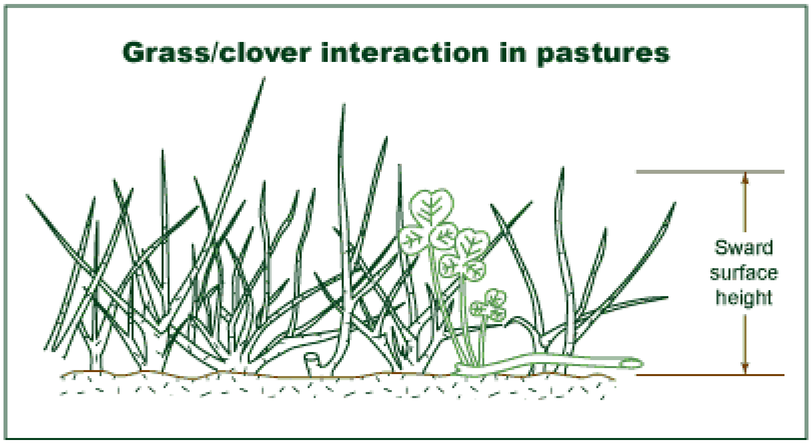
The prostrate legumes, like white clover, sub clover and strawberry clover spread laterally by stolons or stems. Both are above-ground structures, but stolons produce roots whereas stems do not.

In both cases, leaves are produced by an apical meristem in the tip of the stolon or stem. The point at which the leaf is attached to the stolon or stem is called the node, which also supports an axillary bud that can grow out into either a daughter stolon / stem (similar to the tiller bud in the grasses) or a flower. In the case of the stoloniferous species such as white clover, the node also supports a root primordium that may develop into a shallow, adventitious root.



A white clover stolon, showing the region of the apical meristem where new leaves are produced, and nodes where leaves are attached to the stolon. Daughter stolons and roots are produced at nodes. Note: Roots are not shown.

The lateral, spreading habit of these species means they generally occupy the space between clumps of grass when grown in a mixture (see the diagram below). They can migrate through the pasture, exploiting favourable growth sites, whereas most grass plants remain in one spot and are largely stuck with the growth resources that are supplied by their immediate environment. The exception here too are the spreading rhizomatous grass species including couch grass and kikuyu.



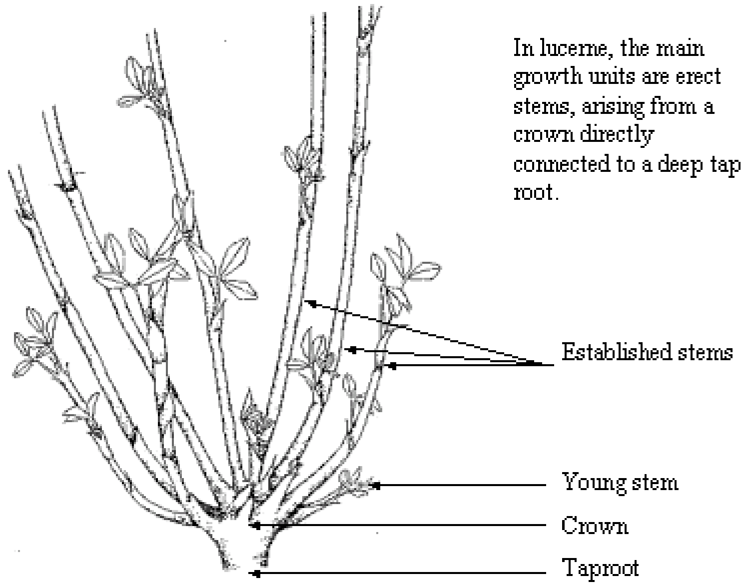
Grass / clover interactions in pastures. Illustration of the way that a spreading legume plant can occupy space between grass plants.

Leaf production and branching in white clover. The stolon nodes are numbered sequentially from the stolon apex, in order of increasing age. Daughter stolons have been produced at nodes 5, 6 and 7, and a young daughter stolon is also evident in the axil of the leaf at node 3. This is a typical pattern for plants grown in favourable conditions.

Erect species

The erect, or upright, legumes resemble the grasses in that they remain largely in one spot for the course of their life. The best example of this habit is lucerne, where stems grow up from a crown, producing leaves from the apical meristem in the tip (unlike the grasses, where the apical meristem is located at the base of the tiller).

Grazing usually removes a high proportion of the growing tips (along with leaves and stem), and the plants must be allowed time between grazings to replace those stems with new ones so that they can continue to produce leaves.



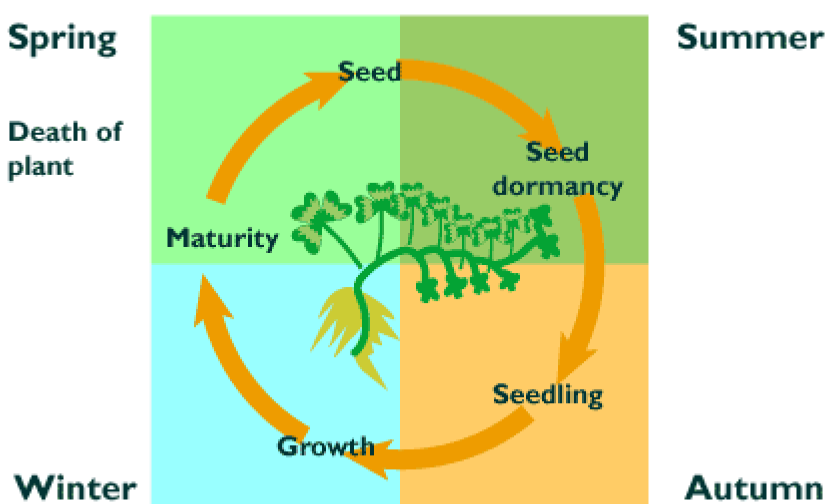
Flowering

Annual legumes, like annual grasses, have a highly controlled pattern of flowering.

The time of flowering is under strict genetic control. In species like subterranean clover, this feature has been exploited by plant breeders to produce a range of cultivars with different mean flowering dates. These cultivars are adapted to different environments.

Plant Population Biology

The growth habit of annual species



Flowering in annual legumes. A stand of arrowleaf clover (*Trifolium vesiculosum*) in full flower.

Flowering time in subterranean clover

Relative ‘maturity dates’ of sub clover cultivars currently available in Victoria

Early	Early/mid	Mid	Mid/late	Late
135 *		155		175
6 – 7 **		7 – 8		8+
Daliak	Clare	Denmark	Goulburn	Limbara
Dalkeith	Rosedale	Karridale	Leura	
	Enfield		Gosse	
	Seaton Park		Larisa	
	Woogenellup			
	Trikkala			
	Riverina			
	York			

* Approximate number of days from germination to start of flowering

** Approximate growing season required

Legumes (perennial and annual) have higher levels of digestible protein than grasses and therefore play a key role in animal production. They also have the ability to increase the soil levels of nitrogen. Although it is desirable to have legumes, a balance is required. Experiments at Seymour in Victoria showed that set stocked plots were excessively clover dominant leading to bare ground by late summer. Simple rotations, with 15% less legumes and more perennial grass, carried two more sheep per hectare and had more stable and sustainable pastures.

White clover

White clover is a major species in higher rainfall pastures and irrigation, especially those environments which receive summer or year-round rainfall . There are a range of cultivars with predominantly two types of growth.
Cultivars such as Kopu, Haifa and Tamar are erect growing with large stolons and leaves. They grow well in winter and compete with grasses when rotationally grazed. They do not survive well when intensively grazed for long periods and are better suited to cattle. Smaller leafed cultivars such as Irrigation, Tahora, Demand and Prestige are more prostrate growing and have a dense mat of stolons. These varieties need to be quite heavily grazed to prevent shading and improve persistence.

Vegetative growth
Vegetative growth of white clover can occur in all seasons. At germination a tap root is produced for anchorage and to supply water and nutrients. This tap root dies after about 18 months, and the mature stolons must rely on the fibrous roots that grow from the nodes at the base of each leaf stem (petiole). It is often at this stage that Haifa dies out of sheep pastures.
White clover spreads by runners (stolons) across the ground.
Figure X shows the basic structure of a white clover plant. Unlike grasses, the growing point of white clover is at the tip of the stolon.
Stolons grow forward from this point and the older sections of the plant die. Growth also occurs when the stolon branches at the rooted nodes to produce daughter stolons.
The production of stolons is reduced when the plant is shaded.
Once leaves are grazed they cannot regrow. Daughter stolons and growing points must be formed to ensure leaf production. Survival through adverse conditions is dependent on stolon mass and the energy reserves in that mass. The stolon mass is affected by grazing pressure (shading or removal), moisture and nutrients.

Reproductive growth
Reproductive growth occurs in spring-summer. Unlike grasses, white clover can maintain feed quality and continue to grow vegetatively during flowering. Seed production follows flowering to ensure regeneration if stolons have died as a result of drought or poor grazing management.

Subterranean clover growth
Subterranean (sub) clover is an annual species that is suited to areas that have an autumn, winter, spring rainfall. The growing season can be between five and nine months depending on the time of the autumn break and the cultivar.
Persistence is dependent on the seed set and regeneration from seed. A portion of the seed is hard and this seed will not germinate until the seed coat becomes permeable to water.
Sub-clover leaves are hairy and the root system forms only at the base of the plant where a large tap root and a system of fibrous roots are formed.

Vegetative growth
Vegetative growth begins each year with seed germination in autumn. After emergence, growth occurs first in the leaves, then in the petioles and finally in the stem internodes (stem between the nodes). The rate of growth over winter is affected by the time and amount of the autumn break but it is soil fertility and grazing management which determine whether it becomes a significant contributor to pasture productivity.
The growing point is found at the end of the runner and is the place where new leaves and branch runners develop. Figure X shows a branched runner and seed burrs compared with a white clover stolon.
Sub-clover growth from germination until spring is slow. Leaf growth will continue until the appearance of the next leaf. In shaded conditions, the rate of new leaf and stem production is decreased.

Reproductive growth

Reproductive growth commences in early spring. The trigger is usually complex, but there are two important factors: the accumulation of a cold requirement and day length. An early strain is one which needs less cold and flowers earlier – but produces less herbage. A strain that
is too late for your environment may not set enough seed if there is a dry spring. High rates of seed set are vital and grazing management at flowering may be altered to enhance it. The plant spreads through the pasture by rapid elongation of the stem internodes. Flowers form on stalks arising near the base of the leaves and their number is dependent on the amount of light reaching this area. Undergrazed sub-clover produces less seed, which may also be softer.
After self-pollinating, sub-clover flowers develop into a burr that contains up to four seeds. The flower stalks bend over, and bury the burr in the soil. Defoliation or leaf loss at this time can affect the amount and quality of seed set which will determine the regeneration capacity of the pasture in autumn. Careful grazing in the first years of establishment is required.
The growth rate of the sward is very dependant on the density of seedlings and managing the seed set the previous spring can have a significant impact on winter productivity.
Once flowering occurs it may pay to reduce grazing pressure.
However, if this leads to a rapid increase and dominance of other undesirable pasture species such as barley grass, fog and bent grass grazing pressure should be maintained.

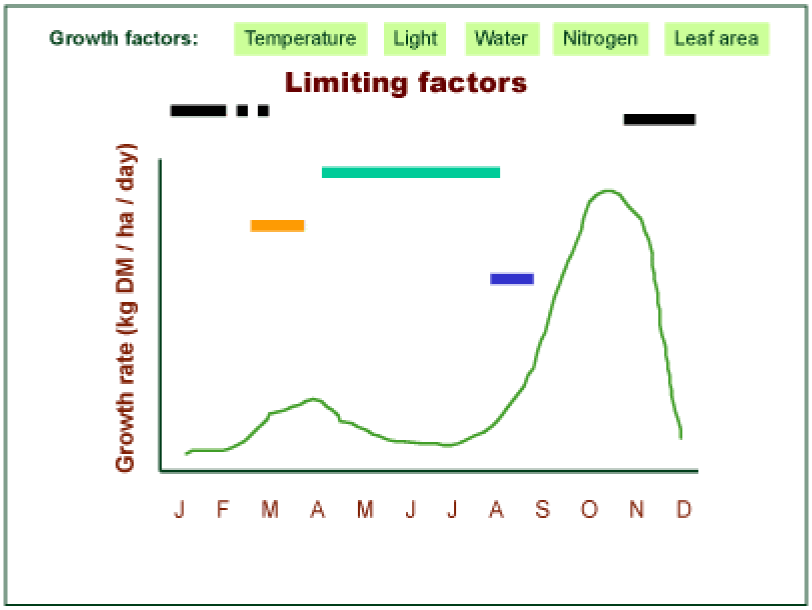
Include pictures of white clover and sub clover

The seasonal pasture growth curve

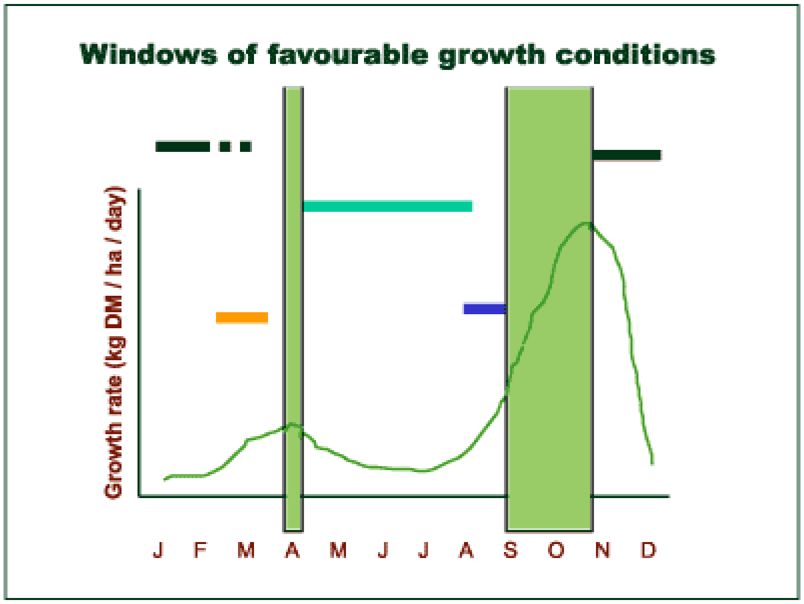
The factors which drive pasture growth rate most strongly are *environmental conditions* (principally temperature, light, and water and nutrient availability), and *leaf area*.

