# Pasture growth

## Key actions

- Map your grazing land into pasture zones based on land capability and primary land use.
- Predict the potential annual pasture production from your grazing land using long-term rainfall records.
- Work out how the water cycle operates on your farm.
- Adopt new strategies to improve and maintain water use efficiency.
- Build and maintain soil nutrients for productive pastures and healthy soils.
- Manipulate your pasture composition and productivity by using combinations of grazing management, fertiliser and herbicide application.

## Why are pasture growth and quality important?

The productivity and profitability of many grazing beef enterprises in southern Australia can be greatly improved by increasing the quantity, quality and utilisation of pasture grown. Together, these three factors determine the most profitable stocking rate, herd structure and target markets for all grazing-based beef enterprises.

**How much pasture energy is converted into saleable beef depends on the amount and quality of pasture presented to the herd**

Pasture utilisation and tactical control of stocking rate (see Module 3: Pasture utilisation) are fundamentally linked to pasture growth and quality. The health and fertility of the soil and stage of growth at which pasture is grazed have a major effect on pasture growth and quality. Developing your expertise in areas that influence pasture growth and utilisation will boost your productivity and profitability.

## How does this module assist you?

Every farm has a unique combination of existing pasture species, soil, topography and climate, which together make up *land class capability*.

This module will help you to manage water use, soil health and fertility and manipulate pasture composition to achieve the highest possible pasture growth and quality from the grazed area on your property.

To achieve the best possible pasture growth and quality, you need to:

- Define the capacity and limits of pasture production of all grazed land by mapping pasture zones based on land class and capability.
- Identify the opportunities for and limits to pasture production by knowing the normal annual pattern and variability of soil moisture, temperature and sunlight.
- Achieve water use efficiency across all pasture zones by ensuring the highest possible rainfall infiltration, capacity of soil to store water and ability of pasture roots to access stored water. Efficient water use also reduces the potential for environmental damage from soil erosion and deep drainage.
- Manage soil nutrients to increase pasture growth, quality and composition in all pasture zones.
- Ensure that each pasture zone maintains a pasture composition that produces best growth, while contributing to species diversity and balance, efficient water use, and environmental protection and stability across the farm.

### Linkages to other modules

This module describes and quantifies the farm's physical resources, climate, current pastures and soil nutrition status for use in Module 1: Setting directions.

Pasture growth and quality are directly linked to Module 3: Pasture utilisation and indirectly through pasture utilisation to Module 5: Weaner throughput and Module 7: Meeting market specifications. It is also linked to Module 6: Herd health and welfare through nutritional and metabolic disorders that can arise from particular pasture and weed species or seasonal growth conditions.

### Principles of pasture growth and quality

- Pasture growth and quality are determined by land class capability.
- Actively growing pastures have the highest quality and enable the largest intake by livestock.
- A correct balance of species and composition of pastures can significantly increase livestock production and profit per hectare.

### Procedures for achieving best pasture growth and quality

- Procedure 1 – Map grazing land
- Procedure 2 – Characterise seasonal rainfall patterns
- Procedure 3 – Build and maintain soil nutrients
- Procedure 4 – Pasture species composition

# Procedure 1

## Map farm grazing land into pasture zones based on land class and capability

### Guidelines to mapping farm grazing land into pasture zones

Assess the soil characteristics and topography of land allocated to the beef enterprise and define pasture zones according to the potential of the grazing land to support high-quality pasture composition and growth and environmental stability.

This assessment involves developing a map of grazing lands to define land capability based on primary land use, pasture productivity, soil, and spatial and environmental constraints (see Tool 2.1 for guidelines). The classification allows for variation in management practices to achieve best possible pasture growth and quality while ensuring economic and environmental sustainability.

Higher land class numbers indicate there are greater limitations to land use. Higher levels of inputs and expertise will be required to manage the land. Within each landclass there are a range of limitations. These limitations can be caused by climate, soil type, slope of the land, aspect, nutrient levels, acidity, salinity, drainage and presence of stones. To make full use of the capability of the landclass, these limitations need to be managed.

#### Create accurate maps to assist with precision planning

Mapping enables better planning of the pasture resource base to maximise water use efficiency and adjustment of stocking rates to minimise under and oversupply of pasture throughout normal seasonal variations. It also shows where environmental damage may occur from unsuitable fertiliser application and cultivation practices. Both on-site and off-site impacts of management actions need to be considered when mapping the land classes.

#### Manage each pasture zone carefully to achieve full productivity potential

To maximise the productivity of your grazing land, you need to manage each pasture zone differently to ensure the needs of each zone are met, such as aligning fences to soil types, installing water points to allow better grazing management or maintaining critical ground cover targets to minimise erosion (see Tool 2.2 for groundcover guidelines). Providing new infrastructure may involve significant capital expenditure, so you need to examine the marginal returns on such an investment and look carefully at cash flow budgeting to determine your priorities.

#### Map pasture zones

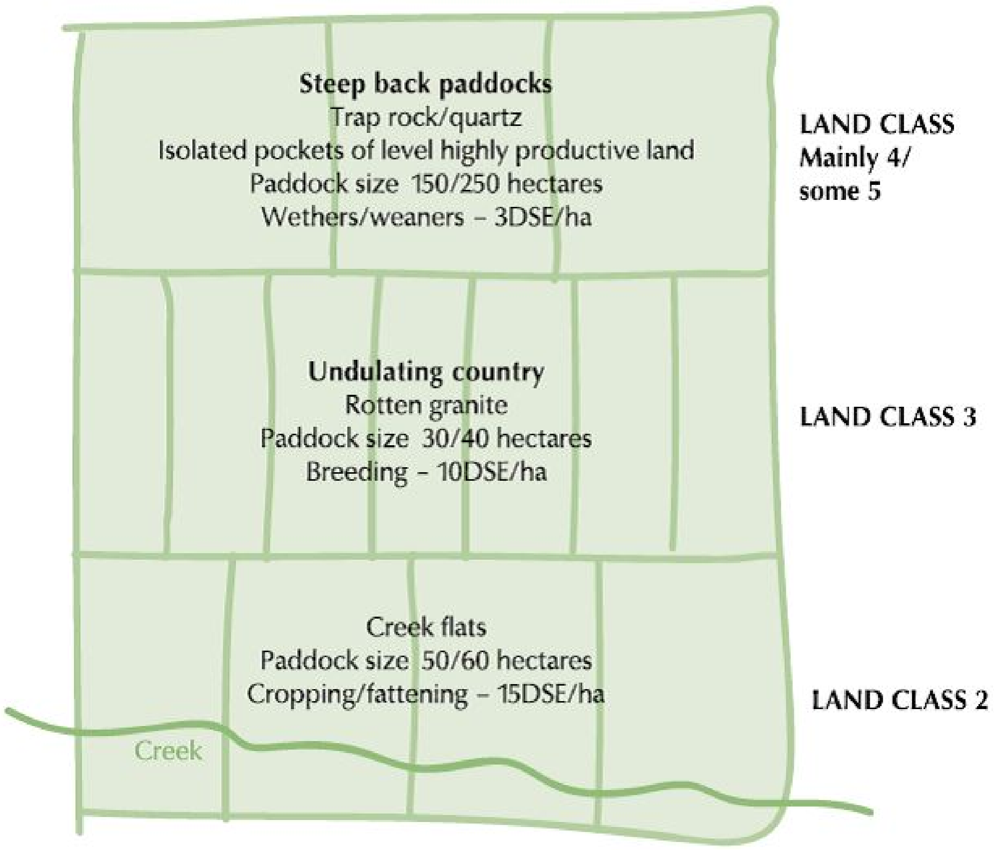
The following visual characteristics can be used to assess grazing land and identify different pasture zones (see Tool 2.1):

- **Soil texture**: define areas of different soil textures; where there is a change of more than one class for either A or B horizons, create a new pasture zone (see Tool 2.3 for simplified soil texture classes).
- **Slope**: define areas where the slope is greater than 10º. Slope determines the volume and speed of water run-off.
- **Aspect**: identify north-facing slopes as +/- 30º from due north, and south-facing slopes as +/- 30º degrees from south.
- **Streams and drainage lines (riparian areas):** define the areas 5-10m from the top of the stream bank to disperse flows and prevent soil and nutrients from entering streams and rivers.
- **Salinity (EC):** identify areas where soil salinity is limiting pasture growth and productivity by looking for the visual indicators described in Tool 2.4.
- **Primary land use:** separate land used primarily for cropping or specialty fodder crops.

Assess existing farm plans and maps against this list and overlay the common mustering routes. Where limitations are identified or no farm map has been prepared, use the guidelines provided in Tool 2.1 to develop a plan. Tools 2.2, Tool 2.3 and Tool 2.4 provide further assistance in mapping farm grazing land into pasture zones based on landclass and capability. Your local state department may also run courses in whole farm planning, as do many TAFE colleges.

Figure 1 shows how one producer mapped the property, ‘Greener Pastures’, into distinct pasture zone. You can simply chart information such as topography, location, soil type, paddock size, class of stock and average stocking rates for your own farm.

**Figure 1: Pasture zone map for ‘Greener Pastures’, South West Slopes, NSW**




## What to measure and when

As part of the annual planning cycle, review the grazing lands map to determine whether it still accurately shows land capability and class. The map may need to be updated to incorporate any new knowledge or changes in practice or measures (eg appearance of new saline discharge areas). The growth of tree lines over time may change animal behaviour.

# Procedure 2

## Characterise the seasonal pattern and variability of rainfall and establish water use efficiency

This procedure covers:

- characterising rainfall and water use efficiency
- understanding water balance
- applying water use efficiency information

### Guidelines for characterising rainfall and water use efficiency

#### Build a record of the farm's annual total and normal monthly rainfall distribution

Rainfall is a key determinant of pasture growth on your farm. To know the potential of your grazing land to produce pasture, you must understand the pattern of rainfall on your land. Assess historical rainfall records (for the farm, district or regional centre) and note down the normal monthly rainfall distribution and the extent of variability from year to year (see Tool 2.5).

Knowing the rainfall characteristics on your farm can help you to:

- improve pasture growth and financial and environmental management through efficient use of rainfall in all seasons, particularly during periods of lowest pasture growth
- reduce costs and maximise returns from pasture re-sowing, by selecting the most appropriate pasture species for the normal pattern and variability of plant-available water and sowing at the right time.

#### Use long-term rainfall records to determine the annual pasture production from grazing land

Tool 2.5 provides guidance on how to source, collate and analyse rainfall data for application in this procedure.

**Rainfall to Pasture Growth Outlook Tool**

MLA's Rainfall to Pasture Growth Outlook Tool presents the actual rainfall and indices of soil moisture and pasture growth for the past nine months and an outlook for the next three months for over 3,300 locations across southern Australia.

This tool enables producers to factor this information into enterprise planning. Because the tool covers such a diverse range of soil and pasture types across southern Australia, it provides an index of potential pasture growth, not a prediction of actual growth.

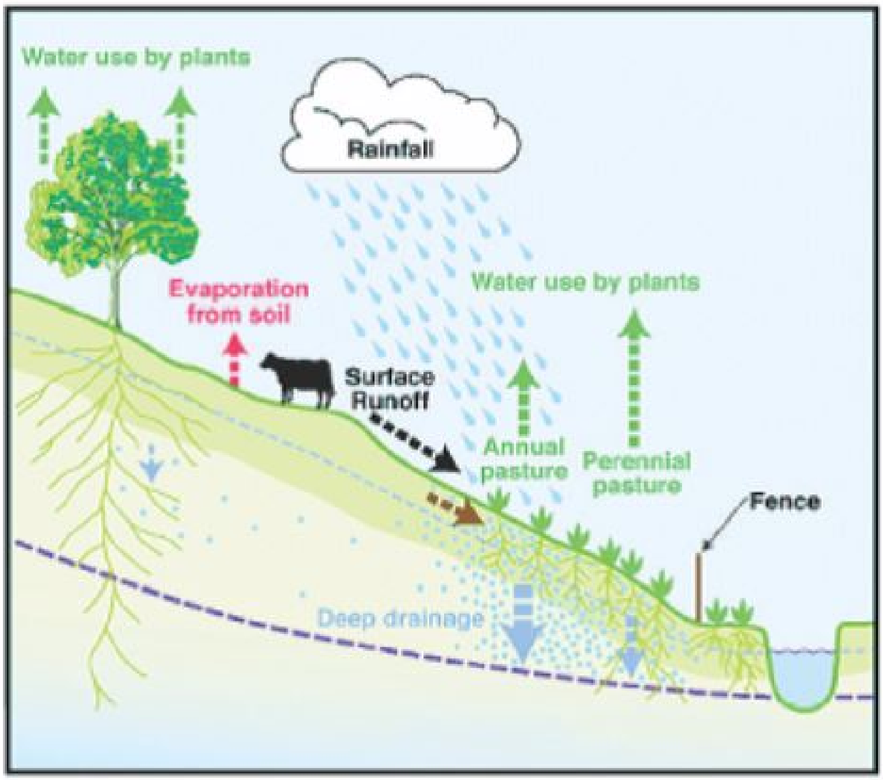
The pasture growth index should be interpreted in light of local knowledge about species, soil type, fertiliser history and aspect.

SeeMLA Rainfall to Pasture Growth Outlook tool for further information.

### Understanding water balance

To maximise the potential of rainfall in a grazing system, it is necessary to understand the water cycle and what happens to rain after it falls (see Figure 1).

**Figure 1: The water cycle**




When rain falls on a pasture paddock it either:

- moves across the soil surface (run off)
- is caught on bare soil, litter or plants and evaporates (evaporation)
- infiltrates the soil and is used by plants (transpiration)
- infiltrates the soil, drains below the roots and joins the water table (deep drainage)

When soils have reached saturation point or the soil surface is hard or crusted and infiltration is slowed down, water is forced to move across the surface and becomes runoff. Some runoff is encouraged as it fills dams and enters streams and rivers. Excessive runoff means less water might be available for plant growth. Soil and nutrients might also be removed, impacting on pasture growth.

Low plant density, compacted soil surfaces, low litter levels and saturated soils all increase the amount of run-off.

It is important to maximise plant water use because it is one of the drivers of pasture production. Plant water will be reduced if groundcover is low, annual species dominate, pastures are overgrazed, set stocked or nutrients aren't applied to maintain fertility.

Water that drains past the root zone into the water table falls into the category of deep drainage. This water is lost for pasture growth and could cause increased salinity levels and possibly contaminate the groundwater with nutrients.

The amount of water vegetation uses determines how much water goes into deep drainage. Annual pasture species and crops use the least amount of water. Perennial plants use more water due to their longer periods of growth.

Temperature also influences pasture growth potential. Unlike rainfall, it varies only slightly from its normal seasonal pattern throughout the year. Its major impact is on pasture production as all species have different upper and lower limits for growth. It also needs to be considered when selecting new temperate pasture species and Procedure 4 refers you to agronomy advice to assist with selection and appropriate management of pasture species.

While sunlight is a critical element in plant growth, it is not considered to be a climatic variable that limits plant growth in southern Australia. Physical disruption of sunlight through slope and aspect (south facing slopes) is a factor and is covered in Procedure 1 of this module. It increases in importance with increasing latitude. Growth and quality can also be limited through shading from other plants, and should be considered in Procedure 1 of this module (eg heavily timbered land) and in pasture utilisation practices (see *Module 3: Pasture utilisation*).