When any one of these is sub-optimal for growth (too cold, too dry etc.), then it becomes a limiting factor for growth and growth rate will be restricted. Conversely, when there are no limiting factors present, growth rate will be high.

It is apparent then that there are only relatively small windows of time throughout the year when there are no serious limitations to pasture growth. These windows are shown on the graph below.



Seasonal pasture growth. A typical summer scene in Australia with no green leaf.

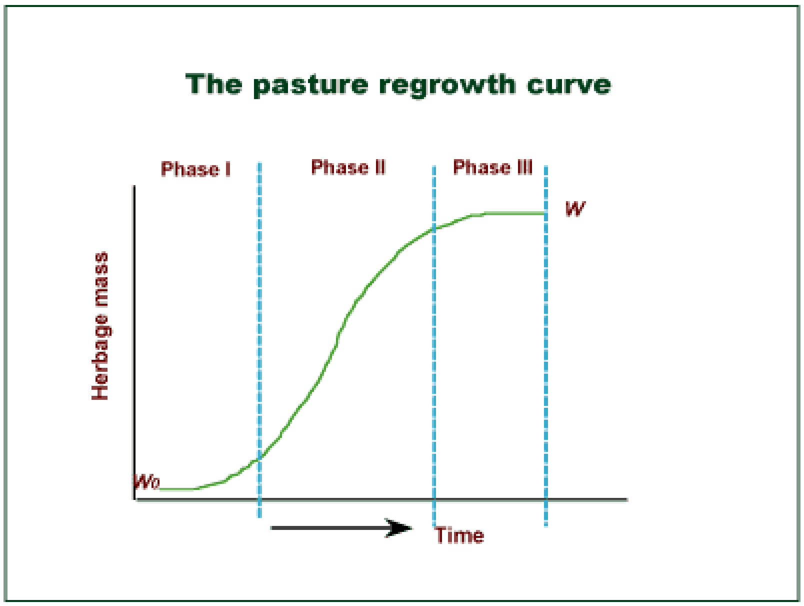


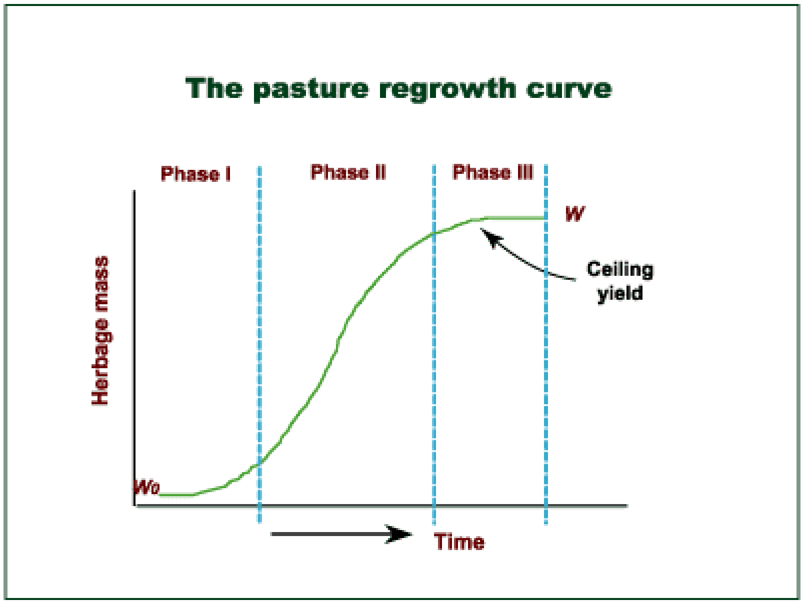
Phases of pasture growth
The individual species growth habits discussed above can be fitted into an overall sward growth pattern or curve. Figure Y shows the typical growth curve of pastures, consisting of three phases.
Phase I
Pasture has been grazed down to less than 2cm. Pasture growth is slow because the leaf area has been grazed to a point where there is insufficient leaf to capture light to generate fuel for fast pasture regrowth. Extended grazing of pasture in Phase I will result in slow growth, plant death, erosion, run-off and weed invasion. Sheep pastures set stocked to <1cm (approx. 400kg DM) in winter have been shown to produce 20 to 30% more DM if rotationally grazed. At <1cm plants simply do not capture enough light to grow efficiently.
Pastures kept in Phase I develop a smaller root system and absorb and transpire less water than if allowed to reach Phase II. Ground water levels and associated salinity problems can be exacerbated.
Phase II
This is the stage of greatest pasture growth. More sunlight is intercepted by the increased leaf area and more carbohydrates are photosynthesised into pasture growth. Pastures in Phase II are between 2cm and 12cm in height (800 and 3000kg DM/Ha).
Keeping pastures in Phase II will delay flowering and therefore a decline in pasture quality. Pastures in Phase II are productive and nutritious. They recover quickly after grazing, persist well and reduce soil degradation.
Phase III
Pasture swards are mature and are of lower quality. Growth is slow and the death rate of plant material is frequently greater than growth. Animals are likely to be more selective in their grazing which can affect composition. Pastures in phase III will be above 12cm in height and have more than 3000kg DM/ha with less than 10% bare ground.

Ideally, pastures should be maintained in Phase II. This however is often not possible, especially in winter when growth rates are slow. Under these circumstances grazing pastures in Phase II will not be detrimental to their long term survival as long as they are allowed to recover in spring.

Rotational grazing over winter (see later Segment) will help ensure that pastures have sufficient leaf area to optimise growth. Experiments have demonstrated that rotational grazing can increase carrying capacity by at least two to three DSEs during winter.

Include picture of phases of plant growth





'Ceiling yield' is reached at the point when the mass of new leaf material being produced equals the mass of old leaf material dying.

Optimizing pasture utilization: the 'three-leaf' rule

Because of the dependence of regrowth dynamics on the rate of leaf appearance, a simple rule of thumb for managing rotationally-grazed pastures is to graze when an average of three new leaves has been produced since the previous grazing.

This method is now being adopted by many farmers, especially dairy farmers. To check the stage of leaf development, farmers are advised to pull up about 20 tillers in a paddock, and count the number of intact (ie ungrazed) green leaves.

If three *new* leaves are present on most of the tillers examined, then the pasture is in, or close to, the optimum stage of regrowth for grazing.

The three-leaf rule works well where the magic number '3' applies - that is, to ryegrass-dominant pastures that are grazed down relatively heavily.

Three leaves might not be appropriate for other species, or where there is a mixture of species in a pasture but it provides a good approximation of the optimum time to graze for many situations.

The ‘3-leaf’ rule in ryegrass. The leaf being held is a ‘remnant’ leaf, which was present when the pasture was last grazed. We can tell this by the cut (flat) end of the leaf, which indicates that some of the leaf length was removed at the previous grazing. Ryegrass leaves are usually pointed at the tip.

Optimizing pasture utilization: continuous grazing

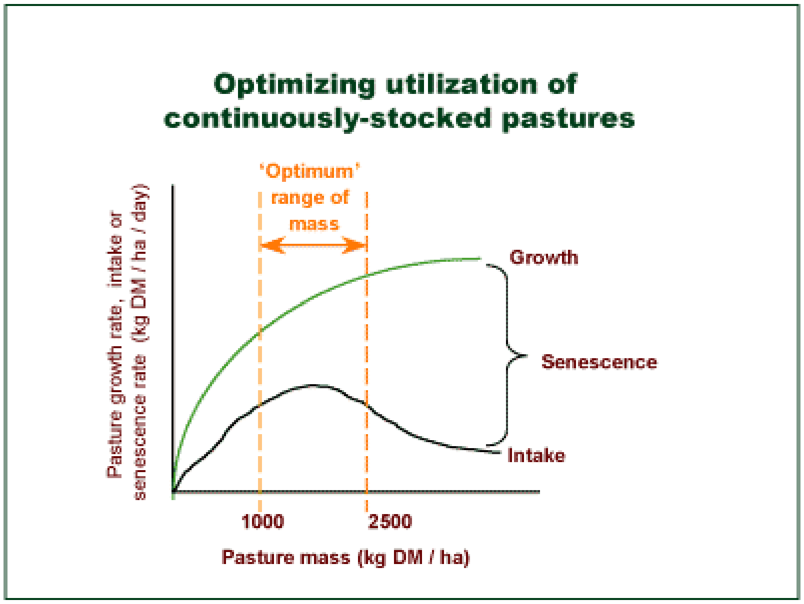
Is it possible to translate the principles of efficient utilization of rotationally grazed pastures to those which are set stocked?

The graph below describes how the processes previously discussed are expressed in continuously-stocked pastures.

Note that pasture growth increases as pasture mass (also known as Leaf Area Index) increases, up to some maximum level (equivalent to the ‘ceiling yield’). Also, pasture intake increases as mass increases, but reaches a maximum well before the pasture growth rate maximum is reached. Beyond this, the high rate of leaf death limits the animal's daily intake because of the amount of dead matter clogging up the pasture. This also limits stocking rate and means there are not enough animals grazing the pasture to eat the feed that is grown.

Keeping continuously-stocked pastures somewhere in the range 1000 - 2500 kg DM / ha, referred to as Phase 2 gives a good solution to the dilemma of maintaining high rates of green leaf growth while utilizing as much of this green leaf as possible for animal production.

However, continuous stocking (commonly called set stocking) still leaves quite a lot of the grazing process under the control of the animal, rather than the farmer, so it's not always possible to maintain control over pasture. Rotational grazing systems do allow more control by the farmer over grazing and the state of pastures, which can have important benefits for pasture growth and animal intake.



Segment 7 Grazing Management of Pastures

Grazing Management in context

Grazing management can be defined simply as the way we match feed supply from pasture with animal demand for feed over an annual cycle. However, it also has important effects on the conditions for pasture growth, and the composition of pastures.

'Grazing management' in turn comprises several components, namely species and class of livestock on the property, stocking rate, stock management policies (eg. lambing and/or calving dates), and grazing method (set stocking, rotational grazing etc.). Changes to all of these, particularly the first three, will affect the balance between feed supply and demand.

Of the different grazing management decisions that are made on the farm, the stocking rate decision is generally the most important. This is because stocking rate strongly influences pasture growth and utilization, the balance between feed supply and demand, animal production, and profitability. It can also have a major bearing on the persistence of improved species in pastures, and hence pasture composition and the sustainability of grazing systems.

It must be remembered that grazing management is just one component of the whole farm system. Other components include fertility, pasture species, stocking rate, annual calendar of operations.

To retain the right balance, it is important to realise that grazing management cannot substitute for, or overcome, shortcomings in any of the other factors.

The importance of stocking rate

"… no more powerful force exists for good or for evil than control of the stocking rate in grassland farming. Properly used, it can influence productive efficiency for good more than any other single factor".

This statement, issued by New Zealand grazing management researcher C.P McMeekan in 1960, remains equally true today, despite the advances in pastoral technology that have been made in that time.

Why is stocking rate so important?

Firstly, it is a key determinant of gross pasture production. Pastures that are over-stocked are also 'overgrazed' - that is, the leaf area of the pasture can be suppressed to the point where the pasture is unable to grow to its potential. This is akin to pasture being 'trapped' in Phase I growth.

Secondly because of the effect of stocking rate on pasture growth, animal intake and feed supply/demand balance, it is readily apparent that stocking rate will have a large effect on animal production, and therefore on farm income and profitability.

Striking the right stocking rate to achieve high and sustainable levels of animal production, as well as profit on the farm operation, is perhaps the most important farm management decisions that livestock producers must make.

The objectives of grazing management

There are several objectives that need to be met through good grazing management in order to achieve an efficient grazing system.

These as follows:

1. Match feed supply from the pasture with animal demand as closely as possible on an annual cycle;
2. Maintain green, leafy pasture cover for as much of the year as possible;
3. Meet target pasture covers at key times of the year;
4. Graze to favour the desired species in the pasture; and
5. Control selective grazing and nutrient transfer.

There is an old adage used by farmers which sums this up: "Nothing grows grass like grass". In fact, the adage should probably be "Nothing grows grass like green grass".

Another simple way to look at this is to think of the pasture as a giant solar panel. The greater the panel area, the more heat (growth) that is generated. When there are gaps in the panel, the potential to generate heat (growth) is lost.

Similarly light falling on dead leaf or other non-photosynthetic tissue is like putting shade cloth over the solar panel - the efficiency of heat generation (growth) will be reduced.

Maintaining green leaf cover is impossible in summer and into autumn in many regions where pastures are used for animal production in south eastern Australia. This is all the more reason to concentrate on good grazing management practices at other times of the year when moisture supply does not restrict growth.

There are critical times of the year in the pasture / animal system when the stability of production can be threatened if too much or too little pasture is present.

The interaction between pasture availability at key times and system performance has been the subject of much research, leading to the identification of pasture cover targets. Most of these are aimed at ensuring optimum conditions for pasture growth and nutritive value are maintained for as long as possible, either by having sufficient leaf area present to drive growth, or by controlling surplus growth to prevent a fall-off in pasture quality.

The use of feed supplements can help when there is a risk of falling short on a particular target. This is a good example of the benefits of having an integrated, planned feed system in place. Where the cost of failing to meet a pasture target is known, it is relatively easy to determine the cost: benefit result of using supplementary feed.

Finally, it's worth noting that it is very difficult to put together a grazing management system if there are no targets in place - this means both pasture and animal performance targets. A corollary to this is that both pasture and animal performance need to be monitored regularly in a well-managed system - for example, pasture cover might be estimated fortnightly, and some classes of animals weighed every month. A lot of information must be collected, analyzed and applied to successfully manage a modern grazing system.

Grazing to encourage desired species

The basis of pasture improvement is to create the environment that allows the plants we want in the pasture to flourish. This usually means increasing soil fertility, because these are the conditions that give the perennial grasses and clover a competitive advantage over the weeds.