## Plant-available water capacity (PAWC)

The difference in yearly pasture production is better explained by the variation in plant available water capacity (PAWC) than by total rainfall. PAWC depends mainly on texture (clay content), the ability to hold water and rooting depth.

**Table 1: Examples of plant available water capacity (mm water/cm soil) in soils of different texture**

| Texture | Plant available water capacity (mm water/cm soil) |
|---|---|
| Coarse sand | 0.4 |
| Fine sand | 0.6 |

| | |
|---|---|
| Loamy sand | 0.8 |
| Sandy loam | 1.2 |
| Light sandy clay loam | 1.3 |
| Loam | 1.5 |
| Sandy clay loam | 1.5 |
| Clay loam | 1.8 |
| Clay | 1.5 |
| Self mulching clay | 2.0 |

Source: Better soils: A project of the Agricultural Bureau of South Australia

PAWC is a function of both plant rooting depth and the soil moisture storage capacity. This combination determines how much water can be held in the root zone available for plant use. Rooting depths are:

- 0.6–1.0m for sub clover, annual and perennial ryegrass
- 1.5–1.8m for perennial pasture grasses
- over 3.0m for lucerne, chicory and trees.

Deep, heavy clay soils can take in and hold a lot of water (ie a large PAWC) allowing a perennial pasture to use up to 100mm/year more than on a sandy soil. Lighter, sandy soils not only have a small PAWC, but also tend to have very high infiltration rates. This results in little or no run-off, greater deep drainage and pasture plants wilting more quickly between rainfall events.

In southern Australia, the more common duplex soils tend to have a balance between drainage and run off. In the northern, summer rainfall zone these same soils produce a lot of run-off and very little deep drainage.

## Water use efficiency

Water use efficiency (WUE) is the amount of rainfall (water) that is converted into pasture growth

Water use efficiency is a measurement used to assess the opportunities for improved pasture growth through better soil nutrition and pasture composition (see Tool 2.6, Procedure 3 and Procedure 4). Knowing rainfall variability and water use efficiency makes it possible to manage soil fertility, pasture composition and grazing management to maximise the use of rainfall for pasture growth. Water use efficiency is an indicator of the amount of rainfall (water) that is converted into plant growth. Calculate water use efficiency for the pasture zones defined in Procedure 1 by following the guidelines provided in Tool 2.6.

### Applying information about water use efficiency

Knowing rainfall variability and water use efficiency enables precision management of the grazing system. This knowledge allows you to manipulate pasture species and soil fertility to achieve the best spread of pasture growth across grazed land in all seasons. It also enables you to anticipate and act to prevent under-and overgrazing when there is a high probability of rapid growth (eg in spring) or low growth (eg in winter).

- Undergrazing results in shaded pastures, lower growth rates and lower water use by pastures, which can lead to increased water loss through deep drainage.
- Overgrazing results in high rainfall run-off, poor infiltration rates and high evaporation caused by inadequate ground cover, low litter levels, surface crusting and poor soil permeability.

Understanding water use efficiency enables you to implement methods to improve soil water-holding capacity, such as building soil organic matter. This leads to reduced rates of deep drainage and pasture growth when soil moisture moves below the root zone.

Pasture composition and soil fertility have a major influence on water use efficiency. Good grazing management in the following areas can lead to more efficient water use and therefore higher rates of pasture growth:

- **Groundcover** reduces run-off and protects soil from erosion. Depending on rainfall (pattern and intensity) and soil type, maintain at least 70% ground cover (including leaf, dead and litter material plus dung) on grazed lower to middle slopes (landclass 3); and, a minimum of 100% on non-arable upper to steep slopes (landclasses 4 and 5). See Tool 2.1 for a description of landclass capability.
- **Surface ponding** and **evidence of run-off** indicate crusted or impermeable soil surfaces that lower rainfall infiltration rates. Tool 2.7 describes how to measure ponding and run-off.

### Water use efficiency is influenced by pasture composition and soil characteristics

- **Erosion** or **sediment deposits** are further indicators of the need to apply management to slow or reduce run-off.
- **Organic carbon** (as measured in routine soil analysis) should where possible be maintained above 3% and up to a maximum of 12% of soil content to ensure improved soil water-holding capacity (see Tool 2.8).
- **Soil biota** (presence of living organisms) generally improves soil health and structure. This benefits water-holding capacity and infiltration

rates, as well as helping to mobilise soil nutrients for uptake by plants.

### Strategies to improve and maintain water use efficiency

1. Adopt tactical grazing (a range of grazing management methods) to meet animal production targets and pasture objectives at different times throughout one year, or over a series of years.
2. Assess soil nutrient status, as described in Procedure 3 and take corrective action where appropriate.
3. If soil nutrition status is within critical limits, assess pasture utilisation (refer to Module 3: Pasture utilisation for guidelines) and soil surface management and take the appropriate action.
4. Anticipate periods where analysis of annual rainfall patterns indicates an increased risk of overgrazing (low pasture growth rates) together with high-intensity rainfall events.
5. When pasture utilisation, soil nutrition and soil surface management are within the guidelines for maximising water use efficiency, or your analysis of rainfall against the pattern of pasture growth indicates that current pastures are unlikely to achieve the best possible seasonal growth throughout the year, evaluate the pasture composition using Procedure 4 of this module.

### Tactics for managing the soil surface

- Maintain growing pastures near the start of growth phase II (about 1,200kg green DM/ha) for as long as possible to aid regrowth. This has the added benefit of ensuring the highest possible pasture quality for grazing stock.
- Maintain (or increase) ground cover to manage run-off by removing stock before minimum pasture mass limits are reached (1,200kg DM/ha).
- Aim for medium to high levels of litter (at least two or three handfuls in a 30 × 30cm area) to increase soil organic matter, protect the soil surface, decrease evaporation and increase water-holding capacity. Litter is preferably actively decaying plant matter, not old and inert material.
- Manage grazing practice to increase litter quality and breakdown rate.
- Avoing excessive cultivation and the application of soil biota-reducing chemicals to encourage build-up of soil biota, to improve soil structure (increased porosity or aeration), litter breakdown rates and incorporation of surface organic matter.
- Avoid grazing when soil is waterlogged to pervent pugging (where animals hooves work clay or loam soil into a soft, plastic condition with no porosity)
- Create stock containment areas to remove stock from at-risk grazing areas.
- Change the pasture composition to deep-rooted perennials to ameliorate soils with declining structure.

## What to measure and when

Use historical rainfall records to assess the normal monthly pattern and variability of rainfall throughout the year before beginning a program to improve pasture growth and quality.

- Collect and analyse records for each farm or farm sector where rainfall might be different across the farm. Where these records are not available obtain district or regional centre information from local sources as the starting point.
- Tool 2.5 provides a range of sources and methods to complete this analysis.

Assess water use efficiency annually. Tools 2.3 and Tool 2.7 describe the methods and measures for field observations. Collect the following measures from all pasture zones where water use efficiency is monitored:

- an estimate of daily pasture growth rates (kg DM/ha/day) for native and improved perennial pastures – as a guide, Tool 3.3 of Module 3: Pasture utilisation provides estimates of daily pasture growth rates (kg DM/ha/day) in a range of localities and regions across southern Australia
- percentage of groundcover and bare ground at the start and end of the growing season
- mass and quality of litter – aim for at least two or three handfuls in a 30 × 30cm area
- evidence of soil erosion or sediment deposition – observe routinely after rain;
- rate of surface ponding of water and run-off to dams – at least once every three years (see Tool 2.7 for technique);
- organic carbon content (%) at increasing depth – initially and then every three years (refer to Procedure 3); and
- soil density or penetration – tested with a penetrometer.

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# Procedure 3

## Build and maintain soil nutrients to improve soil fertility and health in all pasture zones

Nutrients are a key element to growing good pastures. It is also important to ensure that the pasture currently being grown is suitably used by increasing stocking rate where appropriate, before growing surplus pasture.

This procedure covers:

- building and maintaining soil nutrients
- soil health
- earthworms
- organic matter.

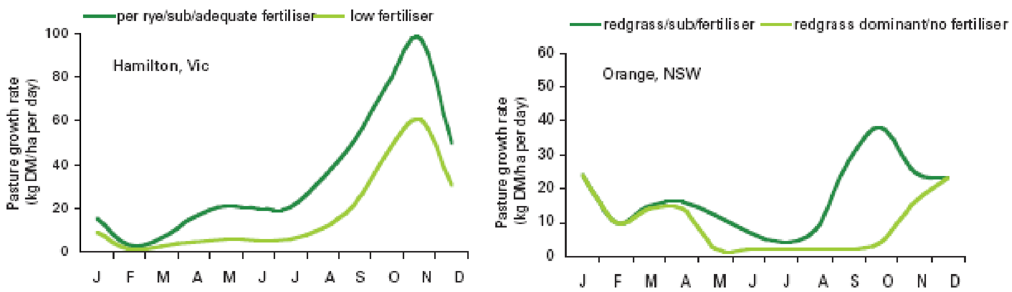
### Guidelines for building and maintaining soil nutrients

#### Pasture growth and quality depend on healthy soils and adequate nutrients

Soil nutrient availability is the factor most commonly responsible for lower than expected pasture growth and quality across much of southern Australia. The following are the most common causes:

- nutrients removed in the forms of meat and other saleable products are not replenished
- soils are inherently deficient in one or more nutrients
- nutrient imbalance limits the availability of one or more nutrients
- plants cannot access nutrients due to physical or chemical barriers
- one or more nutrients are present at toxic levels

**Figure 1: (a) The effect of fertiliser on average monthly growth rates at Hamilton, Western Victoria (winter rainfall area). (b) The effect of fertiliser on average monthly growth rates at Orange, Central Tablelands NSW (uniform rainfall area). Source: Hamilton data simulated from GrassGro; Orange data from NSW PROGRAZE®; *Making More From Sheep* Module 7, 'Grow More Pasture'.**




While economic factors play a role in soil nutrient rundown, so does the perceived lack of a response from traditional applications of fertiliser. The following factors should be considered when applying nutrients to maximise the benefits of application:

- **Nutrient supply** – failure to supply all limiting nutrients will reduce the potential response from fertiliser applications. For example, phosphorus applications in sulfur-deficient soils will not have any effect unless sulfur is also supplied.
- **Timing of application –** poor timing of application can greatly reduce response. For example, applying phosphorus to wet and cold soils, as is commonly carried out in southern winters, may waste some of the phosphorus applied because it is rapidly turned into non available forms.
- **Trace elements –** supply of essential trace elements, such as molybdenum, may be necessary. Molybdenum is essential for root nodulation in legumes. When it is deficient, nitrogen-fixing capability is reduced, and pasture growth will slow.
- **Application of lime –** applying lime is the only recognised method of correcting soil acidification.

#### Balance major and micro-elements for productive pastures and healthy soils

Two major groups of nutrients are needed for optimum pasture production:

- major or macro-elements, such as phosphorus (P), sulfur (S), nitrogen (N), potassium (K), calcium (Ca), and magnesium (Mg)
- micro-elements, such as copper (Cu), molybdenum (Mo), boron (B) and zinc (Zn)

All these major and micro-elements are important for productive pastures and healthy soils. To get the most out of pastures and nutrients, it is necessary to identify key nutrient requirements and understand how they move through the soil, pasture and animals.

**Take care with fertiliser application rates and placement to reduce product losses**

Inappropriate nutrient application rates or placement of nutrient may result in:

- desirable pasture species may suffer poor vigour or death
- desirable introduced perennial grass species need high phosphorus levels to achieve their potential
- many native perennial grasses will decline under competition from clover and annual species when phosphorus levels are raised
- economic loss and environmental damage may occur through leaching of applied nutrients into aquifers (underground waterways) or through run-off with soil particles into streams, rivers and dams.

To control these risks, test the soil nutrient status of all mapped pasture zones. Carefully analyse these results to identify the range and extent of actions required to achieve the best possible soil health and nutrient status. Use Tool 2.8 as a guide to analyse soil test results.

### The P-Tool - a decision support tool

The P-Tool (available on the MLA website) outlines five easy steps that allow producers to understand the value of soil testing and how to use soil test information to plan fertiliser and livestock investments. The information package provides a better framework for understanding and planning the use of phosphorus (P) fertilisers.

The tool is intended to assist producers in determining suitable levels of P-fertilisation for temperate pastures grazed by beef cattle on acid soils in southern Australia. However, fertiliser decisions are made by the user – not the tool – and the tool's purpose is primarily to **support** your thinking and fertiliser decisions.

**Once a decision is made to apply nutrients, complete the following:**

1. Increase the nutrient application and stocking rate over a three- to five-year period to manage cash flow and feel confident that a higher grazing intensity is sustainable over time.
2. Use the guidelines in Tool 2.9 to determine the quantity and cost of nutrients required to lift all pasture zones above minimum limits and correct the balance and any identified toxicities.
3. When substantial financial capital is to be invested, establish priorities that will provide the biggest gain from the investment in nutrients. Use relative assessments of land capability, water use efficiency, current pasture composition and potential productivity to set priorities (see Procedure 1, Procedure 2 and Procedure 4 and guidelines in Tool 2.9).
4. Complete partial budgets or a whole farm analysis to determine the marginal return on investment; then revise the priority list based on the value and economic benefit from an investment in a nutrient application program.
5. Review herd structure and stocking numbers against investments in capital applications of nutrients to ensure that increased pasture growth and quality is being used to gain the highest economic returns from the investment.
6. Once the initial 'capital' application has been completed, apply phosphorus and other nutrients required annually to keep nutrient levels within economically justifiable limits (see Tool 2.9).
7. Monitor nutrient levels to assess the need for future 'capital' applications in an annual maintenance program. Re-test every two to three years at the same time of year and avoid collecting samples when soil is likely to be cold and waterlogged.

## Soil health

The presence of soil biota (living organisms) generally improves soil health and structure.

Soil invertebrates, such as earthworms, play a major role to break down plant material into smaller pieces more prone to microbial attack, and to stabilise soil structure by building networks of soil macro pores. Earthworms are a well recognised indicator of soil condition. They move up to the soil surface when organic matter (their food source) and moisture are plentiful. Earthworms are a primary incorporator and degrader of decaying pasture and dung.

Other soilborne life (eg ants, mites, other insects and fungi) may be more prevalent in some soil types due to the harshness of the environment and may have a similar function to earthworms. In general, the more abundant and diverse the soil biota, the more fertile the soil.

## Earthworms

Earthworms can substantially improve the quality and quantity of pasture production. Feeding and burrowing activities increase the cycling of soil nutrients and organic matter and are beneficial to soil structure.

Earthworms are counted in spadefuls of soil taken from the top 10cm of a $25cm^2$ block. Samples should only be collected when soil moisture is high (generally in late winter or early spring) as worms will retreat to greater depths when surface drying has commenced. Separate soil carefully to avoid splitting the worms and always count the worms twice to confirm the number.

Less than 10 earthworms per block is considered low, 15 moderate, and more than 20 represents an abundant population. When soil is moist, most worms will be found near the surface in the root zone of the pasture.