This must then be complemented by appropriate grazing management to keep the desired species in the ascendancy in the mixture. Generally this means moderate - high grazing pressure, since most of the productive pasture species are well adapted to compete with weed species under this form of management.

The proviso is that grazing pressure must not be too high, otherwise it may jeopardize the survival of key species such as perennial grasses.

Controlling selective grazing and nutrient transfer

'Nutrient transfer' refers to the process whereby grazing animals move nutrients from the areas where they graze to the areas where they camp. Stock camps receive large amounts of animal excreta, and so they accumulate high levels of the nutrients found in dung and urine, especially nitrogen, phosphorus and potassium. These nutrients are often well in excess of plant requirements in the camp areas. They are drawn from the grazed areas of the paddock, and therefore stock camping creates variability in nutrient availability within the paddock - depleting nutrients in some areas, and over-supplying them in others.

The extent to which nutrient transfer occurs depends on a number of factors, including terrain. Camping is more pronounced on rolling and steep country where sheep, especially, seek out higher ground to camp on. Solutions include increasing the level of subdivision so that different slopes, aspects or terrain can be controlled, changing grazing management to some form of rotational grazing to control nutrient re-distribution, and avoiding camp areas when spreading fertilizer.

Grazing method

'Grazing method' is the term used to describe the way animals are moved around the farm to harvest pasture. The common grazing methods are set stocking, mob grazing, and some form of rotational grazing.

Grazing method is separate from the other aspects of grazing management (stock species and class, stocking rate, stock management policy), and generally not as powerful in balancing feed supply and demand. Perhaps the proper perspective is to think of grazing method as the key that locks the other elements together to drive animal production.

There are countless grazing methods, but set stocking, mob grazing and rotational grazing (and variations around them) account for the majority of the grazing systems used in Australia.

An important consideration when evaluating different grazing methods is that at the scale of the individual plant, all grazing methods involve intermittent defoliation. It is simply impossible for animals that are set stocked at a sustainable stocking rate to graze from every plant in the pasture every day. So, although set stocking is also sometimes referred to as 'continuous grazing', at the plant level grazing is not continuous at all.

However, a key difference between grazing methods is that they allow different levels of control over the intermittent defoliation process, and this is important for management of pastures and animals.

Set stocking

Set stocking (SS) is where animals have access to more-or-less all of the farm, or a large part of the farm, at once. This could continue for the whole year, or part of the year only. Usually, some paddocks will be 'locked up' in spring to make hay or silage.

The main physical features of this method are low stocking density, with low levels of subdivision and often large paddocks.

Mob, or block grazing

Mob grazing, or 'block', grazing is where paddocks are grazed for perhaps 1 - 2 weeks and then the animals are moved on, but not in any particular planned sequence. The main features are moderate - high stock density during grazing (maybe 50 - 200 sheep / ha) and low-moderate subdivision.

Mob grazing if often used tactically to regain control of pastures by 'crash' grazing them to remove or break down excess rank feed.

Rotational grazing

Rotational grazing is where the animals are moved around the farm in sequence with a controlled rest period between grazings. Grazing duration varies from 1- 2 weeks in a 'simple' system such as a four-eight paddock rotation, to 1 - 2 days in an 'intensive' system.

The farm is much more highly subdivided, often with electric fences and temporary wires to break paddocks up at some times of the year. Strip grazing is an intensive form of rotational grazing, with pasture area allocated daily in amounts calculated to meet daily animal feed requirements.

Rotational grazing should be used as part of an overall farm production strategy. It involves a lot more planning and the use of clear criteria by which animals are moved from paddock to paddock. The best criteria to use are ones that relate to stage of plant growth and / or pasture 'readiness' for grazing. Simple, time-based criteria are useful, but don't cope so well when conditions for pasture growth are changing frequently.

Grazing methods compared: pasture production

In regions of southern Australia where pasture growth is severely curtailed by summer dry conditions, Rotational Grazing can result in improved pasture growth after the autumn break compared to Set Stocking.

This leads to better autumn and winter pasture growth rates and better pasture availability in winter / early spring, and fits well with the feed demands of a spring lambing or spring calving system.

The reason for better autumn / winter pasture production under RG can be related to the model of pasture growth and the solar panel analogy.

Imagine a pasture beginning to re-establish green leaf area after a 'late' autumn break (for example, autumn rains arrive in May, instead of March or April). If the pasture is set stocked, animals will preferentially graze the new green leaf, especially if they haven't seen any green leaves for the past few months! This will suppress leaf area, and hold back growth rate for a time, until the pasture can 'get ahead'.

If pastures are rotationally grazed instead, using a long interval between grazing (say 35 - 45 days), sheep will be confined to a limited proportion of the farm area (2 - 3%) at a time. The areas that are not being grazed have a chance to 'get ahead' and build up solar panel (leaf) area. Thus, while extra feed may be needed to maintain a slow rotation at this time, the benefits further down the road will outweigh those costs.

In terms of the effects of grazing method on pasture composition, there is good evidence from phalaris / sub clover pastures that rotational grazing favours phalaris growth and leads to lower sub clover content in pastures compared to set stocking in summer-dry environments.

This illustrates how important it is to know what the production goals are for the farm when making grazing management decisions. If the production goals require high levels of per head production (for example, to grow young stock quickly), then rotational grazing may not be the appropriate system. If, however, the goal is to maximize production per hectare (for example wool clip per hectare), then RG might be appropriate because higher stocking rates compared to set stocking more than compensate for lower per-head production. It is 'horses for courses'.

Grazing methods compared: pasture utilization

Moving from set stocking through to intensive forms of rotational grazing involves applying an increasing level of control over the grazing system.

Under set stocking, the animal largely determines what, where and when it grazes. There is little management control over grazing frequency and severity, and considerable opportunity for selective grazing. It is extremely difficult, then to manage for the desired species in the pasture and to control selective grazing.

However, as noted earlier, selective grazing can be a good thing if the objective is high rates of animal growth because animals can select a high quality diet. This principle is often applied in 'leader-follower' systems, where high priority livestock (such as growing lambs) are allowed first use of a fresh break of pasture, and then followed by a class of livestock that do not require such high quality feed.

Patch grazing is a common result of selective grazing under set stocking when there is an excess of feed. Here, animals concentrate their grazing in short, green, leafy patches, leaving other areas to become long and rank.

The result is a pasture with areas trapped in Phase I growth, areas that have moved to Phase III growth, and nothing in Phase II growth - which is where pastures should be for optimum performance. Overall pasture utilization will be low under these conditions.

Clearly, patch grazing is detrimental to pasture productivity.

By contrast, under rotational grazing, there is a high level of management control over grazing frequency, severity, and selectivity. The more intensive the rotational grazing system applied (eg “cell” grazing, versus a four-paddock rotation), the greater the level of control.

Under RG patch grazing is less of a problem, and there is generally a more-even utilization of the feed on offer in a paddock. It is possible to implement managements that favour the desired species in a pasture, and to control selective grazing, using a rotational system.

Grazing methods compared: Nutrient Distribution

Rotational grazing generally achieves better control of patch grazing and therefore better pasture utilization than set stocking, and may also lead to more-even re-distribution of nutrients in dung and urine across the grazing area.

Include info from Richard Simpson ie Equivalent of 2-4 kgs P /ha

Grazing methods compared: management of feed supply

It is evident that intensive rotational grazing systems can help manage both feed deficits and feed surpluses, and so give some extra ability to match feed supply and demand.

Also, because farmers are seeing their pastures and animals more often, mismatches between feed supply and demand can be picked up earlier and corrective action taken (eg apply N fertilizer, buy in feed, sell surplus animals).

On the other hand, set stocking gives some ability to cope with a pasture surplus (by closing areas for silage or hay conservation), but no ability to deal with a feed deficit in the way rotational grazing can. Generally, stocking rate has to be set at a level where all animals can be fed from current growth in all seasons, unless supplements are used.

Grazing managements compared: the bottom line

Overall, it can be seen that rotational grazing allows more ability to manage the feed supply / demand equation than set stocking, and can give better pasture growth and utilization.

Essentially, the answer to the question "When should I use RG and when should I use SS?" boils down to consideration of three factors:

1. current pasture cover on the farm;
2. expected pasture growth rates; and
3. expected animal demand

If 1 and 2 are low, and 3 is high, then RG will win out, because of better ability to feed animals from the pasture base.

This analysis also illustrates one other important consideration about changing to rotational grazing. If the stocking rate on a property is such that there is never really a shortage of feed, then there would be little benefit from using rotational grazing - animals will be well fed from the current pasture supply. The appropriate response in this situation is to increase stocking rate. Once stocking rates are increased to a level approaching the optimum for the environment (see Segment X), then a change of grazing method is recommended.

Grazing method: Summary

1. The main grazing methods used in livestock production in southern Australia are set stocking, mob (sometimes also called block) grazing, and some form of rotational grazing. As we move from set stocking to intensive rotational grazing, we exert more and more control over the grazing process.
2. No one grazing method will work best all of the time in all situations. The aim should be to exploit the advantages of different grazing methods when they are available, and if they are consistent with the goals established for the farm business.
3. When comparing and contrasting the different grazing methods, we sould consider their relative effects on pasture growth, pasture utilization, and the ability to manage the balance between feed supply and demand.
4. Compared to set stocking, rotational grazing can increase pasture growth and cover from the autumn break until late winter in phalaris / subterranean clover pastures in the medium - high rainfall zones of southern Australia (550 - 700mm). Under these conditions, it leads to higher phalaris content in pasture, but lower clover content and lower individual animal production.
5. Rotational grazing generally achieves better control of patch grazing and therefore better pasture utilization than set stocking, and may also lead to more-even re-distribution of nutrients in dung and urine across the grazing area.
6. Intensive forms of rotational grazing allow greater ability to match feed supply and demand over an annual cycle, and therefore manage the feed supply, than set stocking or mob grazing. This is the main reason why rotational grazing is practiced on dairy farms, where efficient feed management is very important for high levels of farm productivity.
7. When deciding which grazing method to use for any given situation, it is important to consider the current pasture availability, expected pasture growth rates, and current and expected animal demand. If the first two of these are low, and the third is high (as may happen, for example, in winter in systems operating at high stocking rates), then rotational grazing will generally lead to better animal production per hectare than set stocking. Where feed supply from pasture is adequate to feed animals to required levels, then there may be little benefit in using a rotational system instead of set stocking.

The leaf stage approach to grazing

The basis by which leaf stage can be used to manage rotations has been previously described in Segment X .

In short, it is possible to use a rule of thumb for the timing of grazing which is based on leaf stage because there is a fixed number of live leaves per tiller in the grass species. Once this leaf complement is reached, the appearance of a new leaf will be accompanied by the death of old leaf material and, therefore, an increase in senescence rate and a decrease in the rate of net pasture accumulation. The point at which this occurs is roughly equal to the theoretical optimum time to graze during regrowth.

It is well established that the 'magic' number in ryegrass is 3, hence the '3-leaf' rule that is currently gaining favour over other approaches for managing grazing rotations in ryegrass-dominant pastures, in dairy as well as sheep/beef systems. The essence of this rule is that paddocks should be grazed when the ryegrass plants have reached between 2.5 and 3 leaves per tiller, all year round. Grazing at 2.5 - 3 leaves may also have the added advantage of allowing energy reserves to be restored between grazings, to enhance plant persistence especially in marginal environments for the species.

Some species such as phalaris are best managed at the 4 leaf stage while kikuyu is optimally managed at 4.5 leaves.

Managing the r.g system

Deciding when to shift animals from paddock-to-paddock in a rotational grazing system is an important aspect of grazing management, and one that is complicated by variation in pasture growth and animal requirement over time.

There are several criteria that can be used, but the most successful ones are those that are linked to stage of plant growth, such as leaf stage. They will automatically be responsive to changing conditions for pasture growth, which is critical for efficient management of rotations.

In general, rotations should speed up when pasture growth increases, and slow down when pasture growth falls. Rotation length (and paddock number) should be emergent properties of the system, rather than fixed constraints on the way feed is harvested. Guidelines for grazing management based on the leaf stage of development account for these important responses, and give a good approximation of the optimum timing of grazing during regrowth.

The importance of grazing

Grazing is one of the most important factors in the management of pastures. Grazing affects pasture productivity, quality, persistence and animal health, and is a major determinant of the economic productivity of an enterprise.

The objectives of grazing management are:

- To optimise pasture growth and quality.
- To use the pasture efficiently and profitably.
- Ensure pasture quality is satisfactory for stock.
- Reduce worms.
- Ensure the persistence of desirable plant species.
- Ensure that groundcover is adequate to prevent erosion and resist weed invasion.

Pasture production is affected by factors such as species present, soil type, moisture, temperature and soil fertility.

However, we also need to remember that plants are, in effect, carbohydrate producing solar factories. Their rate of regrowth after grazing is strongly affected by the leaf area remaining after grazing (to capture light) and whatever carbohydrate reserves they have stored in the base of their stems and roots. Grazing too low (reducing leaf area) or for too long (reducing root reserves) will reduce the rate of regrowth affecting persistence, livestock production and erosion.

The influence of animals on pasture

Selective grazing

Sheep and cattle have different feed preferences and different grazing behaviours, however, they both select leaf in preference to stem and stem in preference to dead material.

When herbage mass is high sheep select green leaf material (particularly clover) and graze closer to the ground (because sheep have a greater impact on the composition of the pasture than cattle). Cattle also select green material but are less selective. They are able to quickly reduce the mass of herbage and remove the taller shading grass and encourage clover growth. Because cattle are less selective than sheep they are more effective in cleaning up rank pastures.

The grazing of sheep and cattle together can increase animal output and maintain pasture stability, particularly if relatively unpalatable species are present.

The degree of selective grazing will depend on the attractiveness of a plant to the animal. Undesirable species such as mature annual grasses, native species or fog grass are avoided and a greater grazing pressure is placed on preferred species, improving livestock production in the short term.
The long term result, however, is that these undesirable species will capture more light and become dominant. The over-grazed, preferred species will grow slower as they capture less light and they may eventually die out. A mixed sward under continuous lax grazing will rapidly become weedy (change botanical composition to less desirable species).