For further information see the MLA Tip & Tool: Increasing earthworms in pastures.

## Organic matter

Organic matter contributes to a variety of biological, chemical and physical properties of soil. It is essential for good soil health and plays a role in:

- providing nutrients and habitats for organisms living in the soil
- providing energy for biological processes
- contributing to soil resilience
- binding soil particles into aggregates improving soil structural stability
- enhancing water holding capacity of the soil
- moderating changes in soil temperature
- providing resilience against pH change
- storing many of the key nutrients, especially nitrogen and potassium.

The amount of carbon (the measure of organic matter) in a soil depends on a range of factors:

- **climate** – in similar soils under similar management, carbon is greater in areas of higher rainfall and lower in areas of higher temperatures
- **soil type** – clay helps protect organic matter from breakdown; clay soils in the same area under the same management tend to retain more carbon than sandy soils
- **vegetative growth** – the more vegetative production, the greater the inputs of carbon
- **topography** – soils at the bottom of slopes generally have higher levels of carbon because these areas are generally wetter with higher clay contents; poorly drained areas have much slower rates of carbon breakdown
- **tillage** – tillage will increase carbon breakdown.

## What to measure and when

Complete comprehensive soil and stream water testing and analysis by National Association of Testing Authorities (NATA) accredited laboratories (see Tools 2.8, Tool 2.9 and Tool 2.10.)

Monitor the following where applicable:

- extractable soil phosphorus status (Olsen, Bray or Colwell)
- phosphorus buffering index (PBI) – used to evaluate Colwell test results and guide level of maintenance and capital phosphorus applications
- soil acidity (pH) and aluminium level
- sulfur and potassium levels
- exchangeable sodium percentage
- electrical conductivity (EC) – a measure of soil salinity
- molybdenum to copper ratio
- cation exchange capacity – an indicator of the likely response to liming
- amount of phosphorus applied as annual maintenance application (kg P/ha) – measured annually
- phosphorus and nitrate content in streams.

## Further information

- The following MLA publications are available from www.mla.com.au/publications or by phoning 1800 023 100:
    - *Towards Sustainable Grazing – The professional producer's guide*
    - *Tips & Tools: Managing soils to keep them healthy and productive*
    - *Tips & Tools: Managing deep drainage*
    - *Tips & Tools: Managing ground cover to reduce run-off and water loss*
    - *Tips & Tools: Increasing earthworms in pastures*
    - *Pasture health kit*
- *Why soil organic matter matters* – CSIRO www.csiro.au/resources/soil-organic-matter.html
- *Northern Rivers Soil Health Card* www.dpi.nsw.gov.au/agriculture/resources/soils/testing/health-card

# Procedure 4

## Manipulate pasture species composition in each pasture zone for best possible pasture growth and quality

### Guidelines to manipulating pasture composition

This procedure assists you to assess the current pasture base, outlines what improvements can be made and when to consider introducing new species.

#### Recognise the most important perennial and native pasture species

A wide range of pasture types are found across southern Australia including:

- mainly native perennial grasses with some annual legume (eg sub clover)
- annual grasses and legume-based pastures
- sown exotic perennial grass pastures and annual or perennial legumes.

#### Avoid costly resowing by ensuring nutrient and grazing practices support persistence of existing desirable species

For each pasture type, species composition and productivity can be manipulated using combinations of fertiliser application, grazing management and strategic herbicide application, which can avoid resowing. Manipulating pasture composition by establishing new species is expensive. It can take up to 10 years to breakeven on the capital invested.

The key to manipulating pasture for long-term sustainable production is to understand the special needs of both native grasses and improved perennial based pasture types and to use grazing systems that will encourage and maintain their productivity. It is important to recognise the perennial and native pasture species that suit your environment. Become familiar with their growth characteristics so that grazing management can be used as a tool to improve pasture growth and quality.

The management principles and special requirements of native-based and improved perennial pastures are presented in 'Chapter 6: Making the most of native pastures', and 'Chapter 7: Improved perennial pastures' of the MLA publication, *Towards Sustainable Grazing: The Professional Producer's Guide* . Chapter 8 of this publication deals specifically with grazing management for higher productivity within the whole farm system.

#### Use grazing systems that will encourage and maintain pasture productivity

It is well known that improving the perennial base of pasture can significantly increase livestock production per hectare. But to achieve this higher productivity, perennial pastures must receive the appropriate nutrients (see Procedure 3) and grazing management (see Module 3: Pasture utilisation) to ensure persistence and stocking rate must be increased to match the higher production of these pastures.

Improving the management of your existing pastures can improve growth rate and quality without the significant cost of replacing species or cultivars.

Assess the species present in your pasture and the percentage of total pasture they make up (eg % grasses, clovers, weeds and bare ground). Consider the proportion of desirables and undesirables on your property, to determine whether the composition can be improved through management (eg addition of fertiliser – see Tool 2.9) or better grazing management (see Module 3: Pasture utilisation). You may also need to consider the higher-risk, higher-cost alternative of resowing some areas.

#### Improve pasture management to avoid resowing

Assess composition of pasture zones

Use Tool 2.7 to assess the existing pastures across all significant pasture zones identified on your farm. Collect additional information on new and alternative pasture species, including their seasonal growth patterns, animal nutritional and production values and any environmental constraints. Seek advice from a local agronomist and gather information on the major pasture species that can improve your pasture productivity.

#### Manipulate the species mix to achieve the right pasture composition

Calculate the areas (estimated in total hectares) of all productive pasture groupings. Use this to assess the balance of species and growth patterns across the farm and through the various seasons. This assessment needs to be made against the normal seasonal rainfall pattern and variability (completed in Procedure 2). Local temperature extremes also need to be considered. Assess pasture composition against the guidelines for minimum and maximum recommended limits in Tool 2.7.

If your assessment indicates that the current pasture composition is unlikely to achieve best possible pasture growth and quality in any of the major zones, across the farm or throughout certain growth seasons, consider the following actions.

**Take corrective action if pasture composition is inadequate**

1. Where practical, change management to bring pasture composition within desired limits by:

- grazing or cutting to increase plant tillering. Using high density, short-term grazing or cutting to prevent undesirable annual grasses from reseeding and maintaining perennial grass and clover cover to limit germination of annuals in autumn (follow the grazing management tactics to increase, maintain or decrease individual species in Tool 2.11)
- addressing soil health and soil fertiliser content for the most responsive and desirable species (see Tool 2.9)
- tactical using herbicides to control weeds (eg low chemical rates in a spray-graze operation to stop seeding or higher rates of selective or non-selective herbicides to kill targeted weeds); low rates of chemicals applied over prolonged periods may result in target weeds becoming resistant
- allowing desirable pasture species to recruit through setting and dropping seed before grazing or cutting. Note that this is not effective for some species, such as phalaris
- improving pasture growth rate, quality and persistence
- extending the spread of desirable plant growth patterns where there is sufficient soil moisture to sustain growth or introduce deeper-rooted species to improve access to nutrients and soil water
- encouraging species diversity in and across all pasture zones
- improving pasture performance in unfavourable conditions, such as more tolerant species for acid soils where liming is not economical or practical.

2. When cost-effective management practices do not achieve best possible pasture productivity, consider establishing perennial species and cultivars that are proven to improve capability. Aim to achieve:

- improved pasture growth rate, quality and persistence
- extended spread of desirable plant growth patterns where there is sufficient soil moisture to sustain growth, or introduce deeper rooted species to improve access to nutrients and soil water
- species diversity in and across all pasture zones
- improved pasture performance in unfavourable conditions, such as more tolerant species for acid soils where liming is not economical or practical.

Conduct economic analyses to determine the marginal returns on investment, cash flow implications and priorities before any significant expenditure is made to introduce new pasture species (refer to Module 1: Setting directions for the appropriate methods).

## What to measure and when

See Tool 2.7 for the methodology required to assess pasture composition. You should check:

- identified plant species and, for each species, its frequency and relative (%) contribution to total pasture mass
- proportion (%) of perennial grass, annual grass legumes, weeds and bare ground in each paddock.

Measurements are best taken early in periods of high growth. Identification of some species is easier once seed heads have formed. Perform all measurements initially and measure annually in pasture zones selected for monitoring.

## Further information

- MLA publications are available from www.mla.com.au/publications or by phoning 1800 023 100:
    - *Towards Sustainable Grazing – The professional producer's guide*
    - *Pasture health kit*
    - *Tips & Tools: Making phalaris-based pastures more productive and persistent*
    - *Tips & Tools: Making perennial ryegrass-based pastures productive and persistent*
    - *Tips & Tools: Maximising production from kikuyu-based pastures*
- The *Livestock production* section of MLA's website also has information relating to grazing and pasture management.

## Commonly used pasture terms

**Annual pasture** – Pasture that only has annual grasses and legumes present. Many annual pastures were never sown to these species, they simply volunteered or invaded.

**Electrical conductivity (EC)** – A measure of the degree of salinity (total salt content) of water or soils. Electrical conductivity increases as salt content increases.

**Evapotranspiration** – The sum of water evaporated from the surface of vegetation (living and dead) and from the soil, and the transpiration of water through plants (pasture and trees).

**Groundcover** – Green, dead and litter material plus dung.

**Improved pasture** – Pasture that has been sown to exotic perennial grasses (eg phalaris, cocksfoot, fescue, perennial ryegrass, kikuyu) in combination with annual or perennial legume (sub clover or white clover).

**Native pasture** – Pastures consisting predominantly of native grass species, but with varying amounts of volunteer annuals. Most native pastures are 'naturalised' in that they contain varying proportions of native perennial grasses and introduced species, and may have been 'top dressed with super and sub' to introduce a legume component.

**Pasture zone** – An area of land that possesses physical characteristics significantly different to adjoining areas. It either presents opportunities, or requires different land use, pasture species or grazing management, to achieve best possible production across total pasture and crop land and throughout seasons.

**Plant-available water capacity (PAWC)** – Defines the amount of soil moisture readily available for uptake by pasture roots. It represents the fraction of soil moisture accessible to the plant within the root zone (not tightly bound to clay molecules). This fraction is the difference between the levels of water held in the soil at field capacity (fully wet) and wilting point (plants are unable to extract sufficient moisture to support growth below this level).

**Water use efficiency (WUE)** – A ratio that measures the efficiency of use of rainfall. Rainfall is lost through run-off, evaporation before use by pasture plants, sideways movement in the soil profile or deep drainage below the root zone. Any of these losses lowers the water use efficiency. Water use efficiency is expressed as the ratio of total growth of pasture (kg DM) over a given period to rainfall received (mm). Only consider water use efficiency as a measure to compare performance within a locality when soil type, rainfall pattern and other factors are similar.

# Mapping pasture zones

**1. Construct a plan that defines grazing land into pasture and cropping zones based on the limits set to determine the best options for establishing and managing pasture for optimum growth, quality and sustainability. The features and options for the various landclasses are shown in the following table adapted from NSW Agriculture.**

Base the initial description of zones on physical properties of the landform and soil type that cannot be altered over time through management.

Further demarcate the zones based on major pasture growth or management limiting factors, such as occasional cropping, that can be changed over time but need to be factored into pasture species and fertiliser decisions. This includes saline affected areas or acid soils with high aluminium content.

Identify zones that are not adjoining but have similar characteristics and group them for farm planning purposes. Their identity should, however, be preserved to assist utilisation practice and analysis to ensure balanced growth, quality and species diversity across pasture based grazing lands.

**Summary of landclasses**

| Landclass (LC) | Key features | Options |
|---|---|---|
| 1–2<br>Arable land suited to intensive (LC 1) and regular (LC 2) cultivation | ■ Arable<br>■ Higher fertility<br>■ Minimal erosion risk<br>■ Non-acid (pH above 5)*<br>■ For pasture and crop production when rainfall is adequate<br>■ High input/high output systems work well | ■ For pasture and crop production when rainfall is adequate<br>■ High input/high output systems work well |
| 3<br>Grazing land suited to cultivation for pasture improvement and/or occasional cropping | ■ Lower to middle slopes<br>■ Semi-arable<br>■ Lower natural fertility • Moderate acidity (pH 4.5–5)<br>■ Moderate erosion risk<br>■ Groundcover and pasture persistence is important<br>■ Maintain pasture base through direct drill options<br>■ Occasional cropping | ■ Groundcover and pasture persistence is important<br>■ Maintain pasture base through direct drill options<br>■ Occasional cropping |
| 4<br>Land suited to grazing but not for cultivation | ■ Middle to upper slopes<br>■ Non-arable<br>■ Low fertility, shallow soils<br>■ Acidic (pH below 4.5)*<br>■ Moderate to high erosion risk<br>■ Only suited to permanent pasture<br>■ Manage to maintain pasture stability and groundcover<br>■ Best suited to lower input management systems<br>■ Generally not suited to introduced perennial grasses | ■ Only suited to permanent pasture<br>■ Manage to maintain pasture stability and ground cover<br>■ Best suited to lower input management systems<br>■ Generally not suited to introduced perennial grasses |
| 5<br>Land suited to lighter grazing only | ■ Steep upper slopes<br>■ Non-arable<br>■ Low fertility, shallow soils<br>■ Acidic (pH below 4.5)*<br>■ Subject to erosion<br>■ Leave natural or revegetate<br>■ Lightly graze to maintain existing pasture/groundcover<br>■ Potential conservation areas | ■ Leave natural or revegetate<br>■ Lightly graze to maintain existing pasture/groundcover<br>■ Potential conservation areas |

*** All pH measured by $CaCl_2$**

## Landclass 1 – very slight to negligible limitations, no special land management practices required

- Onsite impacts of land management practices are minor and may include some effects that can be readily managed such as nutrient depletion.
- Off site impacts of land management are minor.
- Prime agricultural land, capable of a wide variety of agricultural uses that involve regular cultivation.
- Have low slopes (<1%) with no erosion.
- Soils have sufficient clay content to inhibit wind erosion and offer some resistance to soil structure decline even under regular tillage.
- Land is free of rock outcrop and large stones that would restrict farm machinery operations.
- It has good drainage, with sufficient water holding capacity to supply growing crops and pastures.

## Landclass 2 – slight but significant limitations – can be managed by readily available, easily implemented management practices

- Onsite impacts are slight – soil and land condition can deteriorate due to minor water and wind erosion.
- Off site impacts of land management are slight.
- Land is capable of a wide range of uses and management practices – cropping with cultivation, grazing, forestry, vegetables, horticultural production.
- Includes gently sloping land that is capable of a wide range of agricultural uses that involve cultivation.
- Can be subject to sheet, rill and gully erosion as well as wind erosion and soil structure decline.
- Limitations can be controlled by management practices – sowing with minimum disturbance, rotational grazing, maintaining windbreaks and groundcover in areas prone to wind erosion.
- Salinity can be a slight hazard due to deep drainage.
- Acidity can be a slight hazard.