Grazing pressure

Animals can significantly improve the composition and productivity of a pasture if stocking rates are adequate. If under-grazed, plant nutrients will not be recycled by animals and will remain locked up in plant material and be unavailable for new plant growth. An accumulation of excessive amounts of decaying plant material will also tend to tie up nitrogen (“denitrification”). Species better adapted to lower fertility situations and/or lower pressure grazing such as bent grass may invade and dominate such pastures.

Poor grazing management therefore contributes to weed invasion and grazing may need to be modified so that desirable species are not threatened.

Pasture utilisation

Profitable grazing enterprises are based on efficient utilisation of pastures. For example most sheep/beef properties only utilise 20 – 40% of pasture grown. The rest is “wasted” from a production viewpoint and although utilization levels in excess of around 60 to 70% is neither practical nor desirable there is still potential for large increases.

Grazing management encompasses not only the method you use to graze (set stocking or rotational grazing) but includes other important factors that affect utilisation such as stocking rate, stock type (sheep/cattle, ewes/wethers) and time of lambing or calving.

Grazing for production per head or per hectare?

Grazing management strategies involve the manipulation of grazing pressure and frequency. Grazing management decisions aim to match feeding requirements with pasture requirements and production. That is, matching sheep or cattle with the lowest demand (eg dry stock) with lower quality pastures and growing stock on better pastures. Pasture benchmarks can be used as a basis for achieving this. We also need to consider occasional spells to replenish carbohydrate reserves if grazing pressure is constant.

Insert Diagram on p 85 Vic Prograze Manual which includes the following
Stock type
Stocking rate
Time of lambing/calving
Grazing method

Stocking rate

Stocking rate is the most significant determinant of pasture productivity and profitability.

With increasing stocking rate, production per animal may decline but production on a hectare basis increases to a maximum point (economic optimum stocking rate) and then declines. This decline is due to insufficient herbage for animal, greater spoilage by dung, urine and trampling and the invasion of weeds.

The grazier needs to achieve a *compromise* between per head and per hectare production. As discussed previously, infrequent and lenient grazing can also reduce pasture growth.

Determining optimum stocking rates can be difficult and will vary between paddocks, seasons and years. However appropriate guidelines have been developed based on extensive on-farm demonstrations as part of the Triple P Program in southern Australia (see Segment X). In terms of pasture availability, a general pattern prevails in most the Mediterranean winter dominant rainfall environments of Australia of abundant herbage in spring, poor quality but good quantity dry feed over summer, increased availability in autumn following the season break, and limited production in winter. Stocking rates therefore tend to be determined by the minimum acceptable condition stock need to be in during the winter period, the period of most limiting feed availability.
Include a pasture growth curve here?

Grazing management systems
Two broad options are available: set stocking where paddocks are grazed for almost all of the year, and rotational grazing where stock are moved every one to 14 days over perhaps four to 40 paddocks.
There are, of course, many variations on these two basic systems and the ideal system for your farm will be flexible and may include components from both.

Set stocking
Set stocking is perceived as the simplest and most economical system in terms of labour, fencing etc, however it can be detrimental to the persistence of perennial species and winter growth rates are reduced if pastures are kept in Phase I for too long.

Set stocking can lead to poor utilisation (which is more evident in larger and undulating paddocks) and productivity which is well below potential. Grazing tends to be patchy and selective allowing the less preferred – and less palatable - species to dominate. Set stocked paddocks can be excessively bare by autumn.

Under set stocking the animal is effectively “in charge” of the grazing process and is allowed to preferentially select the most desirable species. Consequently animal production on a per head basis is often superior.

Capeweed, erodium, winter grass and sub-clover tend to be favoured by set stocking in winter and perennial legumes are likely to be disadvantaged in summer.

Rotational grazing
Two basic rotational systems are described – intensive and simple. In practice farmers should adjust rotations to suit the paddock number or size, and the mob size available. The objective is to optimise plant growth rates by spelling to replenish carbohydrate reserves.

Intensive rotational grazing requires the use of large mobs for short periods of time (one to three days) followed by a period of rest. This rest period or rotation length is determined by the pasture growthrate, varying between 6-8 weeks in winter and 3-4 weeks in spring.
Grass growth rates and potential stocking rates are certainly higher with intensive rotations than with set stocking or simple rotations.

Selective and uneven grazing, particularly in hill country, is reduced and it allows farmers to allocate feed according to need or to ration as required. It is likely that committed farmers will gain considerable benefits from intensive rotations but in practice the advantages for many will not always be quite as straightforward. The more intensive the rotation the less sub-clover will be in the pasture (although white clover may well increase). For those with very dominant sub-clover this may not matter, and may even be an advantage. Grasses may become dominant in any rotational system and the build up of annual grass weed species may create feed quality problems.

A potential disadvantage of the increasing dominance of grasses and decline of legumes associated with rotational grazing is reduced nitrogen levels which will subsequently reduce grass growth rates. However this has not become immediately apparent due to the variability of seasonal conditions from year to year with some years favouring clover growth. Also if the decline of legumes is a concern then a return to continuous grazing for even a short period will rectify the situation.

Perhaps the main obstacle to the wide scale adoption of intensive rotational grazing systems is that not everyone believes that they have the time, skill or financial resources to adopt an intensive rotation and those with cropping programs, off-farm jobs, or other calls on their time may find the commitment unacceptable. Those who have adopted such systems report that it takes less time to manage small numbers of large flocks and claim these obstacles are overrated. Nevertheless a higher level of skill is required for intensive systems and costly mistakes are possible. Less intensive systems, which still provide most of the benefits, may be more suitable for many farmers.
PROGRA
Simple rotational grazing
Research in Victoria has shown that more feed can be produced through the use of relatively simple, approximately two week on six week off, four or eight paddock rotations with increases in carrying capacity and productivity of around 20 to 30% over set stocking, which can be very profitable.
However, any rotational grazing system can lead to a reduction in feed quality and per head performance and will only be profitable if the extra feed produced is utilised by running more stock.

Flexibility and common sense are the keys to success
Useful Tips:

- Do not set your rotations by the calendar, they should be based on growth rates, feed availability and animal requirements.
- Annual grasses can dominate clover under any rotational grazing system but grass dominance will be reduced if you speed up the rotation in autumn.

- In spring do not move animals into the next paddock in the rotation, simply because it 'is next', if another paddock needs grazing more. Eat out the poor quality silver grass, barley grass, fog, bent grass paddocks while they still have some value and leave the ryegrass/clover paddocks for later.
- Never underestimate the blow-out in the spring flush that will occur under rotational grazing, particularly in a good season – you may grow 50 to 100% more feed in spring and you will need to have strategies in place to utilise it or quality will decline rapidly and next year's growth will be reduced. You may need to have more ewes in the flock, or shift to spring lambing, cut more hay or get in agistment stock.

Research has proven that rotational grazing will improve the persistence of perennial grasses and increase rooting depth. This will reduce ground water leakage and help dry the subsoil. Summer rotational grazing has also been shown to increase green leaf area and moisture transpiration. Both of these effects help reduce the environmental impact of grazing systems.

Seasonal management of pastures
The tolerance of pastures to grazing varies at different times of the year. However, there are seasonal pasture treatments that can be carried out to cause a desirable change in the pasture sward.

Autumn
Autumn is a period when both annual and perennial pastures are regenerating from seed, stolons, crowns or tillers. It is during this period that:
• Dry summer feed needs to be reduced to ~ 1 000kg DM/ha to reduce shading and allow sufficient bare ground to encourage germination of seedlings and to stimulate new tillers of perennial grasses.
• Plants are generally small, and when moisture becomes available, perennial grasses have an advantage over annuals because of their established root system. However, some annual grasses may be a problem if their seed density is very high. The dense seedling advantage of annual grasses may be exacerbated if perennial grasses are over-grazed during this period.
• Heavy grazing in autumn may reduce plant regeneration because of damage to new seedlings, crowns or stolons.
• Grazing strategies over autumn should promote the growth of a dense mat of desirable species, which will provide more total herbage mass during winter.
• In annual pastures, this may mean a period of deferred grazing to allow establishment. This deferment of grazing is more important when the autumn break is late when lower winter temperatures mean growth is reduced.
A similar such benefit will be also be achieved with perennial grasses by allowing them to achieve optimum leaf area and growth rates before winter. This also has benefits from a weed control perspective.

Winter
Over winter the challenge is to manage pasture to increase growth, and maintain adequate clover. It is during winter
that:
• Growth is limited more by low temperatures then moisture deficit.
• Winter feed availability and pasture leaf area will usually determine annual stocking rate. The problem is worsened if stock continually graze pasture, reducing the recovery rate – and growth rates - of plants.
• Grazing should be based on long rotations, eg two weeks on then six weeks off, but if you have had a good autumn break and have plenty of feed it may be beneficial to set stock to preserve clover content and quality.

• Long rotations increase the size of plants, allowing them to intercept more light and therefore increase growth rates.
• Spelling of perennial pastures (rotational grazing) over winter favours perennial grasses over annual clover. But this strategy can reduce the amount of clover. The speed of the rotation should be adjusted to ensure that pastures do not exceed seven to 10cm and extra growth must be well utilised.
If using the leaf stage to determine grazing interval, typical leaf appearance rates are 20-30 days per leaf during winter which equates to a grazing interval of 60-90 days, depending upon environment
• Quick hard grazing at the end of a winter spelling may reduce the seed set of annual grasses by removing (decapitating) the developing seed head but stocking rates of at least 100 sheep per hectare are necessary.

Spring
The control of pastures is critical, but difficult in spring. Decaying plant material, if it is not prevented in spring or removed over the next summer, will reduce growth and restrict germination and tillering in the following autumn.
• To maintain growing clovers, grasses should be restricted in height. If too many paddocks require attention and insufficient animals are available, cut hay, mow or make silage. Alternatively prioritise paddocks for treatment.
• Results from the Victorian Grasslands Productivity Program and Paired Paddock Program (TripleP) together with experiments from PVI Hamilton consistently show that increasing soil fertility, allowing more stock to be run in winter, can enable farmers to utilise the spring feed better. The peaks and troughs are reduced.
• Rapid early growth of tall grasses will shade clovers and reduce subsequent flowering.
• In sub-clover pastures, frequent grazing assists flowering and seed production.
• Try to keep spring growth to around 10-30cm. This will allow pasture to remain vegetative, extending the growing season and preserving quality. Tall, rank pasture is to be avoided in late spring. Alteration of lambing/calving times, spray-topping or closing some areas up for fodder conservation may help to fully utilise the spring flush and force plants to remain in the vegetative state longer.
• Typical leaf appearance rates during spring are 7-10 days suggesting an optimum grazing interval of 21 – 30 days .
• Good spring conditions can lead to undergrazing and if a series of good springs occur over successive years, pasture deterioration is likely. For this reason, pasture topping, fodder conservation and agistment stock may be needed to control growth. For this reason a feed budget undertaken in both late winter /early spring as well as late spring (at the end of the effective growing season) are critical.

Summer
Grazing strategies over summer will differ dramatically between areas with predominantly summer rainfall compared to those with winter rainfall.
• Survival of predominantly winter and spring rainfed pastures can be threatened by hard summer grazing when plants are under moisture stress.
• The bulk of dry feed must be removed, leaving about 1 000 kg/ha by the break.
• Maintain greater than 70% groundcover of pasture to prevent soil erosion.

Management of pasture composition

The botanical composition of a pasture affects the amount and quality of herbage and therefore animal production. Modification of the botanical composition of a pasture can be achieved in a number of ways. These include:

- The use of grazing pressure (stocking rate).
- Increased fertiliser use.
- Spelling (length, frequency and timing) to suit the desirable species.
- Grazing based on the growth stage of the plant.
- Grazing strategies combined with herbicides.
- Heavy grazing over flowering to reduce the seed production of undesirable species.

Legume management

Legume management is important as the percentage of legume in a pasture is directly related to the quality of the pasture sward. In the vegetative form, legumes are very digestible and so animal production will be high. Legumes will add nitrogen to the soil to be used by the grass component of the sward.

Too much clover in the diet can cause bloat in cattle, however sheep will grow well on high clover pasture. Too much clover also makes pastures difficult to manage with excessive bare ground over summer and invasion of weeds such as capeweed, thistles and barley grass. A balanced sheep/beef pasture will contain a minimum of 20% clover on a dry weight basis although this will vary according to enterprise and production goals.

Managing seedling pastures

Pasture seedling management can have a significant effect on the botanical composition of a pasture. In the establishment year of a pasture it is desirable to let the plants set seed, however with well established pastures, allowing the setting of seed annually is not critical. Importantly it is worth noting that seedling recruitment of most perennial grass species, including especially phalaris, fescue and to lesser extent cocksfoot is relatively poor. The exception is perennial ryegrass which has greater seed size and seedling vigour and can therefore establish more readily from the soil seed bank.

Just as spelling at the reproductive stage can preserve species, the same principle can be applied to kill weeds. For example, controlled grazing in late autumn and mid-spring can reduce annual grasses and allow clover to develop.

Management for sustainability

Pasture species vary in their response, and hence their tolerance to grazing. Many perennial species require a rest period after defoliation to rebuild their carbohydrate energy store in the roots. Hard continuous grazing will contribute to poor persistence.

Perennial pastures need to be adequately fertilised and perhaps limed if they are to persist.

Rotational grazing can increase the amount of water perennial pastures use and thus contribute to a reduction in salinity and waterlogging.

The key is to use as much water on the paddock as possible and to ensure that whatever does run-off is clean and free from nutrients.

Managing pasture species

A large mob of sheep being rotationally grazed on hill country.

Grazing imposes a limitation on plants by interrupting their growth – it removes leaf area and therefore cuts the energy supply coming from photosynthesis. The grazing process can also physically damage plants, through trampling and the effects of dung and urine deposits which can bury or scorch plant tissues. These events are often occurring at the same time as the plant is dealing with other limitations, like sub-optimal temperatures, nutrient deficiency, or low water availability. Management recommendations for pasture species are based on knowledge of how they cope with these limitations, which in turn is related to their physiology and morphology.