## Landclass 3 – moderate limitations – can be managed by more intensive management practices

- Onsite affects on soil and land condition can be moderate if limitations are not managed.
- Off site impacts of land management practices can be significant if limitations are not managed – salinity, leachate from acid sulphate soils, water erosion, water quality.
- Includes sloping lands (3–10%) that can erode when cultivated if runoff is not controlled.
- Included are lands that can be subject to wind erosion when cultivated and left bare.
- Land is capable of sustaining some cultivation on a rotational basis.
- Productivity will vary with soil fertility.
- Land can be subject to sheet, rill and gully erosion, as well as wind erosion and soil, structure decline.
- Severe soil erosion can be caused by regular cultivation without effective erosion control measures.
- Poor water quality can be caused by water erosion and dust storms may result from wind erosion.
- Wind breaks and ground cover should be retained in areas prone to wind erosion.
- Salinity can be a moderate hazard.
- Acidity can be a moderate hazard – soil acidity levels should be monitored and lime added.

## Landclass 4 – moderate to severe limitations

- On site impacts on soil and land condition can be moderate if limitations not managed.
- Off site impacts of land management practices can be significant if limitations not managed.
- Includes sloping lands (10-25%).
- Land is generally used for grazing and is suitable for pasture improvement.
- Can be cultivated occasionally for sowing of pastures; however, it has cropping limitations because of erosion hazard, weak structure, salinity, acidification, shallowness of soils, stoniness or a combination of these.
- Erosion problems encountered include sheet, rill, gully and wind erosion.
- Ensuring plant growth is adequate to maintain evapotranspiration rates and maintain perennial pastures minimises salinity risk.

## Landclass 5 – severe limitations

- On site impacts on soil and land condition can be severe if not managed.
- Off site impacts of land management practices can be severe if limitations not managed.
- Land only suitable for grazing – with some limitations.
- Includes sloping lands that can be severely eroded by runoff.
- Not capable of supporting cultivation due to a range of limitations including slope, soil erosion, shallowness and stoniness, or other limitations.
- Soil erosion can be severe without adequate erosion control measures.

**Adapted from Land and Soil Capability – How we safely manage the land, Central West Catchment Management Authority, 2008.**

**2. Use the following observations and previous table and descriptions to define changes in landclass and capability. A new zone**

**should be created whenever maximum acceptable limits are exceeded.**

- **Soil texture class in A and B horizons.** Refer to Tool 2.3 for methodology to assess soil texture. Create a new zone when texture changes more than one class, for example from sand to loam.

- **Depth to impermeable layer and/or to subsoil layers** with low soil pH as an indicator of potential rooting depth. Base initial assessments of soil depth on existing knowledge gained from digging post holes or soil pits and the presence of perched water tables. Then assess current pasture species and growth potential to identify shallow soils.
- **Slope** as an indicator of the risk of excess run-off and soil erosion. When available, use contour maps for precise measurement. Initially map out all land that you regard as steep and prone to higher rates of run-off. Look for evidence of soil erosion.
- **Aspect** as a measure of ambient temperature and its impact on grazing patterns, exposure to sunlight and degree of evapotranspiration. Separate north facing slope land from all others. South facing slopes can also have lower pasture production potential especially in combination with steep slopes and shading.
- **Location of streams** and naturally confined watercourse drainage lines.
- **Soil salinity (EC) and acidity (low pH)**. Use the results of the comprehensive soil testing carried out for Procedure 3.
- **Indicators of saline discharge areas and salt affected land** (see Tool 2.4). This enables you to map out areas for reclamation for special stabilisation or reclamation treatment.
- **Cropping or specialty fodders**, such as lucerne, as the primary land use.

**3. Use the mapped results to guide the development of infrastructure and to allow differential management of pasture zones. If the cost of changes to infrastructure is likely to be significant, conduct an economic assessment. Give highest investment priority to the management of identified fragile zones to ensure environmental protection is not compromised. The following are examples of fragile areas with recommended management approaches:**

- **Riparian areas.** Maintain a minimum of five metres of thickly grassed and unfertilised land along stream banks where water flows are likely to enter, and a minimum of 10m where periodic flows are likely.

- **Problem aspects and slopes.** Develop the capacity to differentially manage aspect to avoid overgrazing of warmer north facing slopes, undergrazing of cold south facing slopes, and landclasses 3, 4 and 5 to maintain high levels of ground cover, litter and pasture mass, especially during expected periods of high evapotranspiration, low soil moisture and risk of high intensity rainfall.
- **Factors that limit pasture growth.** Use species that are tolerant of any limiting factors. For example, use salt-tolerant species in saline discharge areas. Use species that tolerate long periods of soil saturation in zones prone to water logging as identified from indicator species and avoid grazing these areas while water logged.
- **Natural features** will affect grazing patterns and mustering ease.

**4. Sources of planning assistance.**

Whole farm planning packages are available from various agencies. Visit state agency websites (see Tool 2.5), or contact your nearest planning office.

- Mapping software is available from agricultural software suppliers (usually as part of farm database packages).
- Aerial photos (scanned if using computer mapping software). Use clear plastic overlays on aerial photos when the cost of mapping software is not justified.
- Commercially available contour maps of local area district (1:25,000 or better).
- Maps and photos are available from state planning and mapping authorities:
  - NSW – Land and Property Information, 1300 052 637, www.lpi.nsw.gov.au
  - Tasmania – Service Tasmania, (03) 6233 2654, www.tasmap.tas.gov.au
  - South Australia – Mapland, (08) 8463 3999, www.environment.sa.gov.au/Do_It_Online/Mapland
  - Western Australia – Landgate, 1300 556 224, www.landgate.wa.gov.au

# Assessing groundcover

Groundcover is the amount of plant material (dead or alive) that covers the soil surface. It is expressed as a percentage; 100% groundcover means that the soil cannot be seen and 0% groundcover is bare soil.

Common scenarios that reduce groundcover include overgrazing, times of drought, cropping, tilling, poor seed establishment, chemical removal and excessive traffic.

Managing groundcover can ensure that soils do not become susceptible to degradation caused by erosion from wind and water.

The tools allow you to assess the current groundcover conditions using a range of different techniques.

### Monitoring groundcover

The following monitoring tools will provide a range of different monitoring techniques. You can decide to use just one of the tools or both, depending on how you prefer to monitor and how much time you have.

**Goal:** To maintain groundcover at a minimum of 70% to prevent soil erosion from wind and water, remembering that groundcover includes living and dead plant material and litter.

# Tool A: Visual assessment

- ### STEP 1: Select areas to monitor

It is important to record the areas monitored, stating specifically where the assessments were taken and, if possible, marking the areas on a farm map. This will allow you to assess groundcover over time.

- ### STEP 2: Decide the time of year when groundcover is at its lowest level

Groundcover is seasonally variable, therefore it is important to take into consideration the times of the year that the monitoring has taken place and, in some cases, it may be advantageous to monitor twice a year. In southern Australia, groundcover is often at its lowest level prior to the autumn break, and this is the best time to assess the risk of soil loss through erosion.

- ### STEP 3: Choosing a representative area

It is important to make sure that the areas being assessed are representative of the entire area. The best way to achieve this is to walk along an imaginary transect line, diagonally across the paddock from post to post (Figure 1), or take 10 steps in one direction then randomly turn and take 10 steps in another direction (Figure 2).

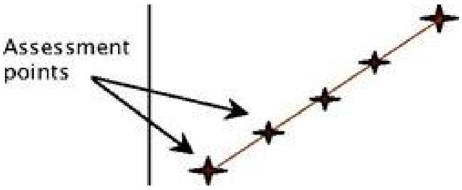



*Figure 1. Transect*

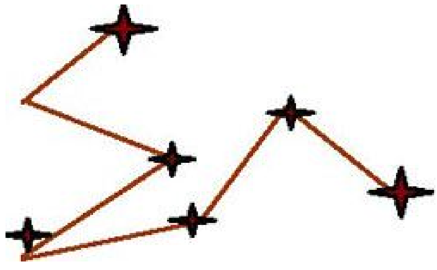


*Figure 2. Zig Zag (random)*

If an area seems quite uniform, 8-10 assessments will give you a good indication of the average groundcover. In areas of high variability, take at least 15 or more assessments (depending on the size of the paddock or area).

Draw your transect roughly on a piece of paper and note approximately where the assessments were taken. Remember to mark on the drawing where North, or the top of the paddock, is to give you a reference point.

- ### STEP 4: Estimate the groundcover

Make a 30 × 30cm quadrat (square) out of sturdy cardboard or wire. A quadrat is used to help focus the eye on a defined area for assessment.

Along the pre-determined transect line (Figure 1 and Figure 2), throw the quadrats out at random and visually assess the groundcover in the quadrant, comparing it with the photo standards. Record the assessments in the pro-forma table provided below.

- **STEP 5: Photographic records**

Photographic records can be used in conjunction with the visual assessment as a permanent reminder of what the pasture cover was like when being assessed. It is important to take the photos in the same spot each time and also to ensure that the photos are taken approximately at the same times of the day.

# Pro forma sheet for recording groundcover assessments

**Open PDF to the pro forma sheet for recording groundcover assessments template**

| **Assessment location** | **Date of assessment** | **Transect type** *(eg line or random)* | **Sample number** *(eg 1, 2, 3)* | **Percentage groundcover** |
|---|---|---|---|---|
| eg Pd 10B | 12/12/11 | line | 1 | 70% |
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# Pro forma sheet for calculating average groundcover assessments

Averaging the measurements in each area monitored will give you an overall % groundcover figure for that area. These can't be compared to other areas of the farm, and priority can be made to the areas of low groundcover % for on-ground works.

Average percentage of all assessments:

- Add up all the percentages taken in the same area and divide that by the number of assessments taken. Then multiply by 100 to give an average percentage of groundcover for that area.

**Example**
Add up the five samples taken in paddock 10B: 70% + 90% + 40% + 70% + 40% = 310%
Then divide the total of the samples by the number of samples taken: 310/5 = 62%

**Open PDF to print below template: Pro-forma sheet for calculating average groundcover assessments**

| Assessment location (Column A) | List samples taken (%) (Column B) | Total of samples taken (%) | No. of samples taken (Column D) | Average percentage of groundcover (%) |
|---|---|---|---|---|
| eg Pd 10B | 70, 90, 40, 70, 40 | 310 | 5 | (C / D) = E<br>310/5 = 62% |
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Minimum levels for pastures in south-eastern Australia are suggested to be:

- 70% for pastures on flat and slightly sloping (<3%) land and on non-erosion prone soils (moderate-good soils generally). Herbage mass should be a minimum of 800–1,200kg dry matter (DM)/ha.
- 80–90% groundcover for lighter, more erosion prone soils and minimum herbage mass should also be 1,000&ndash:1,500kg DM/ha where land is undulating.
- 90–100% groundcover for steep hill country on light and erosion prone soils (eg slopes of greater than 10%, granite or light sedimentary soils with low fertility and often high acidity). Herbage mass should be a minimum of 1,500kg DM/ha.
- In areas such as the Mallee and Western Australia, 50% is often used as the minimum groundcover percentage.

If you have less than the minimum groundcover percentages at the critical time, then your stocking rate is too high for sustainability.

*20% cover* *40% cover*

*50% cover* *80% cover*

*90% cover* *100% cover*

## Tool B: Field assessment - The step point method

- **STEP 1: Select areas to monitor**
- **STEP 2: Decide the time of year when groundcover is at its lowest level**

The first 2 steps of this method are the same as in the visual assessment method.

- **STEP 3: Choosing a representative area**

- Make sure that the areas being assessed are representative of the entire area. For the wire and step point method, it is recommended that you divide the area to be assessed into four line transects (use fences posts or trees to help guide your path along the transect) and sample 25 times at random along the transect.

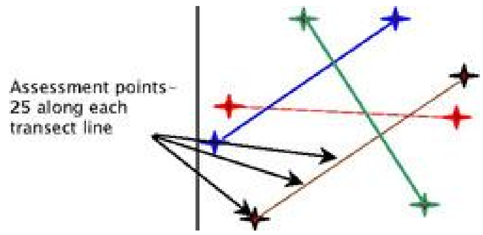



*Figure 3. Transect*

- **STEP 4: Estimate the groundcover**

  Taking the readings:

  - Look straight ahead along your transect line, and take a number of steps along the line (depending on how long the line is to how many steps you can take).
  - Look down and record the presence (yes) or absence (no) of surface cover directly at the toe of your boot on the pro-forma sheet below.
  - After recording the result, repeat steps 1–4 until you have recorded 25 sample points along the transect.

# Example: Pro forma sheet for recording groundcover assessments with the step point method

| | | |
|---|---|---|
| Location: | Old school paddock | |
| Sampling date: | 12/11/11 | |
| Transect | Surface cover | |
| | YES | NO |
| eg 1 | 13 | 12 |
| eg 2 | 15 | 10 |
| Eg. 3 | 14 | 11 |
| Eg. 4 | 11 | 14 |
| TOTAL YES (A) divided by TOTAL SAMPLES TAKEN –<br>Convert to a percentage – | A / (A+B) = D<br>D x 100 = ___% | |
| TOTAL YES divided by TOTAL SAMPLES TAKEN –<br>Convert to a percentage – | 53 / 100 = 0.53<br>0.53 x 100 = 53% | |
| Percentage cover = 53% | | |

# Pro forma sheet for recording groundcover assessments with the step point method

**Open PDF to print the pro forma sheet for recording groundcover assessments with the step point method**

Tool 2.2, Tool B

# The step point method

**Location:**

**Sampling Date:**

| **Transect** | **Surface Cover** | |
|---|---|---|
| | YES (A) | NO (B) |
| | | |
| | | |
| | | |
| | | |
| TOTAL: | | |

FORMULA:

A / (A+B) = C

C X 100 = Percentage cover in %

TOTAL YES divided by TOTAL SAMPLES TAKEN - / ( + ) =

Convert to a percentage - X 100 = %

*Source: Ground Cover Measuring Tool, Victorian Department of Primary Industries (www.dpi.vic.gov.au)*

*Source:* **Ground Cover Measuring Tool,** ***Victorian Department of Primary Industries (www.dpi.vic.gov.au)***

# Assessing soil texture

Below is a brief explanation of the different soil texture classes. The descriptions of the classes and the explanation of terms are based on *Southern Dryland SoilPak* by Nathalie Brown (NSW Agriculture) and Tom Green (CSIRO), compiled for NSW Agriculture.

Following the explanation is a step-by-step outline and flowchart to help you to assess your soil texture.

## Estimating soil texture (simplified texture classes)

### Sand

- Coherence of the soil ball is nil to slight.
- Single sand grains stick to your fingers.
- Minimal ribbon development when extruded between fingers and thumb.
- Clay content less than 10%.

### Sandy loam

- Soil ball coherent but very sandy.
- The sand in these soils cannot be seen with the naked eye but can be felt when rubbed between the fingers. A scratchy noise may be heard when the ball is manipulated between the fingers.
- Soil will form a ribbon 15–25mm long when rubbed between fingers and thumb.
- Clay content 10–20%.

### Loam

- Soil ball coherent and often spongy. May have a ‘greasy’ feeling if significant organic matter is present.
- Soil will form a ribbon 25–40mm long.
- Clay content 25–30%.

### Clay loam

- Soil ball strongly coherent and plastic. Feels smooth.
- Soil will form a ribbon 40–50mm long.
- Clay content 30–35%.

### Light to medium clay

- Soil ball like plastic. Slight-to-moderate resistance to shearing between the forefinger and thumb.
- Soil will form a ribbon 50–75mm long.
- Clay content 35–45%.