There is great diversity among the species used for pasture production, for example in their life cycle, growth habit and morphology, physiology, and adaptive range.

Tall fescue (right), although closely related to perennial ryegrass (left), should not be managed in exactly the same way as ryegrass.

Because pasture species differ in so many respects, it is not surprising that they each perform best under certain management inputs. A single management recipe will not suit all plant species, just as all plant species are not suited to all environments. Thus, it is not a good idea to apply the same management used for common species like, for example, perennial ryegrass, to other species like, eg. tall fescue or phalaris. This is true even when species are quite closely related, as is the case with ryegrass and tall fescue.

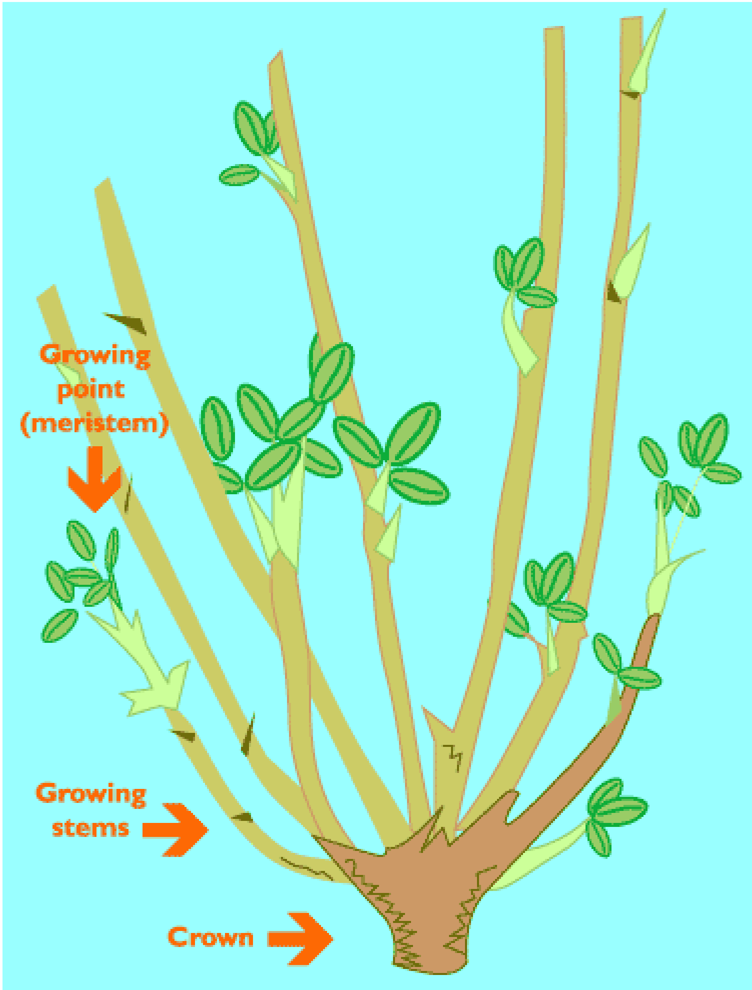
It is important to match the management requirements of pasture species with the management system and skills of the property when designing pasture mixtures. If the management of the property is rigid, then the chosen species must be compatible with that management system. However, if the management system is flexible, a wider choice of species will be available, and there will be more options available to meet the goals of the farm business.

Managing pasture species: An example with lucerne

One of the best examples of a species that needs careful and specific management is lucerne. Lucerne is a high quality, drought-tolerant perennial legume and a very valuable animal feed. To be used successfully, it must be rotationally grazed, allowing 30 – 40 days between grazings. If it is set stocked, the lucerne stand is depleted, leading to an ingress of weed species and loss of productivity.

A good example of a healthy, well-managed lucerne stand.

The reasons for this are found in the physiology and morphology of the species. Lucerne is a crown-forming plant. It produces erect-growing stems from the base of the crown usually at or just above ground level. The growing point, or meristem, of the stem is located in the tip which is in the grazed layer of the pasture and can be easily removed by livestock. If this happens to a high proportion of the stems on a plant, the plant must produce new stems from older bud positions in order to re-establish leaf area and photosynthesis.

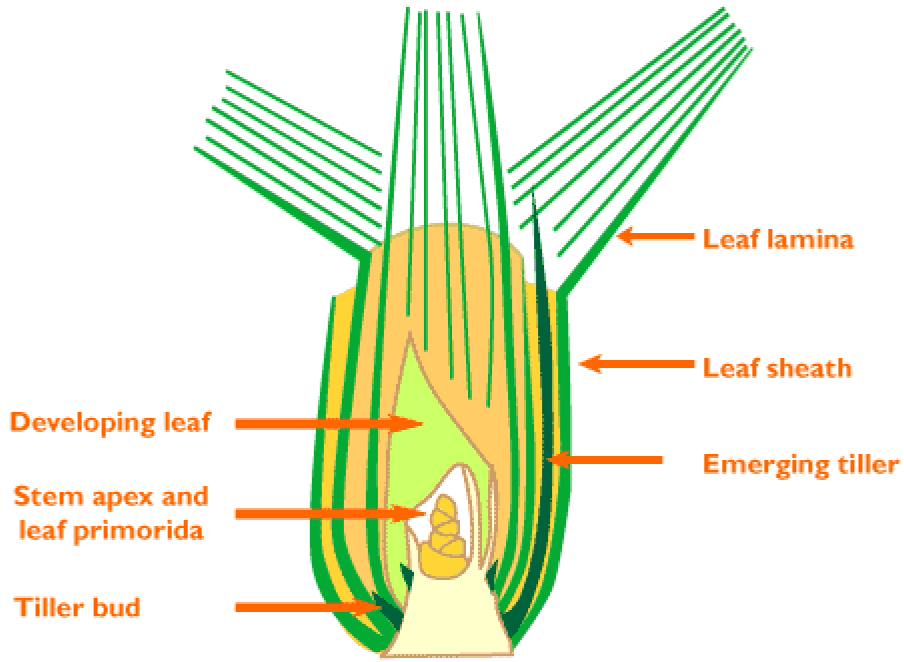


This can use up a lot of the plant's energy and protein reserves. The plant therefore needs time between defoliations to rebuild stem number, leaf area, and reserves. Some form of rotational grazing, where there is a sufficient spell between grazings, allows this to happen.

On the other hand, if the lucerne stand is set stocked, especially at a high stocking rate, plants may be re-grazed before they have had a chance to replenish their leaf area and reserves. If this occurs repeatedly, the plant may go into energy 'starvation' and eventually die, leaving a gap in the stand which might be occupied by weed species. This will happen more quickly if the plant is under additional stress, such as through low soil nutrient availability or inadequate soil water.

Managing pasture species: The grasses

In contrast to lucerne, the unit of growth in the grasses, the tiller, has it's growing point (meristem) located at the very base of the structure, often below ground level. It is further protected from grazing by the surrounding psuedo-stem of the tiller. In addition, each site at the tiller base where a new leaf is produced is accompanied by another meristem, called an axillary meristem, where a new tiller can be produced (this structure is sometimes called the 'tiller bud'). Over time, grass plants build up a capacity to 'tiller out' from the bank of axillary meristems that have accumulated from earlier growth. This feature enables plants to quickly re-establish a dense sward following grazing or fire damage.



Because regeneration of leaf material from protected meristems and new tillers is assured in the grasses, they are generally tolerant of hard grazing (i.e a grazing event that removes a high proportion of their leaf area). They can also withstand frequent grazing, as occurs under set stocking.

However, the perennial grasses, in particular, respond well to some form of rotational grazing. Indeed, where species are being used close to the limits of their adaptive range (for example, perennial ryegrass in a region with 650 mm annual rainfall), it is strongly recommended that they be rotationally grazed and not set stocked. This increases plant growth and persistence, leading to better long-term production and stability of the mixture.

Perennial ryegrass (*Lolium perenne*) can cope well with intensive rotational grazing.

The reasons for this are similar to those that dictate the need for rotational grazing of lucerne. Although the grasses are better equipped for re-establishing leaf area than lucerne, they too use energy and protein reserves to do so. Where the plant is also coping with, say, poor nutrient availability or lack of water, it will struggle to replace those reserves because, in addition to growing more leaf, it must also pump energy into new root growth to sustain the supply of nutrients and water.

In other words, there are a lot of different demands being placed on energy and protein within the plant. Under these conditions, set stocking can increase one of those demands (for new leaf growth), at the expense of other 'sinks' (such as roots). Ultimately, the plant may fail to acquire enough energy or nutrients to supply all it's needs to enable it to compete with other plants in the pasture.

Rotational grazing of perennial ryegrass.

So, while perennial grasses will *generally* tolerate set stocking, they also tend to perform better under some form of rotational grazing especially when there is a risk of other limitations to growth occurring.

The productive, winter-active phalaris cultivars 'Sirosa' and 'Holdfast' must be rotationally grazed if they are to survive for any length of time. Compared to the old 'Australian' phalaris, these cultivars have been bred for greater leaf production and winter growth, meaning that they are less tolerant of the frequent grazing that can occur under set stocking.

In general, cultivars bred for high productivity will perform best under some form of rotational grazing. This includes most of the newer cultivars of grass species.

Managing pasture species: The clovers

The main clover species used in pastures in southern Australia, subterranean clover and white clover, are generally tolerant of set stocking. Their growth comes from laterally spreading stems or stolons, where the growing point is close to the soil surface and usually below grazing height.

They may also perform better under rotational grazing. However, because the grasses respond strongly to rotations, this can lead to some suppression of clover in a mixture. Hence the net effect may be similar or less clover in the pasture under rotational grazing compared to set stocking. It is generally considered that set stocking favours clover in a mixture, since it reduces some of the competitive pressure coming from the associated grasses.

A dense white clover population under set stocking management.

As is the case for the grasses, the more-productive clover cultivars will perform best under some form of rotational grazing. These plants usually have large, upright leaves that are able to capture a lot of light in competition with grasses (hence their greater productive potential). However, this means that when they are grazed, a high proportion of their leaf area is removed, and they must be allowed time to re-establish leaf area before grazing recurs.

Variation within white clover, from large-leaved, upright types (centre) to small-leaved, prostrate types.

Larger-leaved white clover cultivars like ‘Haifa’, ‘Aran’ and ‘Kopu’ are well-suited to rotationally-grazed dairy pastures, but are poorly suited to set stocked, sheep-grazed pastures. On the other hand, medium- and small-leaved cultivars like ‘Prop’, ‘Demand’ and ‘Prestige’ are best suited to sheep grazing, and will not generally produce as much as other cultivars in a dairy system with rotational grazing.

Segment 8 Nutrient Assessment and Monitoring

Also include relevant points from Peter Sale’s paper

Plant / soil interactions

The soil environment can have a profound effect on pasture growth. The soil stores, transfers and, in some cases, transforms the water and nutrients needed for plant growth. The capacity of the soil to provide these growth resources in an available form, and the ability of plants to access them, are the key factors.

In addition, there are distinct soil conditions such as acidity or salinity which can directly affect plant growth. Some plants have adaptive features which allow them to cope with these conditions better than others, in exactly the same way as some plants are better adapted to low soil moisture availability, or high temperatures, than others.

A typical soil profile, showing a relatively shallow topsoil overlying a poorly-drained B horizon.

Soils, and their effect on pasture

There are four soil limitations to consider in relation to pasture growth and choice of species: nutrient availability, acidity, salinity, and soil physical properties. Nutrient availability in the soil environment depends on characteristics of the soil itself (eg. parent materials, and degree of weathering), plus additions of nutrients in fertiliser. Most of the soils used for pasture production in Australia are infertile in their natural state, and several macro-nutrients and, in some cases, micro-nutrients must be supplied to support good pasture growth. Reliance on legumes to supply the nitrogen for grass growth in pasture mixtures means most farm fertiliser programs are targeted to overcoming nutrient deficiencies for legume growth (mainly P, K and in some cases Mo). This in turn overcomes the principal nutrient deficiency limiting growth - nitrogen.

Most of the improved pasture species, such as tall fescue, require moderate high levels of soil fertility to grow at or near their maximum.

Tall fescue (*Festuca arundinaceae*) is an example of an 'improved' pasture grass that performs best at moderate to high levels of soil fertility.

Other species are better adapted to low soil fertility. These species have usually originated from infertile habitats, and have adaptive features such as low relative growth rates, slow tissue turnover, and a capacity to store nutrients for later use. These features reduce their demand for nutrients from the soil environment and so allow them to tolerate nutrient deficiencies. Many of the common pasture weed species display these characteristics.

Some of these low-fertility tolerant species can also pre-empt nutrients through features such as high root:shoot ratios, and a physiological capacity to extract nutrients from the soil solution at nutrient concentrations below those at which other species can operate. These features allow them to out-compete others species when nutrients are limiting. A good example of this is bent grass (*Agrostis castellana*) which can completely dominate pastures in medium and high rainfall zones if soil fertility is low and pastures are poorly utilised.

Bent grass (*Agrostis spp.*) is well-adapted to infertile soils and can dominate pastures.

By contrast, the productive, improved pasture species have mostly originated from fertile habitats and have high relative growth rates, high rates of tissue turnover and minimal nutrient storage. They are more suited to, and competitive in, environments where nutrients do not significantly limit growth.

This is the basis for the so-called high input pasture production systems, which create a soil environment that favours the productive species over the weeds by using relatively high inputs of fertiliser. The result is a more-productive pasture, where the species present are better able to exploit the available rainfall for growth, in turn leading to greater carrying capacity of the pasture.

Like low nutrient availability, the limitation imposed by **soil acidity** can be overcome by management practices, particularly the use of lime. But this may not always be cost-effective, especially when the soil is moderately - strongly acid and requires a lot of lime to raise the pH to a level that allows good plant growth. Also, lime application will not address the problem of acid subsoils.

As with most limiting factors, there is variation within and between species in tolerance of soil acidity. Some sub clover cultivars are tolerant of moderate acidity but sub clover dominance, and the associated accumulation of H^+ ions when excess nitrate is leached from the soil, is an important ***cause*** of acidity.

Perennial grasses play a useful role in managing acid soil problems by preventing the leaching of nitrates from under clover dominant pastures. Among the perennial grasses, cocksfoot is generally more tolerant of acidity and the commonly associated problem of high soil aluminium levels than, for example, phalaris. Lucerne requires soil pH levels of greater than 6, while the medic species perform and persist best in alkaline soils.

Acidity tolerance levels for different pasture species

	Soil pH (water)		Soil pH (CaCl2)	
Plant species	Min	Max	Min	Max
White clover	5.3	6.5	4.5	6.5
Sub-clover	5.3	7	4.5	6.5
Perennial ryegrass	5	6.5	4.3	6.5
Annual ryegrass	5	6.5	4.3	6.5
Phalaris	6	8	5	6.5
Cocksfoot	5	7.5	4.2	6.5
Lucerne	6	7.5	5.3	7

Exchangeable aluminium tolerance levels for different pasture species

	0.01 M CaCl2		1.0 M KCl	
Plant species	Min	Max	Min	Max
White clover	0	15	0	120
Sub-clover	0	15	0	120
Perennial ryegrass	0	15	0	150
Annual ryegrass	0	15	0	150
Phalaris	0	8	0	80
Cocksfoot	0	15	0	150
Lucerne	0	5	0	40

Soil salinity occurs widely throughout Australia, and may impair pasture growth when the saturated electrical conductivity (EC) is greater than about 4 dS /m. Pasture species vary in their tolerance of salt. Clovers, particularly white clover, are more sensitive than the grasses. The reduction of pasture production in salt-affected soils is often due initially to the decline in legume growth which can occur at EC's of around 1.5 dS / m.

The use of deep-rooted perennial grasses or lucerne is an important control strategy for dryland salinity because of their ability to dry down the soil profile to a greater extent than annual pastures, and therefore help control groundwater table levels. In areas already affected by salt, tolerant species like strawberry clover and tall wheat grass can be used to maintain ground cover and some production.

Salinity tolerance levels for different pasture species.

	Electrical conductivity (EC se (sat extract)	
Plant species	Minimum	Maximum
White clover	0	2.6
Sub-clover	0	2.6
Perennial ryegrass	0	4
Annual ryegrass	0	4
Phalaris	0	4.2
Cocksfoot	0	4
Lucerne	0	4

Soil physical properties such as texture and bulk density may also affect the environment for plant growth. They have a large influence on the ability of a soil to store water, as well as the rate at which excess water drains from the root zone. Heavy clay soil texture can mean soils become waterlogged during wet seasons, and waterlogging can directly impair plant growth. A good supply of oxygen in the soil is important for the respiration of microbes and plant roots. When soils are saturated, the supply of oxygen is reduced since oxygen diffuses faster (by a factor of 10^4) through air than through water. Plant root activity can be affected under these conditions, leading to reductions in pasture growth.

Again, there are plants that can tolerate the effects of waterlogging better than others, notably members of the subterranean clover subspecies *yanninicum* such as the cultivars Larisa and Trikkala. These are good options for situations where soil physical properties combine with rainfall patterns to give rise to periodic waterlogging.

Soils like this with a relatively shallow watertable can readily become waterlogged in winter and early spring in southern Australia.

Refer also to More Beef From Pastures Manual Procedure 3 p12 esp p 15
Also Toolkit p33 and p36
Making More From Sheep manual

Healthy soils are the foundation stone of all productive ecosystems. From an agricultural perspective the ideal soil is "one which does not limit productive capacity". When soil health is maintained the physical, chemical and biological needs of plants are likely to be met so that growth and production is sustained in the long term.

The health of a soil can be assessed in terms of its structural (physical), chemical and biological make-up/characteristics all of which are closely interrelated.

The properties which should be considered in determining soil health include:

Friability (tilth):
The surface soil should ideally form small (2-3 mm) aggregates which are structurally stable under heavy rain or tillage. Friable soils:

- Allow water and air to move freely in the soil resulting in improved water infiltration, reduced water logging and so better use of available soil water.
- Are easily worked or drilled, improving seed and soil contact and allow uniform germination and emergence of seedlings.
- Allow roots to penetrate and better exploit water and nutrients in the soil.

Freedom from physical barriers
Physical barriers such as a compacted layer restrict root growth and development and therefore limit nutrient and moisture uptake.

Storage capacity for water and nutrients
The capacity of a soil to hold water, store nutrients and their availability to plants directly affects productive potential.
It depends on the number and size of pores, 'storage sites' in the soil, and the amount of clay and organic matter in a soil.

Resistance to erosion
Exposed soils with poor structure and lack of organic matter or vegetative cover are prone to wind or water erosion.

Biological activity
Soil organisms carry out a wide range of processes that are important for soil health and fertility. There is a two-way relationship between soil organisms and agricultural production. The retention of plant residues provides an important source of energy and nutrients for soil organisms. In turn, they improve organic matter breakdown, nutrient availability, soil structure, disease suppression and the degradation of chemicals and pollutants such as herbicide residues.

Freedom from pests and diseases
Root, stem and leaf pests and diseases can be carried in the soil.

APPENDIX

Paddock Monitoring Tools
A range of simple and practical tools are available to assist with pasture assessment and monitoring. These are regarded as essential in understanding the balance between production and NRM sustainability and include:

1 Measuring pasture dry matter

With practise, graziers will learn to 'eyeball' pastures and estimate the amount of herbage (height and kg DM/ha) available.

To help maintain an eye for pasture quantity, a simple technique has been developed outlined below which measures pasture height and can be related to total pasture quantity. An adaptation of this procedure will also be used to measure pasture composition and help assess pasture quality.

Using a pasture height measuring ruler / stick
Use a 1cm thick dowel about 30cm in length. Flatten on one side to allow graduations and units to be written in. Draw a line 0.5cm from the end and then every 1cm along the stick as shown in Figure M (include picture of stick)

Note: Readings 0.5-1.5cm are recorded as 1cm, 1.5-2.5 as 2cm, etc.
To measure the pasture, throw the stick ahead of you at random as you walk across the paddock. When you reach the stick, stand it up vertically on the soil surface where it landed, being careful not to push it into the ground or leave it sitting on pasture.
Measure the height of the pasture by sliding the thumb down the graduated side of the stick until it touches a green leaf. Ignore stems, dead material or onion grass as stock do not readily eat these parts of the pasture.

Insert picture of a hand/thumb

PROGRAZE
It is important to measure using your thumb as an area (about 1cm x 2cm) rather than a point, which will underestimate the average pasture height. If no green pasture is present, height is recorded as zero. Note that the measured height will be less than that of the taller leaves in the pasture.

As pasture quantity increases in spring the stick becomes less reliable and it will be necessary to cut quadrats to “calibrate” our eye to the amount of feed available.

Recording sheets are at the end of this section. (include recording sheets)
Table 1 estimates green pasture dry matter in kg/ha from pasture height for a mixed ryegrass, clover and annual grass pasture. The table demonstrates the differences between a dense, usually sheep grazed, pasture and an open pasture. This relationship may change with different species and pasture density, and may require local calibration.

Table 1 – Approximate relationship between pasture height and kg green DM/ha

Height (cm)	**Lightly grazed 50% green**	**Mod. grazed l00% green**	**Dense 100% green**
1	250	400	500
2	500	700	800
3	600	1000	1100
4	800	1200	1400
5	1000	1400	1700
6	1150	1600	2000
7	1300	1750	2300
8	1450	1900	2600
9	1600	2000	2800
10	1700	2100	3000

Note: Even though GrazFeed DMs are based on cutting to the ground, it assumes that some dry matter will be left behind as unavailable to animals or clippers. If you cut quadrats so low that you have to sieve the dirt out you will need to take approximately 200kg off your estimates when using GrazFeed.

Using a quadrat
To complete herbage mass assessment using a 0.1m2 quadrat:
• Make a rectangle 400mm x 250mm using 5mm rod.
• Place the quadrat over the pasture and cut the vegetation to ground level (remove any sticks, stones, dirt or manure).
• Weigh the cut herbage (pasture) and if possible dry it.

The dry weight in grams x 100 = kg/ha pasture dry matter mass.
If the pasture cannot be dried, then weigh the green pasture (in grams) and multiply by 100 to give kg/ha green pasture. Then apply your estimate of percentage dry matter to this figure.
For example:
If there is 10,000kg/ha green pasture and an estimated 15% dry matter the calculation indicates 1500kg/ha pasture dry matter.

Using median quadrat
For detailed explanation of this technique refer to Prograze Manuals

2 Assessing percentage groundcover

1 Quadrat
This involves Placing the a quadrat on the ground and imagine how much of the soil would still be covered if all the pasture were moved into one corner, so you could not see any soil in that corner. If 70% of the rectangle is covered in pasture – the groundcover will be 70% (or conversely 30% bare ground). The 70% rule will apply regardless as whether there is dry or green pasture or whether the pasture is 1cm high, 5cm high or 20cm high.

2 Using the "end point technique" using the same procedure as that for assessing pasture composition. The main difference is that the paddock is assessed only for two categories ie the presence or absence of ground cover or bare ground.

3 How to measure pasture composition

Pasture composition assists in assessing the quality of a pasture, level of weed infestation, and whether the paddock is capable of achieving relative to pre-determined paddock targets. See section on pasture targets.
A simple 'pointed stick technique' is quick and provides some objectivity. A pointed stick can be made from a 30cm length of 1cm dowel with a nail driven into the end.
The stick is thrown randomly on the pasture and the pasture component touched, or directly below the end of nail head, is recorded.
Repeat the process 50-100 times throughout the paddock recording the number of 'hits' on each component. The total hits for each pasture component divided by the total number of hits indicates the percentage of each component in the pasture.

Include technique from CMA info sheet

4 Assessing Dry Feed and Litter

Include Technique form Triple P Manual

Assessing Soil Health
The following is a list of symptoms together with simple Tolos and tests for assessing soil health characteristics. They from the basis of a Series of tips and Tools currently being developed.
The following is a guide to the various symptoms of poor soil health, together with possible causes and a number of simple tools and tests which can be used on farm to help diagnose such problems as well as proposed remedies.

Symptoms:
- Poor pasture growth, small size of leaves and pale leaf colour
- lack of legumes

- increasing weediness notably capeweed, onion grass, Bent grass, sorrel

Cause: Imbalance of soil chemistry and/or nutrient depletion; also influenced by grazing management
Tests: Soil chemistry tests for available macronutrients, pH and cation exchange capacity; leaf analysis for micronutrients and trace elements
Possible Action/Remedy: Correction of nutrient deficiency through application and strategic use of appropriate fertiliser(s) and/or lime.

Symptom:

- Uneven or patchy germination and growth of plants within the same paddock and with the same management inputs

Cause: Soil surface and topsoil structural decline; lack of organic matter; water repellence
Tests: Soil test to determine electrical conductivity (salinity); dispersion and slaking tests; penetrometer and bulk density tests
Possible Action/Remedy: Gypsum may need to be applied according to soil tests. Improve the amount of recycling of organic matter into the soil by increasing the amount of surface litter. Best achieved by consciously resting pastures in spring and maintaining adequate ground cover through rotational grazing over summer.

Symptom:

- Increasing bare ground and /or lack of ground cover
- low levels of surface litter and decaying plant material

Cause: Lack of organic matter related to stocking rate and grazing management as well as nutrient depletion causing reduced biological activity
Tests: Pasture assessments-quadrat and end point techniques to determine pasture cover and litter levels; soil chemistry tests; calico test for biological activity
Action/Remedy: Increase amount of organic matter and surface litter by resting pastures in spring; implement planned rotational grazing program to maintain higher levels of ground cover and surface litter; avoid overgrazing.

Symptoms:

- trees dying in clumps for no apparent reason;
- the spread of bare patches of soil;
- loss of 'desirable' pasture species, being replaced be salt–tolerant species including sea barley grass, couch, annual Beard grass, spike rush …….;
- presence of scalds with white or red crystals;
- wire rusting on fences or flood gates
- presence of spiny rushes in and along drainage lines

Cause: Dryland salinity
Tests: Soil chemistry test for electrical conductivity (EC); dispersion test
Action/Remedy: Investigate the reasons for the development of dryland salinity at the catchment scale; introduce salt tolerant pasture species; possible application of gypsum in accordance with soil test results; improve grazing management

Symptoms:

- Water lying in pools on the soil surface of flat land even after relatively small, infrequent rainfall events;
- high rates of water runoff and surface water movement from sloping ground after storm activity.

- Soil surface crusting, cracking and compaction; hard setting after rain.
- Surface soil lacks “friability” and crumbly feel

Cause: Poor surface soil structure; lack of organic matter and biological activity; water repellence
Tests: Physical tests – slaking; dispersion; calico strip tests; penetrometer and bulk density tests
Action/Remedy: Increase amount of organic matter and surface litter by resting pastures in spring; implement planned rotational grazing program to maintain higher levels of ground cover and surface litter; avoid overgrazing.

Symptoms:

- Waterlogged soils usually associated with the presence of ordinary rushes
- Soil colour grey-white; mottled
- Soil smells sharp and ‘sewagy’

Cause: Poor drainage and lack of aeration either caused by poor surface structure &/or impermeable subsoil; presence of clay pan; lack of organic matter and biological activity
Tests: Physical tests – slaking and dispersion; calico strip test
Action/Remedy: Increase amount of organic matter and surface litter by resting pastures in spring; implement planned rotational grazing program to maintain higher levels of ground cover and surface litter; avoid overgrazing.

Symptoms:

- Poor persistence of perennial grasses most notably Phalaris
- increasing dominance of annual species, especially sorrel and onion weed

Cause: decline in soil pH / increasing soil acidity
Tests: Soil chemistry test for pH, Aluminium and Manganese; soil pH kit
Action/Remedy: Application of lime in accordance with soil tests

Symptoms:

- Loss of topsoil and deposition of sediments on lower slopes;
- obvious signs of active erosion
- cloudy water in dams
- possible build up of algal blooms in farm dams and streams

Cause: Inadequate ground cover and surface litter due to overgrazing; surface or subsoil structural problems; lack of organic matter;
Tests: Pasture assessment – quadrat and end point techniques for ground cover and litter levels; physical tests – dispersion and slaking; penetrometer and bulk density tests
Action/Remedy: May require gypsum application in accordance with soil test results; increase amount of organic matter and surface litter by resting pastures in spring; implement planned rotational grazing program to maintain higher levels of ground cover and surface litter; avoid overgrazing.