### Medium to heavy clay

- Smooth soil ball that handles like plasticine and can be moulded into rods without breaking.
- Soil has moderate-to-firm resistance to shearing.
- Soil can be rubbed between fingers and thumb to produce a ribbon 75mm long or more.
- Clay content greater than 45%.

## Explanation of terms used

**Coherence:** The ball of soil holds together tightly.

**Sandy:** Feels gritty and you can see coarser grains. Very fine sand grains (too small to see and feels a bit like silt) make a grating sound as you rub between your fingers.

**Spongy:** High organic matter content creates a spongy feel that is typical of loams.

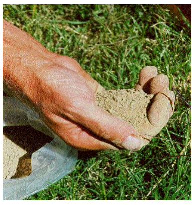
**Silky:** The smooth, soapy, slippery feel of silt.

**Plastic:** The ball can be deformed and it holds its new shape strongly. Typical of clays.

**Resistance to shearing:** How firm the soil feels as you form a ribbon (place the ball between your thumb and forefinger and squeeze, sliding your thumb across the soil). The firmness is a good way to distinguish light, medium and heavy clays. A light clay soil is easier to shear; a medium clay is stiff; a heavy clay is very stiff and it usually takes two hands to form a ribbon.

## How to texture your soil

1. Take a sample of soil that has been crumbled and crushed, sufficient to fit comfortably in the palm of your hand.



2. Moisten the soil with water, a little at a time. Knead the soil until it forms a ball 3.0–4.5cm in diameter, or about golf ball size. Knead it until the ball just fails to stick to your fingers, adding more water if needed. The ball of soil should not be saturated (water dripping out) or too dry (still a bit dusty, lumpy and hardly wet at all).

3. Continue kneading and moistening, if necessary, until there is no apparent change in the feel of the ball; this usually takes 1–2 minutes, but may take longer with clays.

4. Assess the soil for coherence (the way the ball holds together) by squeezing the moist ball in your hand. Knead the ball for a further minute.

5. Assess the feel as you knead it. Rub the soil between the end of your thumb and forefinger to detect grains of sand.

6. Press the soil between your thumb and the side of your forefinger and squeeze it to make a thin, continuous ribbon about 2mm thick until it breaks of its own accord.

7. Measure the length of the ribbon. Repeat this ribboning test a few times to obtain an average length of the ribbon.

8. Try to roll it into a rod 8–10 mm thick. If it makes a long rod, see if the rod can form a ring without cracking.

### The flowchart method

Follow the flowchart by manipulating the soil and answering each question 'yes' or 'no'.

**Tool 2.3**

## Methodology for assessing soil texture

| Number | Question/Heading | Answers |
|---|---|---|
| 1 | Does the soil form a coherent ball? | ▪ Yes, Easily<br>▪ Yes, but only with great care |

- No

| | | |
|---|---|---|
| 2 | What happens when the ball is pressed between thumb and forefingers? | ▪ The ball flattens<br>▪ The ball collapses |
| 3 | **SAND** | |
| 4 | Can the ball be rolled into a thick cylinder? | ▪ Yes<br>▪ No |
| 5 | **LOAMY SAND** | |
| 6 | Can the ball be rolled into a thick thread? | ▪ Yes<br>▪ No |
| 7 | **SANDY LOAM** | |
| 8 | Can the thread be formed into a horseshoe without cracking? | ▪ Yes<br>▪ No |
| 9 | Can the thread be moulded round a curved surface, e.g: side of the hand? | ▪ Yes<br>▪ No |
| 10 | What is the general feel of the soil? | ▪ Rough and gritty<br>▪ Silky |
| 11 | Can a ring about 2.5cm diameter be formed by joining two ends of the thread without cracking? | ▪ Yes<br>▪ No |
| 12 | **LOAM** | |
| 13 | **SILT LOAM** or (rarely) **SILT** | |
| 14 | Mould back into a ball and attempt to polish the surface with the thumb - what is the general feel of the soil? | ▪ A smooth surface with a few irregularities is formed<br>▪ The surface takes a high polish but a few gritty particles stand out<br>▪ The surface takes on a high polish |
| 15 | What is the general feel of the soil? | ▪ Very gritty<br>▪ Moderately gritty<br>▪ Doughy |
| 16 | **CLAY LOAM** | |
| 17 | **CLAY or SILTY CLAY** (this distinction based subjectively on stickiness) | |
| 18 | **SANDY CLAY** | |
| 19 | **SANDY LOAM** | |
| 20 | **SILTY CLAY LOAM** | |

21 **CLAY LOAM**

Access flowchart as pdf here.

***Source:*** **Assessing the texture of your soil*****, Naomi Catchment Management Authority, NSW***

# Visually identifying soils

Use the following indicators to identify problem soils. Soil testing may need to be carried out to confirm the source of the problem.

- Patchy growth areas of pastures
- Loss of productive pasture species
- Trees dying for no apparent reason
- Waterlogging and permanently wet areas
- Bare patches that increase in size and are prone to erosion
- Evidence of salt accumulation on the surface of bare patches
- Indicator species including rushes, sea barley grass, couch grass, strawberry clover and annual beard grass
- Regional and perched water tables.

**Indicators of saline land**

| Salinity rating | Indicator species | Other indicators |
|---|---|---|
| Low | ▪ No limitation to desirable species<br>▪ Even growth of pastures | ▪ Even growth of pastures |
| Moderate | ▪ Wimmera ryegrass (*Lolium rigidum*)<br>▪ Water buttons (*Cotula coronopifolia*)<br>▪ Windmill grass (*Chloris truncate*)<br>▪ Wallaby grass (*Danthonia eriantha*)<br>▪ Spiny rush (*Juncus acutus*)<br>▪ Sea barley grass (*Hordeum marinum*)<br>▪ Couch grass (*Cynodon dactylon*)<br>▪ Reduced growth in areas<br>▪ Clovers, capeweed disappear<br>▪ Grasses are pale from low nitrogen due to lack of clover and salt effects<br>▪ Generally no bare areas | ▪ Reduced growth in areas<br>▪ Clovers, capeweed disappear<br>▪ Grasses are pale from low nitrogen due to lack of clover and salt effects<br>▪ Generally no bare areas |
| High | ▪ Sea barley grass<br>▪ Couch grass<br>▪ Windmill grass<br>▪ Spiny rush<br>▪ Creeping brookweed (*Samolus repens*)<br>▪ Ice plant (*Mesembryanthemum crystallinum*)<br>▪ Australian salt grass (*Distichlis distichiphylla*)<br>▪ Annual beard grass (*Polypogon monspeliensis*)<br>▪ White crystals may appear on the bare soil when the soil is dry<br>▪ Animals graze and lick salty areas<br>▪ Water in dams and drains may become very clear<br>▪ Water table shallow (<1m)<br>▪ Clay soils may have appearance of being well structured | ▪ White crystals may appear on the bare soil when the soil is dry<br>▪ Animals graze and lick salty areas<br>▪ Water in dams and drains may become very clear<br>▪ Water table shallow (<1m)<br>▪ Clay soils may have appearance of being well structured |
| Extreme | ▪ Samphire (*Halosarcia pergranulata*)<br>▪ Sea blite (*Suaeda australis*)<br>▪ Trees will be dying<br>▪ Areas of bare ground<br>▪ Sheet and gully erosion | ▪ Areas of bare ground<br>▪ Sheet and gully erosion<br>▪ Water table at or close to the soil surface |

| | | |
|---|---|---|
| | ▪ Water table at or close to the soil surface | |

***Source: Making More from Sheep, www.makingmorefromsheep.com.au***

## Further information

- Salinity in Australia factsheet, CSIRO: http://www.csiro.au/resources/Salinity-Factsheet.html
- National Dryland Salinity Program: http://www.ndsp.gov.au/
- Saltland Genie: http://www.saltlandgenie.org.au/
- Department of Agriculture and Food (Western Australia)
    - Salinity in Western Australia: http://www.agric.wa.gov.au/PC_92418.html
- NSW Trade & Investment
    - Salinity: http://www.dpi.nsw.gov.au/agriculture/resources/soils/salinity
- Department of Primary Industries, Victoria
    - Salinity Management: http://vro.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/lwm_salinity_management,
    - Salinity: http://www.dpi.vic.gov.au/agriculture/farming-management/soil-water/salinity
- Primary Industries and Regions, SA
    - Salinity: http://www.pir.sa.gov.au/pirsa/more/factsheets/salinity

# Rainfall patterns

Rainfall is the key driver of pasture growth and the major factor behind variation in pasture growth rates between locations. A sound knowledge of the normal seasonal trends and the extent of year to year variability within seasons or months is essential to designing a pasture mix across grazed land that will optimise the seasonal growth and quality of pasture. Until tools become available to allow producers to better analyse historical trends in plant available water, the best indicator to use is still monthly rainfall patterns.

Producers are advised to look for either raw data, such as locally based historical rainfall records, or professionally developed data software such as Rainman™. Local sources include:

- on property records, if they go back at least 30 years
- records from neighbours (most are very willing to share such information)
- records from nearest meteorological station (eg www.bom.gov.au/climate/data/)
- records periodically published in local newspapers.

Once you have a complete set of records, calculate both average monthly rainfall and plot on a graph. Perform a more complex analysis if you have access to a computer spreadsheet program.

As an alternative, producers may consider obtaining a copy of Rainman. This provides historical data from 3,800 locations around Australia and will analyse chosen data sets to produce seasonal monthly and daily patterns in rainfall. Other features include information on stream flows and seasonal forecasts based on the *El Nino* phenomenon. Rainman is available on a CD-ROM which can be obtained from Queensland Primary Industries and Fisheries 07 4688 1200, or online from http://www.dpi.qld.gov.au/26_15734.htm.or http://www.bookshop.qld.gov.au/

## Using the information on rainfall

Look for patterns in seasonal or monthly distribution that provide guidance to the optimisation of pasture growth.

- Determine the normal start and end of your main growing season. Remembering that temperature is also an important factor. You might discount summer rainfall due to the higher evapotranspiration rates. Winter rainfall may not produce much growth but does fill the soil profile for pasture growth in spring. Excessive winter rainfall may result in waterlogging of some areas.
- Use MLA's Rainfall to Pasture Growth Outlook tool ( www.mla.com.au), which presents the actual rainfall and indices of soil moisture and pasture growth for the past nine months and an outlook for the next three months for over 3,300 locations across southern Australia. This tool enables you to factor this information in your enterprise planning. Because the tool covers such a diverse range of soil and pasture types across southern Australia, it provides an index of potential pasture growth, not a prediction of actual growth.
- Use knowledge of your growing season to assess likely feed supply and quality. Use MLA's Feed Demand Calculator ( www.mla.com.au) to help determine your feed supply and demand chart for your farm. Use this information to determine the most appropriate herd structure and stocking rates (see Module 3: Pasture utilisation).
- Look for out-of-season weather that may present unique opportunities – eg growing specialty fodder, such as lucerne or chicory, to take advantage of deeper soil moisture reserves from summer storms.

Examine the extent of variation from normal patterns. Monthly averages may disguise high variability that needs to be taken into account in feed supply budgeting. It can also be important in deciding when to perform certain pasture operations such as re-seeding and fodder conservation.

# Measuring water use efficiency

## Measuring water use efficiency

Water use efficiency (WUE) is not easily calculated for grazing systems where the ‘growing season’ is hard to define. Calculating water use efficiency at the paddock level is, however, a valuable objective measure of current pasture performance. The following is a guide to using the information to determine priorities for fertiliser applications and pasture species manipulation.

- Define the start date for your ‘year’. This should ideally include all of the normal reliable growth periods for a year. As an example, in areas where late autumn to spring rainfall predominates (or is the most reliable), choose a start date that occurs before the normal autumn break. In northern summer rainfall areas, a date in winter may be more appropriate.
- Take pasture mass readings (kg DM/ha) at the start and end of the defined year.

Calculate the pasture consumed (kg DM/ha) for the defined year from grazing records that estimate total intake by grazing animals. This is calculated from paddock records that include the length of each graze in days (Gl); the number of animals grazing in the herd (No); and the average predicted daily intake per animal (Di). Pasture consumed at each graze is calculated as:

$$(Gl \times No \times Di)$$

Pasture consumed at each graze is then added up through the defined year to estimate total consumption for the year. If pasture growth rates are not known for the farm, refer to Tool 3.3, ‘Daily pasture growth estimates for localities and regions across southern Australia’ in Module 3: Pasture utilisation as a guide to mid-monthly estimates of pasture growth rates (kg DM/ha/day) in average seasonal conditions.

- You need to know the rainfall recorded for the period.
- Pasture growth = pasture mass at end of grazing + consumption + decay – pasture mass at start of grazing.
- WUE = pasture growth (kg DM/ha) divided by rainfall (mm) = kg DM/ha/mm of rain.
- Pasture and allowance information are collected from grazing records as part of Module 3: Pasture utilisation.

## Guidelines for the use of WUE

Water use efficiency should be used as an individual farm benchmark only. Recent research has shown that indices based on rainfall are poorly correlated to pasture growth and should not be used for comparison between regions or across a region. Recommended use in this module includes:

- As a guide, temperate improved pastures may have a maximum potential water use efficiency of 18kg DM/ha/mm of rain and native pastures a potential of 10kg DM/ha/mm of rain. These maximums have been assessed under experimental conditions and it is likely that they overestimate what is achievable in commercial field practice.
- Latest research suggests that 15kg DM/ha/mm of rain is a more reasonable target for water use efficiency with temperate improved pastures when all nutrient and species limiting factors have been corrected.
- The length of growing season, as measured by plant available water capacity (PAWC), is a major determinant of variation in pasture growth. As variability in plant available water capacity increases it is likely that potential water use efficiency will decrease due to the inability to manipulate stock intake in line with fluctuations in pasture growth rates and the need to store ‘dry standing feed’.

## Suggested methodology

1. Classify pasture zones (identified in Procedure 1) into levels of potential pasture production once all limiting factors responsive to management have been corrected.

    - High potential pasture zones are those where there are no physical limitations to growth, for example deep clay loams on moderate to level slopes, with no limiting factors such as soil chemistry (salinity or acidity), proximity to riparian zones and aspect.
    - Low potential zones are those where significant physical and soil limitations exist, or have been identified for use for pasture production at significantly less than their natural potential because of management constraints, for example areas identified for native pasture conservation.
    - Most properties will also have one or more intermediate zones between these extremes due to variability of physical and soil properties across the property.

2. Assess water use efficiency in paddocks where current pasture performance is judged to be closest to the potential level of performance for each representative class. Water use efficiency in these paddocks become the current internal benchmarks for performance.
3. Assess water use efficiency in all other paddocks and compare the assessment against the appropriate internal benchmark.
4. Use the assessments to determine priorities for fertiliser applications and pasture manipulation as described in Procedure 3 and Procedure 4 of this module.
5. Raise internal benchmarks for water use efficiency as paddocks are improved to a performance level above the current internal benchmark.

6. Initially (and then every three years) compare internal benchmarks against suggested targets developed in recent research. If the gap is large, there may be a case for accelerated investment to raise water use efficiency and pasture performance across the property. Analysis should include assessment of the variability of plant available water capacity at this site and the relevance of stated targets to this property. Analysis can be complex and advice should be sought.
7. If water use efficiency is outside the desired level, consider fertiliser application or pasture species manipulation to boost the amount of rainfall (water) that is converted into pasture growth.