Symptom:

- Low numbers of earthworms and soil ‘bugs’ in the topsoil

Cause: Lack of organic matter and litter on soil surface
Test: Calico test; pasture assessment for litter
Action/Remedy: Improve the amount of recycling of organic matter into the soil by increasing the amount of surface litter. Best achieved by consciously resting pastures in spring and maintaining adequate ground cover through rotational grazing over summer.

There are a range of practical tools and tests available to help measure and monitor changes in soil health.

Surface soil strength and friability

Penetrometer test: Push the sharpened point of a pencil into moist soil with the centre of the palm of your hand. The degree of difficulty of pushing the pencil into the soil provides a guide to soil strength and friability in the topsoil and indicates the ease of seedling emergence and root growth.

An alternative to the above 'pencil test',for determining bulk density, and and one that can be used with dry soils, is the 'dig and replace' test. Dig a small hole, say 10cm by 10 cm, remove the soil and pulverise in a container. Return the pulverised soil to the hole and press firmly and evenly to ground level. Any surplus soil represents the 'bulking factor', the extra soil that compacts over time to increase the resistance of the soil encountered by the plant's growing point.

Soil structure – aggregate stability and sodicity (level of sodium)

Take a number of small air-dry soil clods or 'aggregates' about the size of a pea from the soil surface as well as different soil horizons and place into clean water. Observe what happens.

Assess whether the clods float or sink; the rate and extent to which they fall apart (slaking); and whether the clear water becomes cloudy/milky (dispersion). These simple observations are used to determine the structural stability of the soil and also whether it is sodic (high in sodium).

If the clods float or sink and remain intact, it means that there is enough organic material to act as a glue between particles. Structural conditions are stable and excellent for plant growth. The channels between clods remain open after wetting and water drains quickly, roots penetrate easily and there is no compaction or hard crust on drying.

If the clods fall apart there is not enough organic matter and this collapse as water replaces air is referred to as slaking. Slaking soils are usually hard-setting after rain and may crust badly, resulting in poor infiltration, run-off and erosion. Germination and seedling growth will also be restricted. Such soils can be improved by increasing the amount of organic matter.

If the aggregates disperse readily and the water become cloudy there is a high proportion of sodium attached to the clay particles and the soil is referred to as sodic. Such soils are often susceptible to waterlogging, poor aeration and erosion and can present barriers to root growth and seedling establishment. Crusting and soil compaction is also associated with sodicity. Sodic soils can only be improved through application of gypsum.

Biological activity

Burying a small piece of unbleached calico (raw cotton) provides a useful visual means of determining the amount of biological activity in the soil. Calico is used because it is largely comprised of cellulose, similar to the composition of organic matter. The rate of breakdown of the calico (indicated initially by discoloration and then gradual rotting of the cloth) provides a ready means of assessing and comparing biological health between soils.As a guide a healthy soil may start to break down in 2-4 weeks under warm moist conditions while one with low levels of biological activity will require considerably longer.

Soil composition

Shaking soil in a jar of water allows the soil particles to drop out in order of weight (sand at the bottom, then silt, clay and organic matter), thus giving a clear picture of the composition and texture of that soil.

Soil texture

Soil texture can be determined using the common 'ribbon technique'. A small handful of moist soil is kneaded into a ball and then squeezed out slowly in a ribbon between thumb and forefinger. The length of the ribbon provides a useful guide to the texture of the soil – the relative proportion of sand, silt and clay. The longer the ribbon the higher the clay content. Texture is important because it affects the movement and availability of water and nutrients in the soil.

Soil nutrition and pH

Chemical analysis by an accredited laboratory provides an accurate indication of the level of available nutrients and therefore soil chemical fertility. It also indicates soil pH, cation exchange capacity and electrical conductivity and therefore helps to predict acidity, salinity and buffering capacity of the soil.

Water infiltration

Gently pour water into a ring or tube (ie a piece of PVC, polypipe or jam tin) embedded into the soil surface and measure the rate of movement into the soil. The higher the flow rate, the easier it will be for rainfall to infiltrate the soil. This is strongly influenced by soil surface structure and texture.

Groundcover and surface litter

Use either a square quadrat or wire coat hanger opened out to form a square of approx 25cm in diameter. Toss the quadrat randomly across the paddock and estimate the percentage of bare ground or ground cover and the number of handfuls of litter within the frame.

Aim to have a minimum of two handfuls of litter per quadrat and at least 70 % ground cover.

Pasture composition and ground cover

Use a 30–50cm length of rod sharpened to a point at each end. Throw the rod randomly across the paddock and record what is immediately below the pointy ends, noting plant species, bare ground and litter. After a minimum of 50 throws it is easy to get an idea of percentage composition. This test helps to assess the percentage of bare ground, litter, clover content and other key indicator species.

Soil pH

Simple and cheap kits for measuring soil pH are readily available from hardware stores and gardening nurseries and are a useful preliminary indicator of soil pH. A more accurate and reliable guide is provided by having soil tested through an accredited laboratory.

The soil as a medium for growth

Using a spade to open the (moist) topsoil, examine and note the following features:

- how hard it is to dig
- the ‘feel’ of the soil, ie how gritty or greasy it is
- soil depth, noting the presence and depth of any organic stain beneath the soil surface
- amount of organic matter, including decaying plant material
- density and depth of roots
- soil colour
- number of earthworms and other insects
- smell of the soil
- number and size of pores in a clod of soil

Include reference to Pasture Health Kit

Include the SGS Sustainability Profile

Appendix 2

CMA Training Workshop: Lesson Plan

Introduction

Activity

- Listening
- Questioning
- Discussion

Purpose

- Welcome the participants and set the scene for the day.
- Introduce participants.
- Outline the objectives, format and content of the workshop.
- Establish some ground rules for the group.
- Establish the participants' expectations from attending the workshop.
- Gain some insight into the level of knowledge and understanding of "production agriculture" within the group

Key messages

- Welcome the participants to the workshop.
- The format of the workshop.
- Outline all relevant health and safety issues or hazards the participants need to be aware of and explain how to avoid these issues.
- State that the workshop places emphasis on practical learning.
- Active participation, questioning and discussion are encouraged throughout the workshop.

Suggested approach

- If the group is new or you are new to the group – complete an introduction exercise. It will also be useful to ask each participant to describe their background and practical experience. This is important so that you can tailor your workshop accordingly. (Note: Preferably this information should have been provided before the workshop to assist in your preparation.
- Describe the format for the day (break and finish times etc) and write this up on butchers' paper so that is can be displayed to one side throughout the workshop – to help keep to times.
- Outline the venue facilities (such as tea and coffee, location of toilets and any other necessary instructions).
- Introduce the Workshop Goal and Learning Objectives, so the participants can see and understand what they may get out of the workshop.
- Present an overview of the workshop program and explain the process and what the outcomes of each session will be.
- Ask the group to outline their expectations of the course; record on butchers' paper – this should be reviewed during the final session.

- Present any key point or learning outcome at the outset; this may be in the form of a rhetorical question to get the group thinking

Running A Sustainable Grazing Business

Activity

- Brainstorm
- Discussion

Purpose

- Set the scene for the rest of the day
- Introduce the concept of sustainability
- Describe the key economic profit drivers and link these to environmental and social drivers

Key Messages

- It's hard to be green when you're in the red".
- The Triple Bottom Line emphasises the need to balance profitability with social and environmental objectives
- Two elements that influence return on investment and determine profit are *income* and *costs*.
- The major profit drivers are:
- Cost of production is a major determinant of farm profitability
- Farm benchmarking studies provides guidelines to describe the characteristics of the most profitable farmers
- A successful grazing enterprise is one which builds "social capital",
- Historically environmental outcomes have not been recognized as key objectives as in grazing businesses. This has resulted in potential depletion and run-down of the environmental capital in the grazing business.

Suggested Approach

- Ask the group to define the term "sustainability". Allow each participant to provide his/her own definition. List on butcher's paper. This can be used as an introductory exercise as well as setting the scene for the rest of the day.
- Use their responses to link to the messages above.

- Introduce the fundamental concept that there is a need to balance profitability with environmental and social outcomes ie the Triple Bottom Line. This is very important within the overall context of the Goal of this training Workshop (see workshop Goal).

- Describe the basic but essential definitions and characteristics of on-farm profitability as described in the Participant's notes. This can be done by using overheads or computer.

- Emphasise the importance of cost of production as well as key profit drivers and signpost to the EDGE cost of production workshop. Do not spend too much time here.

- Outline the factors which contribute to the profitability of a livestock enterprise

- Describe the characteristics of what makes a "successful" pasture manager. This helps them to appreciate that grazing is a complex business which requires considerable skills across a diversity of management areas.

Note: Do not spend too much time on this section; this is more about familiarizing participants with some key concepts and raising awareness of basic principles

Segment 2 The Water Cycle – Converting Rainfall into dollars

Activity
- Demonstration
- Discussion

Purpose
- Describe the water cycle and the concept of water use efficiency

- Highlight the critical importance of water both from a production as well as environmental perspective

- Describe the 4M Approach to water management

Key Messages
- Water is arguably our most precious and most limiting agricultural resource

- One of the key indicators of efficiency of production of any farming enterprise is Water Use Efficiency (WUE)

- In order to fully maximize the potential of rainfall in a grazing system it is necessary to understand the water cycle ie what happens to rain after it falls

- In the context of increasing pasture production the aim is to increase the amount of rainfall that the pasture uses.

Suggested Approach

- Obtain two sponges each of different depth and/or density; using the same quantity of water, pour the water slowly into the sponge observing /measuring how much water is absorbed until it spills or leaks out of “the system”. Use this as an analogy of what happens in the environment.

- Much of the remainder of the session will need to be undertaken by way of explanation and discussion.

- Present the picture of the water cycle either on an overhead or computer screen and use this as a basis to relate most of the important concepts

- Similarly describe the 4M approach again by relating to the diagram presented on either an overhead or screen

Segment 3 Pasture Assessment

Activity

- Discussion
- Demonstration

Purpose

- Understand the role and importance of pasture assessment in on-farm decision making

- Describe the various components of pasture assessment

- Demonstrate and discuss different methods/techniques of pasture assessment

Key Messages

- Assessment of pasture involves being able to measure (or accurately estimate) the quantity of pasture, predict the quality of what is available, and determine the percentage groundcover.

- There are various simple practical methods and tools for assessing pastures which should become a routine practice on grazing properties .

- Being able to objectively assess the quantity and quality of feed on offer, together with the level of ground cover/bare ground forms the basis of on-farm decision making both from a production and environmental perspective.

Suggested Approach

- At the outset pose the question “why assess pastures”. Allow each participant to provide his/her own explanation. List on butcher’s paper. This can be used as an introductory exercise to this session. It also provides a guide as to the level of practical (production related) knowledge within the group.

- Conduct a brief theory session to explain the principles and components of pasture assessment.

- When describing the quality of pasture, have previously collected – and present to the group - two “samples” of pasture, the quantity should be that required to maintain a dry sheep for one day. Each sample should be of a different quality, for example a highly digestible, leafy, legume based pasture as well as a poor quality sample. After describing the quantity and quality of each sample ie kg/ha Dry Matter and % digestibility, pose the question “Which bag will produce the highest level of animal (sheep) performance?”

- The purpose of this exercise is demonstrate the interaction between quantity and quality of feed and can be used also as an introduction to the concept of feed budgeting.

- Take the group out into an adjoining paddock and demonstrate the different methods of undertaking pasture assessment.

Segment 4 Animal Production from Pasture /Targeting Markets

Activity
- Discussion

Purpose
- Link pasture assessment with the requirements and nutritional needs of grazing animals. In doing so to make “sense” of pasture assessment

- Explain the concept of ‘pasture benchmarks’ both from a production perspective *as well as well as an environmental perspective*

- Provide a guide as to how to go about determining farm stocking rates and link this with farm profitability

- Discuss the factors which influence stocking rates

Key Messages
- Pasture benchmarks have been developed which provide a ‘ballpark’ estimate of the minimum herbage mass needed to satisfy the nutritional requirements of various categories of livestock

- Highlight that the needs of different animal classes vary in accordance with their physiological state and that feed availability will also be influenced by the production goals

- Stocking rate is the basis of farm profitability.

- In much of southern Australia stocking rate *potential* is primarily determined by rainfall; length of the growing season; and paddock size.

- *Achievement* of that stocking rate potential is influenced by management factors including pasture utilisation; maximising pasture growth rates and water use efficiency; as well as optimising the number of breeding units per hectare ie matching "feed with need".

- Both pasture growth rates and Water Use Efficiency are largely governed by the following three aspects of management over which farmers have direct control: soil fertility; grazing management; and pasture species selection

Suggested Approach

- This segment will need to be undertaken mostly by way of discussion and explanation

- Present the Pasture Benchmark Tables for different animal classes and for different levels of digestibility. Describe the practical significance of these. Do not go into too much detail and description – this is NOT a Prograze® course!

- Pose the question: 'What determines farm stocking rate potential?' Seek feedback.

- Briefly outline the various factors which determine farm stocking rates and the management practices which enable farmers to realise this potential.

Segment 5 Feed Budgeting / Meeting Production Targets

Activity

- Discussion
- Demonstration

Purpose

- To describe the role and usefulness of feed budgeting and its critical importance both from a production and environmental perspective

- To demonstrate how to undertake a feed budget

Key Messages

- A feed budget is useful for determining whether a feed surplus or deficit is likely and is used to predict:
  -Potential stocking rate
  -Grazing days or how long feed in a paddock will last
  -How many livestock will this paddock support
  -Area of paddock required

- In order to undertake a feed budget accurately it is important to have access to:
  -pasture growth rates
  -predicted daily livestock intakes

- A feed budget plays a vital role in assessing production and environmental sustainability

- Feed Budgets can be used for short term and long term decision making.