# Field based pasture measurements

## Pasture mass

Pasture mass can either be assessed by cutting, drying and weighing representative pasture samples or by the use of tools of varying levels of sophistication.

Pasture assessment tools save much time in collection and are considered to be the only practical method for use when day-to-day assessments are being made. Three broad groups of tools are used to measure pasture mass:

- Pasture rulers or ‘sticks’ that measure pasture height are simple, cheap and easy to use. Heights are easily converted to an estimate of kg green DM/ha via lookup tables.


*Figure 1: The MLA Pasture Ruler - order your copy* ***here*** *for free*

**Also have a look at these handy Tips & Tools to understand how to get most out of the Pasture Ruler.**

- Pasture density also needs to be estimated and used as a correction factor when growing or mature pasture is less than 100% of groundcover. See methodology for assessing groundcover and pasture composition below which can be used to estimate the percentage density of pasture.
- The measurements also give a guide to the mass of dry standing feed, but usually underestimate the reading. PROGRAZE® notes describe a method to adjust.
- With experience, you can use the height assessment method to gain reasonably accurate estimates of mass, especially when periodically checked against assessments made by cutting and weighing.

- Rising plate meters measure total pasture mass, green and dry standing feed, and are based on a plate that rises up a probe depending on the amount of compressed pasture material between the plate and ground.

  - Sophisticated models are available that will collect and store field measurements to average readings across a paddock or a number of paddocks
  - They are available from a number of commercial outlets and price generally depends on the degree of automation of collection.
  - Generally slightly cheaper than electronic probes and may be preferable when frequent automated assessment of pastures with significant levels of non-green pasture is needed.

- Electronic pasture probes measure dry matter of green material only.

  - They are quick, easy to use and usually fully automated, including the capacity to directly download readings into office computers.
  - Some also allow collection of user defined and read assessments such as groundcover or phenology.
  - Their accuracy declines if there is any free moisture present in the pasture (eg after rain or heavy dews).

These are normally the most expensive of the three groups.

Satellite imaging is currently under experimental assessment to measure the growth and amount of pastures across southern Australia. See the Pastures from Space website www.pasturesfromspace.csiro.au for more information

Numerous commercially available meters and probes can be found on the internet (search for "pasture + meter"). Most rural supply firms will also help locate commercially available models.

### Measuring pasture height using the ruler/stick method

Use a 1cm thick dowel about 30cm in length. Draw a mark 0.5cm from the bottom, then every 1cm along the stick. Readings between 0.5cm and 1.5cm will be recorded as 1cm, readings between 1.5cm and 2.5cm as 2cm etc. Measure the height from at least 50 sites chosen at random as you cross the paddock. The best way is to throw the stick as you walk across the paddock.

To measure the pasture, place the stick vertically on the soil surface at the point where the base of the stick landed. Slide your thumb down the stick until you touch a green leaf and note the cm. Record on the record sheet.

## Pasture height record sheet

**Open PDF to print the pasture height record sheet**

| **Paddock Name:** | | | |
|---|---|---|---|
| | | | |
| **cm (A)** | **Place a tick in the appropriate row** | **No. measurements (B)** | **A x B** |
| 0 | | | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | | | |
| 19 | | | |
| 20+ | | | |
| | Total number of measures and pasture heights (C) | | |
| | Total height of pastures (D) | | |
| | Average pasture height = D/C | | |
| | Average pasture mass kgDM/ha | | |

Approximate relationship between pasture height and kg DM/ha

| Height (cm) | Lightly grazed 50% green | Moderately grazed 100% 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 | 1700 | 2300 |
| 8 | 1450 | 1900 | 2600 |
| 9 | 1600 | 2000 | 2800 |
| 10 | 1700 | 2200 | 3000 |

***Source: PROGRAZE Victoria manual, 2009***

## Example of completed pasture height record sheet

| **Paddock Name:** Far Back | | | |
|---|---|---|---|
| | | | |
| **cm (A)** | **Place a tick in the appropriate row** | **No. measurements (B)** | **A x B** |
| 0 | üüü | 3 | 0 |
| 1 | üüüüü üüü | 8 | 8 |
| 2 | üüüüüüüüüüü | 11 | 22 |
| 3 | üüüüü | 5 | 15 |
| 4 | üüüüüüüüüüüüü | 13 | 52 |
| 5 | üüüüüüü | 7 | 35 |
| 6 | | 0 | 0 |
| 7 | üü | 2 | 14 |
| 8 | ü | 1 | 8 |
| 9 | | | |
| 10 | | | |
| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | | | |
| 19 | | | |

| | | | |
|---|---|---|---|
| 20+ | | | |
| | Total number of measures and pasture heights (C) | 50 | |
| | Total height of pastures (D) | | 154 |
| | Average pasture height = D/C | | 154/50 = 3.08 |
| | Average pasture mass kgDM/ha | | 1000 kgDM/ha |

### Groundcover

Groundcover includes existing pasture, weeds and other herbage, as well as litter. To estimate groundcover, stand in a representative part of the pasture with your feet half a metre apart. Picture a half metre square in front of you and, looking vertically into the pasture, estimate the percentage area covered by plant matter and litter. Walk over the paddock and repeat the assessment at about 30 random sites. Record and average the results to accurately determine the percentage of groundcover. See Tool 2.2 for detailed information.

## Pasture composition

There are a number of methods for measuring pasture composition. The one you choose is likely to depend on the amount of area you wish to sample and the time you have available to complete the assessments.

Outlined below are:

- PROGRAZE stick method
- Transect method
- Motorbike method
- Quadrat method
- Blundstone method.

These have been taken from *Towards Sustainable Grazing – Weed Removers, Pasture Improvers* workshop notes.

### PROGRAZE stick method

You can use the same stick you used to assess pasture height. Drive a nail into the top of the dowel stick to allow it to measure both height and composition.

1. Select transect across paddock
2. Throw the stick
3. Use the recording sheet provided to note the plant species touching the head of the nail
4. Walk a number of steps
5. Repeat the above until the paddock has been traversed
6. Calculate the percentage of hits for each species/groupings.

### Transect method

Similar to PROGRAZE stick method, but without the stick.

1. Set and permanently mark a transect (eg paint fence posts on either side of paddock)
2. Walk the transect stopping every x steps (x is determined by the length of the transect but should be sufficient to enable up to 50 points to be sampled)
3. At each point, record the species touching the toe of your right boot
4. Continue the process until sufficient observations have been made
5. Calculate the percentage of hits for each species/groupings.

### Motorbike method

For an experienced person with a trained eye, this is a rapid method of assessment that is particularly good for large paddocks.

1. Ride the paddock in a uniform manner – corner to corner is a good suggestion
2. Every 100m (on the odometer) or count of 20–30 seconds stop the bike and record the species that is at the toe of your boot
3. Continue until 50 points have been recorded
4. Calculate your composition.

### Assessment sheet for the PROGRAZE Stike Transect and Motorbike methods

**Open PDF to print below: Assessment sheet for the PROGRAZE Stike Transect and Motorbike methods.pdf**

**Assessment sheet for the PROGRAZE Stick, Transect and Motorbike methods**

Date: ____________ Assessor: ________________ Paddock Name/No.: ________________ Method used: ❑ PROGRAZE ❑ Stick ❑ Transect ❑ Bike

| Sample Number | Legume | Desirable grass | Weed grass | Broadleaf weed | Litter | Bare ground |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |
| 13 | | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |
| 17 | | | | | | |
| 18 | | | | | | |
| 19 | | | | | | |
| 20 | | | | | | |
| 21 | | | | | | |
| 22 | | | | | | |
| 23 | | | | | | |
| 24 | | | | | | |
| 25 | | | | | | |
| 26 | | | | | | |

| Sample Number | Legume | Desirable grass | Weed grass | Broadleaf weed | Litter | Bare ground |
|---|---|---|---|---|---|---|
| 27 | | | | | | |
| 28 | | | | | | |
| 29 | | | | | | |
| 30 | | | | | | |
| 31 | | | | | | |
| 32 | | | | | | |
| 33 | | | | | | |
| 34 | | | | | | |
| 35 | | | | | | |
| 36 | | | | | | |
| 37 | | | | | | |
| 38 | | | | | | |
| 39 | | | | | | |
| 40 | | | | | | |
| 41 | | | | | | |
| 42 | | | | | | |
| 43 | | | | | | |
| 44 | | | | | | |
| 45 | | | | | | |
| 46 | | | | | | |
| 47 | | | | | | |
| 48 | | | | | | |
| 49 | | | | | | |
| 50 | | | | | | |
| Totals | | | | | | |
| % Composition* | | | | | | |

## Quadrat method

A quadrat is a means of defining a small sample area that can be assessed.

1. Place quadrat on the ground
2. Stand vertically above (helicopter view) the quadrat and estimate the proportion of the quadrat area occupied by each class of species
3. Record the proportions on the worksheet
4. Repeat the process until sufficient sites have been sampled
5. Calculate the average cover for each species.

## 'Blundstone' method

1. Stand in the paddock with your feet about half a metre apart
2. Visualise a square 0.5 × 0.5m in front of your toes
3. Estimate the proportion of this square that each plant type occupies
4. Take at least five random estimates from five different parts of the paddock for a reliable guide to your pasture’s composition
5. Record your results on the worksheet.

## Assessment sheet for Quadrat and Blundstone methods

**Open PDF to print below: Assessment sheet for Quadrat and Blundstone methods.pdf**

**Assessment sheet for Quadrat and 'Blundstone methods**

**Paddock Name/Number:** ______________________________ **Date:** ________________

| % Cover estimate | Random sample number | | | | | | | | | | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| % Legume | | | | | | | | | | | |
| % Desirable grass | | | | | | | | | | | |
| % Broadleaf weed | | | | | | | | | | | |
| % Grass weed | | | | | | | | | | | |
| % Litter | | | | | | | | | | | |
| % Bare ground | | | | | | | | | | | |
| | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Paddock Name/Number:** ______________________________ **Date:** ________________

| % Cover estimate | Random sample number | | | | | | | | | | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| % Legume | | | | | | | | | | | |
| % Desirable grass | | | | | | | | | | | |
| % Broadleaf weed | | | | | | | | | | | |
| % Grass weed | | | | | | | | | | | |
| % Litter | | | | | | | | | | | |
| % Bare ground | | | | | | | | | | | |
| | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

# Guidelines to composition measurements

## Pasture composition – for optimum production

- Legume component in pastures as companion to introduced grass species – minimum of 20%, maximum of 30%, unless paddock is to be used specifically for high animal production (growth rates) when a higher maximum legume content may be desirable (up to 40%). Take precautions to avoid bloat in cattle when legume content is towards maximum limits.
- Legume content in native pastures – maximum of 20%.
- Productive and perennial grasses – minimum of 60%, maximum of 80%.
- Annual grass and broadleaf weeds – maximum of 10%.
- Bare ground – maximum of 10%.
- Noxious weeds – maximum of 0%.

## Pasture composition – number and proportion of desirable perennial grass species

The most appropriate number and relative proportion of desirable perennial grass species within the total perennial grass component of a pasture will vary with the genetic capacity for growth and quality of each species and the objectives set for that pasture zone. The limits stated in the following table are a guide only:

- High input grass based pastures – maximum limit of two desirable grass species (difficulty of grazing management increases with number of species), with combined minimum composition of 90% of total grass component of pasture mix.
- General purpose pasture zones (native, introduced or a mix) – minimum of two desirable grass species with the dominant species a maximum of 60% of total desirable grass component.
- Special purpose pastures – limits will be defined by purpose (eg one species, such as tetraploid ryegrass, may be used in a short-term high performance pasture).

## Pasture phenology

Assessment of phenology is made for target species and involves the examination of individual tillers from perennial grass clumps to count the number of new leaves on each tiller. The number of leaves is a good indicator of the start of senescence (dying) of the oldest leaf on each tiller. Generally the ideal number lies between three and four tillers; however, the number of leaves varies from species to species. *Figure 1* indicates the correlation between levels of water soluble carbohydrates and leaf number for perennial ryegrass.

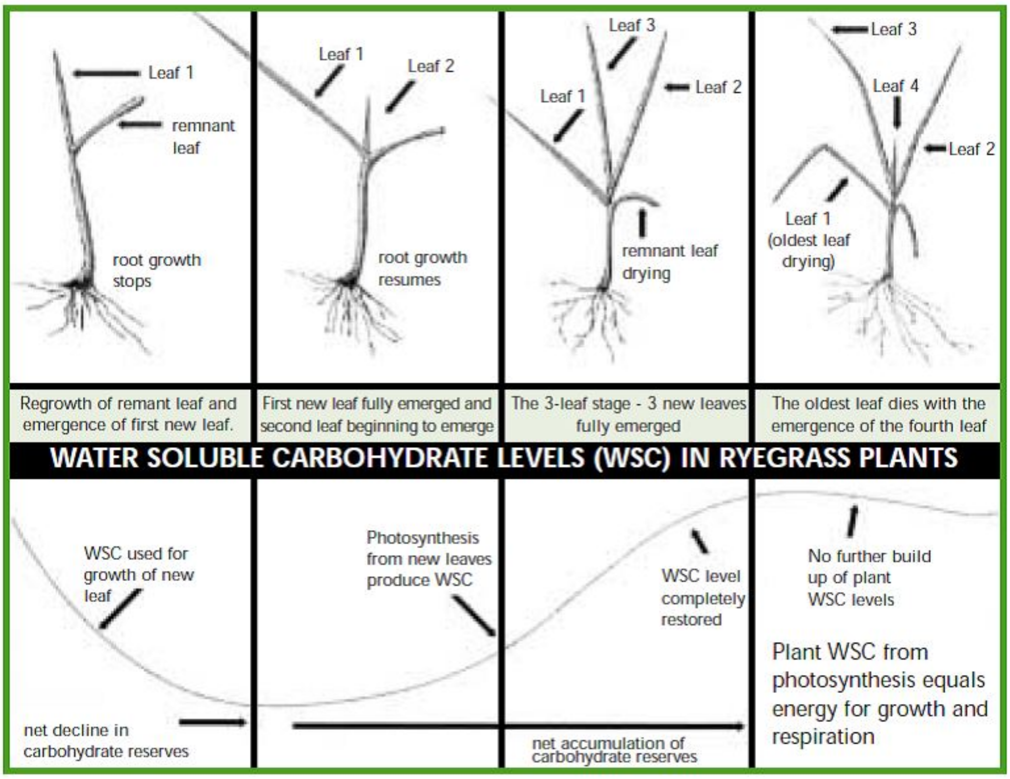



***Figure 1: Regrowth of a perennial grass tiller***

Module 3 Pasture utilisation contains information on the number of active growing leaves for different species, plant based grazing management methods and guidelines for monthly growth rates across the regions of southern Australia.

It is important that you can estimate pasture growth rates for your own property to better fine tune the management of your pastures.