Suggested Approach

- This segment is best undertaken be a combination of discussion and visual demonstration.

- Explain in simple terms what how to go about a feed budget mentioning the different components of a feed budget and likening it to a household budget or that for the bank manager.

- Undertake this slowly and step by step, being mindful to describe how and where farmers obtain the appropriate information. This will be related back to the pasture assessment and pasture/livestock benchmarks described in previous segments.
- Outline the different options which farmers have as well as the implications if there is either a surplus or deficit of feed. This should be related both from a production viewpoint as well as the environmental consequences.

- Undertake this by way of example using both a “seasonal” feed budget as well as the summer feed budget.

Segment 6 Principles of Plant Growth

Activity

- Discussion
- Demonstration

Purpose

- To understand the basic physiology and ecology of pasture plants, including both grasses and legumes

- To relate the principles of plant growth to pasture and grazing management

Key Messages

- Understanding how a plant grows is of fundamental importance in the adoption of rotational grazing and improved grazing management.
- Plants grow by absorbing carbon dioxide from the air and water from the soil and in the presence of sunlight, converting them into carbohydrates. These carbohydrates are used either immediately for growth or stored in the base of the stem and roots.
- The rate of growth is determined by the size of the leaf area. The rate of regrowth after grazing is strongly influenced by the leaf area left after grazing and the size of the energy reserves, which are affected by the length of the previous spell period.
- The basic unit of growth in grass plants is the tiller. The growth and spread of an individual plant depends on the number and size of tillers connected to that plant.
- Tiller density does not indicate how much dry matter a pasture will grow, or how best to manage the pasture to dry matter production. It is of major importance when the pasture is subjected to severe stress such as overstocking and drought when losses or death may occur. In those degraded situations, re-establishment of a tiller population by spelling from grazing is necessary before the pasture can recover.
- Pasture dry matter production is largely determined by the dynamics of leaf growth. The rate at which leaves are produced, their rate of expansion, and their final size are all influenced by the environment for plant growth.
- As a rule of thumb the timing of grazing should be based on leaf growth stage because there is a fixed number of live leaves per tiller. This will vary between grasses but is generally between 3 and 4.
- Grazing according to leaf growth stage allows for optimum utilization while also enhancing plant persistence by allowing energy reserves to be restored between grazings. This represents a WIN:WIN for both production and the environment.
- The change in plant growth habit from vegetative to reproductive is associated with higher growth rates, increased dry matter production but a decline in nutritive value and feed quality.
- The factors which drive pasture growth rate most strongly are *environmental conditions* (principally temperature, light, and water and nutrient availability), and *leaf area*. These together contribute to a seasonal pasture growth curve.
- The seasonal growth curve provides a guide to how best to match “feed with need” through adjusting the annual calendar of livestock operations and in doing so optimize feed utilization.
- It is possible to segment the seasonal growth pattern into three ‘phases’ of pasture growth according to the level of feed availability, leaf area and pasture growth rates.

Suggested Approach

- Describing the principles of plant growth is best undertaken by way of example /demonstration using live plant specimens.

- Collect a number of whole live plants representative of those growing in the local area. Ryegrass is suggested as the preferred plant as its growth has been comprehensively studied.
- Systematically dissect the plant in front of the group indicating major structural components including tiller growth and tiller density as well as the pattern of leaf growth and development.
- Compare and contrast this with other key pasture grass species found in the production system.
- Link this basic plant physiology to the principles of pasture growth and, in turn the consequences for pasture and grazing management
- Undertake a similar approach for key legume species, notably sub clover as well as lucerne and/or white clover if appropriate
- Using butcher's paper or prepared overheads outline a seasonal pasture growth curve as well as the three phases of pasture growth. Explain the practical significance of these in terms of pasture and grazing management as well as feed utilisation

Segment 7 Grazing Management of Pastures

Activity
- Discussion
- Brainstorming

Purpose
- To explain some of the key basic principles of grazing management including the different components of grazing management
- To describe the various grazing methods outlining their relative advantages and disadvantages of each system
- In doing so to emphasise the importance of rotational grazing including the benefits of rest to long term pasture stability and environmental sustainability
- To link some of the themes and concepts described in previous segments to the "real world"

Key Messages
- Grazing management can be defined simply as the matching of feed supply from pasture with animal demand for feed over an annual cycle.
- Grazing management is comprised of several components including species and class of livestock on the property, stocking rate, stock management policies (eg.

lambing and/or calving dates), and grazing method (set stocking, rotational grazing etc).

- Grazing management is just *one* component of the whole farm system. Other components include fertility, pasture species, and stocking rate. Grazing management cannot substitute for, or overcome, shortcomings in any of these other factors.
- Of these stocking rate is *the* most significant determinant of pasture productivity and farm profitability.
- The objectives of grazing management are:
  To optimise pasture growth and quality.
  To use the pasture efficiently and profitably.
  Ensure pasture quality is satisfactory for stock.
  Reduce worms.
  Ensure the persistence of desirable plant species.
  Ensure that groundcover is adequate to prevent erosion and resist weed invasion.
  Match feed supply from the pasture with animal demand as closely as possible on an annual cycle;
  Maintain green, leafy pasture cover for as much of the year as possible; Meet target pasture benchmarks at key times of the year
  Control selective grazing and nutrient transfer.

- 'Grazing method' describes the way animals are moved around the farm to harvest pasture. The common grazing methods are set stocking, mob grazing, and some form of rotational grazing.

- No one grazing method works best all of the time in all situations. The aim should be to exploit the advantages of different grazing methods when they are available, and if they are consistent with the goals established for the farm business.
- The decision about what is the most appropriate grazing method needs to consider the current pasture availability, expected pasture growth rates, and current and expected animal demand.
- Rotational grazing allows more ability to manage the feed supply / demand equation than set stocking, and can give better pasture growth and utilization as well as contributing to greater stability and resilience of the pasture system.
- Rotational grazing generally achieves better control of patch grazing and therefore better pasture utilization than set stocking, and may also lead to more even re-distribution of nutrients in dung and urine across the grazing area.
- The tolerance of pastures to grazing varies at different times of the year. However, there are seasonal pasture treatments that can be carried out to cause a desirable change in the pasture sward.
- A single management recipe will not suit all plant species, just as all plant species are not suited to all environments.
- It is important to match the management requirements of pasture species with the management system and skills of the property when designing pasture mixtures
- Where pasture species are being used close to the limits of their adaptive range and where stocking rates are near to their maximum, the benefits of rotational grazing

are more clearly apparent compared with set stocking. This increases plant growth and persistence, leading to better long-term production and stability of the mixture.

Suggested Approach

- Much of this segment will necessarily need to be conducted by explanation and discussion using prepared overheads or computer graphics. There is a temptation to go into too much detail so keep this short and to the point.
- Start by posing the introductory question "What do we mean by grazing management?" The purpose here is more to raise the subject and get them thinking rather than to come up with a definitive answer. Inevitably they will suggest something related to a grazing system or grazing method.
- Present the different components of grazing management using your prepared graphics or overhead and discuss. Stress the importance of stocking rate. The purpose is to put grazing method into perspective as just one component of grazing management.
- Similarly ask: "What are the outcomes or objectives of good grazing management?" Brainstorm and present list of benefits using your prepared graphics.
- Next ask the question: "What are different or methods systems of grazing management?" List on butcher's paper. For each system mentioned try and extract from the group what is actually meant by the term ie come up with a working definition. Once this is achieved try and collate these under the two broad headings of set stocking/continuous grazing and rotational grazing.
- Under each ask the group to outline the advantages and disadvantages of each broad system. List on butcher's paper. Brainstorm.

Segment 8 Soil Nutrient Balance / Nutrient Assessment and Monitoring ? Assessing/Monitoring Soil Health ?

Question: What do we need to cover in this segment ie just nutrient assessment and monitoring via soil testing or other aspects of soil health?

Activity

- Discussion
- Demonstration
- Brainstorming

Purpose

- Describe soil health in terms of its chemical, physical and biological characteristics
- To provide some messages about how to improve the health and productivity of agricultural soils including management practices to do so
- Explain how to go about assessing and monitoring soil health

Key Messages

- The soil environment has a profound effect on pasture growth. The soil stores, transfers and transforms the water and nutrients needed for plant growth. The capacity of the soil to provide these growth resources in an available form and the ability of plants to readily access them are especially important.
- In addition, there are distinct soil conditions such as acidity or salinity which can directly affect plant growth
- The health of a soil can be assessed in terms of its physical, chemical and biological properties each of which is closely interrelated.
- There are a range of practical tools and tests available to help measure and monitor changes in soil health.
- There are four soil limitations to consider in relation to pasture growth and choice of pasture species: nutrient availability, acidity, salinity, and soil physical properties.
- Nutrient availability in the soil environment depends on the characteristics of the soil itself (parent materials and degree of weathering) plus additions of nutrients as fertiliser.
- Most Australian soils are very old and infertile in their natural state and therefore must be supplied with several macro-nutrients and, in some cases, micro-nutrients to support good pasture growth.
- Reliance on legumes to supply nitrogen for grass growth in pasture mixtures means that most fertiliser programs are targeted to overcoming nutrient deficiencies for legume growth (mainly P, K,S and in some cases Mo). This in turn overcomes the principal nutrient deficiency limiting growth - nitrogen.
- Soil physical properties such as texture and bulk density also affect the environment for plant growth. They have a large influence on the ability of a soil to store water, as well as the rate at which excess water drains from the root zone.
- The properties which should be considered in determining soil health include: friability (tilth); freedom from (physical) barriers; storage capacity of water and nutrients; resistance to erosion; biological activity; and freedom from pests and diseases
- Soil testing to determine the level of soil nutrients and soil chemistry is a useful monitoring tool to help determine fertiliser and lime application which should be undertaken regularly and systematically.
- The application of fertilisers when applied in a planned way and in accordance with the results of a soil test can be beneficial to the health and productivity of soils
- Conversely inappropriate use of fertilisers can be detrimental to the environment
- Nutrient removal should balance nutrient supply in a sustainable grazing system.
- Management practices to increase organic matter build-up and enhance its breakdown within the soil are beneficial to physical and biological health and indirectly therefore plant nutrient supply (through mineralisation).
- Maintenance of soil surface litter is beneficial to soil health and pasture growth

Suggested Approach

- This segment will need to be undertaken primarily by way of discussion and explanation. Remember that this can be a very comprehensive and complex subject area so keep it simple. Also it needs to be recognised that some CMA staff and Landcare officers may be somewhat “green” and therefore philosophically opposed to the use of ‘artificial’ fertilisers. Despite this it should be emphasised that fertilisers are a necessity in most agricultural systems in balancing nutrient removal or losses and therefore contribute to sustainability.
- Start the discussion by bringing along: a rock (to represent parent material); a small quantity of sandy soil of low organic matter content; a handful of “organic matter” such as leaf litter; a collection of soil “animals” or soil biota such as earthworms, centipedes etc; and a container

of “artificial” fertiliser. Mention that these represent the different factions of the soil and each has a role to play in contributing to a healthy and productive of *agricultural* soils.
- Emphasise the fact that we are talking about agricultural production.
- Pose the question: What are the characteristics of a healthy soil. Brainstorm and list on butcher’s paper. Provide constructive comments.
- Next ask the group what farm management practices can be used to improve the health and productivity of soils. Brainstorm and list on butcher’s paper. Provide constructive comments.
- Finally ask the group what tools are available to help measure and monitor soil health. Brainstorm and list on butcher’s paper. Provide constructive comments.

Appendix 3
CMA Training Group Exercise

The final activity of the day is a group exercise to be undertaken by splitting into 2-3 groups, depending upon numbers. Each group is to address the following “case study” and provide some broad recommendations based on what has been covered in this Course. If the group is interested in pursuing topics more fully then this exercise provides an opportunity to undertake further more detailed analysis and therefore a further meeting if required in the future.

Allow 20-30 minutes for group discussion with a further 20-30 minutes for group feedback.

For each proposed recommendation ask the group: Is this beneficial for production and/or natural resource management? Or, what are the consequences both for production and the environment? This may be done simply by having two boxes to be ticked, for production and NRM outcomes. In doing so participants should be mindful of the need to consider the implications of their management recommendations and highlight those which are a win:win for both.

Farmer in a 650 mm winter rainfall environment in southern Australia (average elevation 600m) currently running the equivalent of 5 dse’s /ha across his whole farm of 800 ha. He and his wife (and three children) have been running the farm for 20 years since he took over the farm from his father. Father used to apply fertiliser regularly and tended to set stock for most of the year. Son, ie current manager has tended to follow in his father’s footsteps and undertakes a similar management approach although due to reduced income has cut back fertiliser program so that only applied ‘occasionally’. He too practices set stocking. He went away to school but had to return to the farm due to his father’s ill-health at the time. He is intelligent but with no formal tertiary education.

Due to a run of poor seasons and his desire to maintain his current stocking rate and the sheep genetics, the property is starting to suffer and show signs of decline. This evidenced most noticeably by increasing weeds and wind erosion, especially on the ridges and westerly slopes, due to increasing bare ground. It is also apparent that there is a worsening problem of water erosion along gullies and creeks which run through the property. Rabbits too are presenting a growing problem.

The property is mostly comprised of lighter sedimentary soils and there is a mixture of sown introduced pastures as well as native pastures. The property is undulating and quite exposed with some remnant native trees on the ridges.

As is normal practice in the district he tends to lamb during autumn in order to “make the most of the spring growth”. His lambing rates have been averaging 70-80%.

He has invited you out to his property because he has heard from a mate that there is money available “from the government” for pest control, fencing and tree planting. He is not a member of Landcare and has not attended any formal training, although his wife is keen for him to improve their productivity so that they can “make more money…”

Confronted with this scenario and based on what has been covered in this course what would be your recommendations to this landholder.

Break it down into broad general categories but try to be as specific as you can including the actual activities or tasks and the time of the year. Ask yourself is this a win for production or NRM or both.