To estimate pasture growth rate of a paddock under rotational grazing;

1. Estimate herbage mass kg DM/ha as stock leave the paddock **(A)**
2. Estimate herbage mass kg DM/ha at a point in the future (eg 30 days after stock left paddock) **(B)**
3. Record number days between readings (eg 30 days) **(days)**

Calculation is: (B – A) / days = _____kg DM/ha/day

Example: Pasture height 1,200kg DM/ha when cattle left paddock. 30 days later pasture was estimated at 1,900kg DM/ha, therefore (1,900 – 1,200)/30 = 23kg DM/ha/day.

If stock are in a paddock and you need to estimate growth rate you can use the following method as described in the Pasture Management Checklist for Northern Rivers of NSW.

1. Calculate the average stocking rate (DSE/ha) for the period between the two estimates of herbage mass **(SR)**
2. Calculate the number of days in that period **(T)**
3. Estimate the herbage mass (kgDM/ha) at the start of the period **(HM1)**
4. Estimate the herbage mass (kgDM/ha) at the end of the period **(HM2)**

Calculation is: (SR xT) + (HM2 – HM1) / T = _____kgDM/ha/day

Example: 24 head of 300kg steers growing at 1kg LW/day. Steers at this weight and growth rate have a DSE rating of 10. They are grazing an area of 20ha. Therefore the average stocking arte for this area is (24 x 10)/20 = 12DSE/ha.

It has been 60 days between herbage estimates. The first herbage estimate was 1,300kg DM/ha. The second herbage estimate was 1,500kg DM/ha

So: (12 × 60) + (1500 – 1300) / 60 = 15kg DM/ha/day

## Rate of run-off or surface ponding

The run-off rate is estimated by taking a full nine-litre plastic garden watering 'can' and, with the sprinkler top in place, steadily pouring the water evenly over a representative one metre square soil surface (soil and plant material). Finish pouring after 60 seconds. Any run-off or ponding existing at the end of this period is evidence of poor infiltration rates but will depend on the current moisture content of the soil.

## Pasture quality

Assessment of pasture quality (energy content) normally requires full laboratory analysis. Field observations provide a useful guide to energy content in MJ ME/kg DM. Actively growing green material is normally in the range of 11.0–12.0MJ ME/kg DM. Actively growing legumes normally have slightly higher energy content (+ 0.5MJ ME/kg DM) than perennial grass. Therefore pasture that is 100% green, has legume and perennial grass composition within the limits of 20–30% legume and 60–70% grass and the oldest leaf of the dominant grass has not started to senesce, can be assumed to have energy content greater than 11.5 MJ ME/kg DM. Figure 2 below gives a guide to energy decline as temperate pastures mature.

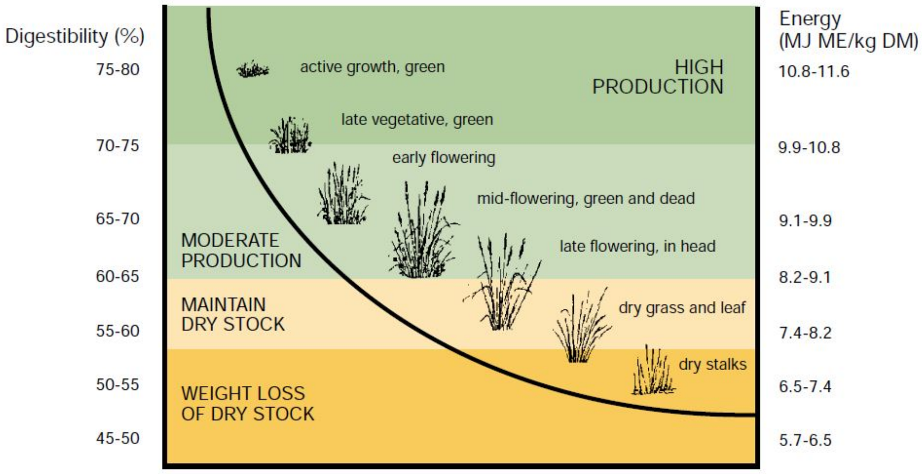



***Figure 2: A guide to digestibility decline as temperate pastures mature***

**Source: NSW PROGRAZE Manual, NSW Agriculture**

# Soil nutrient critical limits

*Acknowledgement: Tables of the minimum and maximum limits for pasture nutrients provided by Cameron Gourley, DPI, Ellinbank, Victoria.*

## Extractable soil phosphorus

The following tables provide minimum and maximum limits for pastures that have been improved by the introduction of exotic perennial grasses. Raising P levels in native grasslands to above the levels described below may increase the risk of loss of species, such as danthonia.

Recent research has demonstrated that it is increasingly difficult on soils with a moderate phosphorus buffering index to retain native perennial grasses once phosphorus levels exceeded 20 Colwell P. At this point legumes and annual grasses started to replace native grass species. Grazing management, involving pasture rest at critical times, can lessen the rate of loss.

Producers wishing to optimise pasture productivity while retaining native grass species should seek advice from agronomists to establish grazing management strategies and minimum and maximum P limits for their region and soils.

**Table 1: Using Olsen and Bray extraction methods**

| | Olsen P (mg P/kg) | Bray P (mg P/kg) |
|---|---|---|
| Minimum P limit | 15 | 15 |
| Maximum P limit | 25 | 25 |

**Note that soil type (texture) has no impact on limits when using Olsen or Bray test procedures.**

**Table 2: Using Colwell extraction – Colwell P in mg/kg**

| PBI* range | 0–50 | 50–100 | 100–200 | 200–300 | 300–600 | > 600 |
|---|---|---|---|---|---|---|
| Minimum P limit | 10 | 20 | 30 | 40 | 60 | 60 |
| Maximum P limit | 20 | 30 | 40 | 60 | 90 | 120 |

*** PBI = phosphorus buffering index**

Phosphorus Buffering Index (PBI) typically increases with soil texture as it moves from sands through to heavy clays. National Association of Testing Authorities (NATA) accredited laboratories now routinely include a Phosphorus Buffering Index with all analysis reports.

P is a relatively immobile nutrient once it has entered the soil, usually remaining within a few centimetres of where it was applied. Losses of P by fixation and leaching depend on soil type and rainfall and are generally greater as rainfall increases. Well fertilised pastures are generally protected from P loss associated with soil erosion as they retain high levels of ground cover throughout the year.

## Extractable sulfur

KCL40 test

- Minimum limit – 6 mg/kg
- Maximum limit – 16 mg/kg

**Table 3: Extractable potassium**

| | Colwell K or Skene K (mg/kg) | | | Exchangeable K (meq/100g) | | |
|---|---|---|---|---|---|---|
| Soil texture | Light | Moderate | Heavy | Light | Moderate | Heavy |
| Minimum limit | 80.00 | 100.00 | 120.00 | 0.20 | 0.25 | 0.30 |
| Maximum limit | 200.00 | 250.00 | 300.00 | 0.50 | 0.60 | 0.70 |

## Organic carbon

Table 4: Organic carbon percentages (%) over a range of conditions

| Organic carbon levels | Pastures – low rainfall | Pastures – high rainfall |
|---|---|---|
| Low | < 1.9 | < 3.1 |
| Normal | 1.9–2.8 | 3.1–6.2 |
| High | > 2.8 | > 6.2 |

## Cation exchange capacity

Table 5: Cation exchange capacity (M NH4Ac, units – cmol(+)/100g or meq/100g)

| Texture | Light | Moderate | Heavy |
|---|---|---|---|
| Minimum limit | 6 | 8 | 10 |
| Maximum limit | 16 | 24 | 34 |

## Soil pH

The following two tables supply limits for soil pH (soil acidity) and aluminium concentrations for commonly introduced pasture species. Each species achieves optimum productivity and stability between the maximum and minimum limits. All will grow outside these limits, but productivity and persistence will be less than its potential.

Native species such as danthonia and microlaena are not included in the tables as they are rarely sown and limits are not as well defined. It is known that microlaena is able to tolerate soils with low pH. Danthonia, on the other hand, has many subspecies that vary in their most preferred range.

Most plants and micro-organisms have defined ranges of pH for optimal growth. The optimal range for plants is generally between 5.5 and 8.0 (pH in $CaCl_2$) whereas most soil organisms function best between pH 6.0 and 7.0.

Table 6: Soil pH

| | Soil pH (water) | | Soil pH ($CaCl_2$) | |
|---|---|---|---|---|
| **Plant species** | **Minimum** | **Maximum** | **Minimum** | **Maximum** |
| White clover | 5.3 | 6.5 | 4.5 | 6.5 |
| Sub clover | 5.3 | 7.0 | 4.5 | 6.5 |
| Perennial ryegrass | 5.0 | 6.5 | 4.3 | 6.5 |
| Annual ryegrass | 5.0 | 6.5 | 4.3 | 6.5 |
| Phalaris | 6.0 | 8.0 | 5.0 | 6.5 |
| Cocksfoot | 5.0 | 7.5 | 4.2 | 6.5 |
| Lucerne | 6.0 | 7.5 | 5.3 | 7.0 |

## Exchangeable aluminium

Table 7: Exchangeable aluminium

| | 0.01 M $CaCl_2$ | | 1.0 M KCl | |
|---|---|---|---|---|
| Plant species | Minimum | Maximum | Minimum | Maximum |
| 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 |

Native species vary in their sensitivity to soil acidity and exchangeable aluminium.

**Table 8: Salinity and sodicity**

| | **Electrical conductivity ($EC_{se}$)** | | **Exchangeable sodium (%)** | |
|---|---|---|---|---|
| **Plant species** | **Minimum** | **Maximum** | **Minimum** | **Maximum** |
| White clover | 0 | 2.6 | 0 | 15 |
| Sub clover | 0 | 2.6 | 0 | 15 |
| Perennial ryegrass | 0 | 4.0 | 0 | 30 |
| Annual ryegrass | 0 | 4.0 | 0 | 30 |
| Phalaris | 0 | 4.2 | 0 | 30 |
| Cocksfoot | 0 | 4.0 | 0 | 20 |
| Lucerne | 0 | 4.0 | 0 | 40 |

# Pasture nutrient applications

## Application descriptions

- **Capital applications** of fertiliser are aimed at lifting soil nutrient levels to target levels determined by the manager. They involve making one or more fertiliser applications over and above the level required for replenishing nutrients lost through export off the farm or paddock in agricultural products. Capital applications are designed to increase yearly pasture growth and quality. Typical fertilisers involved include phosphorus (P), potassium (K) and lime. Sulfur (S) is usually supplied to varying levels with P.

- **Maintenance applications** of fertiliser are aimed at replacing the amounts of key nutrients either tied up in the soil or exported off the farm or paddock through agricultural production practices and products (eg meat, wool, grain, hay and silage where the nutrients are not replaced). Maintenance applications are designed to maintain existing patterns of pasture growth and quality. Maintenance applications usually involve P, K and S.

# Guidelines for making capital applications

1. Expenditure on capital applications must be regarded as investments of financial capital.

   a) There is a negative return on investment unless increased pasture growth is converted to increased profit.

   b) Conversion to profit can only come from increased margins ($/kg sold) or increased volume of turn-off (kg sold /animal, kg sold/ha or kg run/ha if agisting).

   c) The higher the marginal return per unit increase in turn-off or stocking rate the higher the return from capital applications.

   d) Co-investments such as purchase of stock, improved pasture species, water and fencing to improve utilisation may need to be made to maximise returns.

2. Ensure that targets set for minimum nutrient levels are appropriate for each pasture zone, as well as your financial base.

   a) Environmentally fragile zones, for example zones with steep slopes or zones adjacent to riparian areas with high risk of sideways movement of P and N, may not be suitable for capital applications of fertiliser.

   b) Similarly, raising P levels in stable native pastures may disturb pasture stability while failing to give optimum return on investment through the absence of highly responsive species such as clover.

3. Timing is vital.

   a) There is evidence that achieving targets over a number of years is just as effective in lifting soil nutrient levels as a one off application.

   b) All P applications should be made in periods when soil is unlikely to be waterlogged (eg mid-spring to mid-autumn in winter rainfall regions). P is rapidly fixed and becomes unavailable to the plant when soil moisture reaches saturation levels.

   c) Sulfur-based fertilisers can contain both elemental S and sulfate S. Elemental sulfur is not plant available and is only slowly converted by microbial action to water soluble and readily plant available sulfate S. Apply before the end of summer to gain benefit in autumn if S content is largely in the elemental form.

4. All limiting factors should be corrected where economic responses are indicated.

   a) P should come before lime except where indicated below.

      i) P is a major driver of pasture quantity and is also associated with quality.

      ii) The amount needed to increase P by one unit varies with soil type. Heavier textured soils usually require more P than lighter, sandier soils.

      iii) As a rule of thumb, 6–13kg P/ha will increase Olsen P by 1 unit or Colwell P by 3 units depending on the soil’s phosphate buffering index.

   b) Sulfur is normally applied in fertilisers with a mix of P and S in varying proportions.

      i) When P and S are both low, use blends with 1:1 ratios (P/S).

      ii) When P is low and S is within limits, use 2:1 blends.

iii) When P is within limits (or above target) and S is low use sulfur fortified products for capital S while supplying maintenance levels of P.

iv) Base final choice of product within the above guidelines on cost of P or S applied. High analysis fertilisers can be cost competitive after allowing for transport, handling and spreading costs.

c) Liming is indicated when the percentage of aluminium is above maximum or when pH is below minimum for the existing and/or desired species.

i) Note that phalaris is sensitive in its establishment phase. Most cultivars cope with slightly raised aluminium or low pH when established.

ii) Speed of response to liming is normally inversely proportional to soil cation exchange capacity (CEC), ie quickest responses occur in soils with low CEC.

iii) It should also be noted that liming to raise pH has a beneficial effect on soil health through increased biological activity of soil organisms.

**Phoshporus (P) and potassium (K) soil factors (kg/ha) for capital applications based on Phosphorus Buffer index (PBI)**

| PBI value | P required to raise Olsen P by one unit | P required to raise Colwell P by one unit | K required to raise Colwell K by one unit |
|---|---|---|---|
| 0–50 | 6 | 2.2 | 1 |
| 51–100 | 8 | 2.3 | 1 |
| 101–300 | 9 | 2.5 | 1 |
| 301–400 | 10 | 2.8 | 2 |
| 401–500 | 11 | 3.0 | 2 |
| 501–600 | 13 | 3.2 | 2 |
| >601 | 15 | 3.2 | 2 |

Source: Accounting for Nutrients www.accounting4nutrients.com.au

**Sulfur soil factors (kg/ha) for capital applications**

| | Sulfur required to raise soil test (KCl 40 test) by one unit | | | |
|---|---|---|---|---|
| Soil test level | 0–4 | 4–9 | 9–13 | Above 13 |
| Sulfur (kg/ha/year) | 30 | 15 | 7 | 1 |

Source: Accounting for Nutrients www.accounting4nutrients.com.au

## Guidelines for maintenance applications

1. To determine the amount of phosphorus (P), potassium (K) and sulfur (S) to be applied annually as a maintenance dressing.

a) A rough rule of thumb is to base the amount of P required on the phosphorus buffering index (PBI) of the soil. PBI is related normally to soil texture (clay content).

i) When PBI is low (0–100), apply 0.8kg P/DSE.

ii) When PBI is moderate (100–300), apply 1.0kg P/DSE.

iii) When PBI is high (> 300), apply 1.2kg P/DSE.

b) Alternatively, base application rate on rainfall, applying 1kg P/ha for every 25mm annual rainfall (eg if annual rainfall is 700mm, apply 28kg P/ha annually).

c) Alternatively use the following tables which take into account current fertility levels and your soil type (based on PBI)

**Olsen phosphorus (P) soil factors (kg/ha) for maintenance nutrient applications based on Phosphorus Buffer index (PBI)**

| PBI value | Current Olsen P level (mg/kg) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2–4 | 5–7 | 8–10 | 11–13 | 14–17 | 18–25 | 26–35+ |
| 0–50 | 0 | 3 | 6 | 8 | 9 | 10 | 10 |
| 50–100 | 0 | 5 | 10 | 15 | 18 | 20 | 20 |
| 100–200 | 0 | 6 | 13 | 20 | 23 | 25 | 25 |
| 200–400 | 0 | 7 | 15 | 22 | 26 | 28 | 28 |
| 400–600 | 0 | 8 | 16 | 24 | 28 | 30 | 30 |
| > 600 | 0 | 10 | 18 | 26 | 31 | 35 | 35 |

**Source: Healthy Grazing Pastures Manual, Victorian Department of Primary Industries**

**Colwell phosphorus (P) soil factors (kg/ha) for maintenance nutrient applications based on Phosphorus Buffer index (PBI)**

| PBI value | Current Colwell P level (mg/kg) | | | | | | |
|---|---|---|---|---|---|---|---|
| | ≤ 20 | 20–34 | 35–59 | 60–79 | 80–94 | 95–114 | ≥ 115 |
| 0–50 | 1.2 | 4.0 | 7.0 | 9.0 | 10.0 | 10.0 | 10.0 |
| 51–100 | 2.3 | 7.0 | 12.0 | 17.5 | 20.0 | 20.0 | 20.0 |
| 101–300 | 3.0 | 8.0 | 14.5 | 19.5 | 22.0 | 22.5 | 22.5 |
| 301–400 | 3.0 | 8.0 | 14.5 | 19.5 | 22.0 | 22.5 | 22.5 |
| 401–500 | 3.5 | 10.0 | 19.5 | 27.0 | 29.0 | 30.0 | 30.0 |
| 501–600 | 3.5 | 11.0 | 20.0 | 28.5 | 31.0 | 32.0 | 33.0 |
| > 600 | 3.5 | 22.0 | 29.5 | 32.0 | 31.0 | 34.0 | 35.0 |

**Source: Accounting for Nutrients www.accounting4nutrients.com.au**

**Potassium (K) and sulfur (S) soil factors (kg/ha) for maintenance nutrient applications based on Phosphorus Buffer Index (PBI)**

| PBI value | Soil factor K | Soil factor S |
|---|---|---|
| 0–50 | 25 | 12 |
| 51–100 | 20 | 12 |
| 101–300 | 15 | 12 |
| 301–400 | 15 | 12 |
| 401–500 | 10 | 12 |
| 501–600 | 10 | 12 |
| > 600 | 10 | 12 |

**Source: Accounting for Nutrients www.accounting4nutrients.com.au**

d) Choose a P–S fertiliser blend consistent with the guidelines established for capital applications and unit cost of P.

2. Molybdenum should be applied as an additive to P-based fertilisers:

a) When soil pH is less than 5.5CaCl2 or tissue testing indicates levels are lower than critical limits.

b) Whenever legumes are reseeded and/or when poor nodulation and rhizobia activity is suspected.

c) At least once every 4–5 years when applying maintenance P on low pH soils.

Seek advice on suitable rates for your region, but rates used are generally in the range of 50–100 g/ha.

3. Consider maintenance applications of phosphorus, potassium and sulfur in paddocks regularly cut for forage conservation. The table below indicates typical extraction rates for P, K and S in kg/t fresh weight (FW) of hay or silage. For example, if you cut and remove 10t of lucerne hay per hectare from a paddock, you will need to apply 20kg of P, 240kg of K and 26kg of S to maintain existing nutrient levels on each hectare cut. Note the large amount of K removed. Producers who frequently cut forage from the same paddock should consult an agronomist or other adviser to determine the best method of maintaining K levels. Also be aware that nutrient composition, especially minerals, can vary considerably (in some instances more than two-fold).

**Typical extraction rates for phosphorus (P), potassium (K) and sulfur (S) in kilograms per tonne of fresh weight (kg/t FW) hay or silage**

| Type of fodder | Moisture (%) | Mean P conc. (kg/t FW) | Mean K conc. (kg/t FW) | Mean S conc. (kg/t FW) |
|---|---|---|---|---|
| Legume hay (clover, medic) | 89 | 1.7 | 18 | 1.6 |
| Lucerne hay | 87 | 2.0 | 24 | 2.6 |
| Legume–grass hay | 88 | 2.0 | 18 | 1.7 |
| Oaten hay | 90 | 1.6 | 17 | 1.1 |
| Pasture hay | 88 | 1.8 | 15 | 1.6 |
| Grass silage | 44 | 2.8 | 24 | 2.2 |
| Maize silage | 62 | 1.9 | 15 | 1.0 |
| Pasture silage | 48 | 2.8 | 26 | 2.3 |
| Oaten silage | 45 | 2.5 | 23 | 1.8 |

An alternative approach is to have hay or silage tested for P, K and S as well as N and MJ ME/kg DM (M/D).

4. Nitrogen (N) is found mainly in the soil organic matter fraction and as protein in plants and soil organisms. The N present in the soil occurs in two major forms:

- organic N found in the soil organic matter and soil biota (organic N is not available to plants); and
- mineral N found in soil as either ammonium ($NH_4^+$) or nitrate ($NO_3^-$).

Only 2–3% of soil N is in the mineral form and hence available to plants. Organic N is converted to mineral N (mineralisation) during the breakdown of soil organic matter by soil microbes. Nitrogen is reconverted from mineral to organic forms (immobilisation) when it is taken up in plant growth.

The amounts of N removed by sale of livestock products are modest but plants require large amounts of N for growth. Nitrogen application may be considered to boost pasture growth in some grazing situations but can be lost through rapid evaporation if application is not immediately followed by precipitation sufficient to dissolve the N into the plant root zone. A partial budget analysis is recommended when considering an application of nitrogen to assess the benefits against the costs.

## Guidelines for lime applications

Lime can be applied as a top dressing if a paddock is to remain in the pasture phase for several years.

Most pastures on very acidic soils (less than pH 4.2(CaCl2)) will respond to surface applied lime over a period of time. Pastures on soils with very high levels of aluminium or manganese will also respond.

When surface-applying lime; a maximum rate of 5t/ha is recommended to avoid smothering the plants and to avoid possible animal health problems.

### Calculating your lime requirement:

Target pH($CaCl_2$) – soil test pH($CaCl_2$) )/conversion factor = t/ha lime required

Conversion factors

- 0.26 for clay
- 0.37 for clay loam
- 0.47 for sandy clay loam
- 0.57 for sandy loam.

If you soil test shows organic matter level is above 2%, add an extra 0.4t/ha.

For example, your soil is a clay loam with a soil test pH($CaCl_2$) result was 4.5 and your target level is pH($CaCl_2$) 5.0. Your organic matter level in your soil is 3%.

### How much lime should you apply?

(5.0 – 4.5)/0.37 = 1.35 t/ha lime, but with a higher organic matter level.

1.35 t/ha lime + 0.4 t/ha lime = 1.75 t/ha lime

Note: the lime rates calculated assume a pure limestone product.

If the neutralising value of the lime is not 100%, then:

Lime to spread (t/ha) = (lime required (t/ha) x 100)/ neutralising value.

*Source: Healthy Grazing Pastures manual, Victorian Department of Primary Industries*

## Guidelines for taking a soil test

### How to take soil tests properly

It is important to collect soil samples correctly to ensure a meaningful test result:

1. **Representative samples** – Establish monitor areas or transects that represent each of the major classes of land (land management units) across the farm. The objective is to adequately represent the differing areas of the farm that are to be fertilised whilst ensuring a reasonable soil testing load and expense. Using a soil corer, sample in the monitor area or along the transect in a systematic way and record the sampling interval and pattern used so that the sampling pattern can be replicated at later times. To ensure samples reflect the paddock as a whole, avoid stock camps, fence lines, water troughs, fertiliser dumps, burnt timber rows, wet gullies, gateways, tracks or dung patches and sample from different soil types separately.
2. **Mark the site** – Keep a record of the monitor area or transect for future testing. You may do this by noting where you started and finished and the route taken, by taking a series of GPS readings, etc.
3. **Depth** – Extractable P is measured in topsoil samples using a soil sample depth of 10cm. P is typically more concentrated in the top few centimetres of soil so it is very important to obtain the full volume of soil to 10cm depth to avoid biasing the concentration of P in the soil sample.
4. **Sample number and handling** – Take a minimum of 30 soil cores along the transect or monitor area and combine to give a sample that is representative of the paddock. Send the sample to the testing laboratory promptly. Use a NATA or ASPAC-accredited laboratory to take advantage of the quality control that this accreditation represents.
5. **Timing** – Always sample at the same time every year. It is potentially feasible to take annual samples at any time of the year, but soil samples are most commonly taken in late spring. At this time soil is usually moist, but not wet, allowing soil cores to be taken quickly and easily. Moist soil holds together in the corer and this helps to ensure the sample is the full 10cm depth. Never sample within the first few months after fertiliser application.

***Source: 5 easy steps to ensure you are making money from superphosphate booklet.***

# Soil testing laboratories

A list of National Association of Testing Authorities (NATA) accredited laboratories in Australia – part of the Australasian Soil and Plant Analysis Council (ASPAC) proficiency testing program.

Producers looking to use NATA-accredited laboratories can access the website www.nata.com.au and follow the steps below.

- On entry, go to ‘Facilities & Labs’, then to ‘Facilities List by Field’, then to ‘Chemical Testing’, then to ‘Soils’ and finally 'agricultural'.
- This will open a page that provides a list of laboratories with services performed, addresses and contact details.

The limits described in Tool 2.8 apply to tests performed by accredited laboratories using procedures as defined by the ASPAC proficiency testing program. Please check the accreditation status of your normal soil testing providers.

## Grazing management tactics

| Grazing management tactics to increase, maintain or decrease individual species in a pasture | | |
|---|---|---|
| **Pasture type** | **Increase or maintain** | **Decrease or remove** |
| Temperate native grasses | ■ Use strategic, tactical or rotational grazing<br>■ Maintain groundcover at 70% in high rainfall zones or 40% in semi-arid areas<br>■ Allow flowering and seed set of desirable grasses<br>■ Avoid use of legumes and high rates of phosphorus and sulfur | ■ Continuously graze even at low and moderate stocking rates<br>■ Overgraze, especially in dry conditions<br>■ Regularly burn pastures<br>■ Allow shrub and weed invasion<br><br>Note: Many states and catchments restrict native pasture management interventions (see Procedure 5.3 signposts in the Protect Your Farm's Natural Assets module of *Making More from Sheep*). |
| Subtropical grasses | ■ Allow flowering and set seed once a year<br>■ Rotationally graze and supplement stock when green herbage mass is low<br>■ Control growth of temperate species (eg clover, barley grass, ryegrass) in early spring<br>■ Control growth of competitive, summer growing annual grasses<br>■ Provide adequate nitrogen<br>■ Do not overgraze when dry or nitrogen is low<br>■ Maintain groundcover | ■ Reduce fertiliser and nitrogen inputs<br>■ Graze heavily during flowering<br>■ Graze rhodes grass to ground level<br><br>Note: Purple pigeon, rhodes grass and green panic are susceptible to overgrazing when dry and nitrogen is low. |
| Phalaris | ■ Increase phosphorus applications<br>■ In northern environments with more summer rainfall, rest in spring–summer, remove excess trash late in summer, then rest until 3–4 weeks after autumn break<br>■ In southern environments, rest over autumn–winter to allow more tillering of the existing plants<br>■ Graze after the plants reach 4 leaves/tiller | ■ Allow soil fertility to decline<br>■ Graze heavily during spring–summer or repeatedly cut to not allow to run to head.<br>■ Graze heavily any new green shoots in summer and autumn, but monitor stock for any signs of phalaris poisoning such as phalaris staggers and sudden death syndrome |
| Cocksfoot | ■ Graze to maintain above 1,000–1,500kg DM/ha<br>■ Apply high rates of phosphorus fertiliser<br>■ Avoid continuous grazing of green shoots during summer and autumn | ■ To avoid cocksfoot dominance, graze all summer growth including individual tussocks down to 10cm tall at the autumn break<br>■ Graze heavily during autumn to physically pull plants from the ground<br>■ Graze hard down to 2.5cm or less during late spring or summer<br>■ Allow soil fertility to decline |
| Perennial ryegrass | ■ Rotationally graze during summer, ideally after plants reach 3 leaves/tiller | ■ Allow soil fertility to decline<br>■ Do not allow to run to head<br>■ Graze continuously and heavily during summer |
| Tall fescue | ■ Graze frequently (every 14–21 days) for short periods (2–3 days) during periods of active | ■ Continuously graze in hot dry conditions<br>■ Graze heavily during dry summers or early |

| | | |
|---|---|---|
| | growth, once the plants reaches 4 leaves/tiller<br>■ Do not graze until 3 weeks of good active growth or 12–15cm of grass growth<br>■ Set stock or rotationally graze from autumn to spring to maintain 1,000–2,500kg DM/ha (or 5–15cm) of pasture | autumn |
| Subterranean clover | ■ Avoid grazing until seedlings have 3–5 true leaves, usually 3–6 weeks after the autumn break<br>■ Keep groundcover and weeds below 1,000kg DM/ha during summer–early autumn<br>■ Maintain a sward height of 5cm or less until flowering<br>■ Increase phosphorus applications | ■ Maintain groundcover above 1,000kg DM/ha<br>■ Do not control earth mites<br>■ Cut hay or graze heavily during seedset<br>■ Apply herbicides during flowering<br>■ Allow soil fertility to decline, including molybdenum and boron |
| White clover | ■ Keep groundcover and weeds low at break and graze continuously to keep the grasses short<br>■ Over winter and early spring, graze pasture to 750kg DM/ha (or 3cm)<br>■ Heavily rotationally graze in spring to control grasses, maintaining pasture between 1,000–3,000kg DM/ha (or 10–25cm)<br>■ Increase phosphorus applications | ■ Graze heavily during flowering<br>■ Graze to less than 1,200kg DM/ha while under moisture stress during summer<br>■ Allow soil fertility to decline, including molybdenum and boron |
| Lucerne | ■ Allow to achieve well in excess of 10% flowering prior to grazing. This must be achieved at least once per year, preferably in the autumn<br>■ Rotationally graze for most areas<br>■ In summer, 2 weeks rotational grazing and 5 weeks rest<br>■ In winter, 2 weeks rotational grazing and 7–8 weeks rest | ■ Increase phosphorus applications<br>■ Set stock paddocks at heavy stocking rates<br>■ Allow soil fertility to decline, including molybdenum and boron |
| Grazing cereals | ■ Delay first grazing until plants are well anchored and starting to tiller (6–8 weeks post-emergence)<br>■ For winter types, longer deferment can increase growth and winter feed supply<br>■ High stock density rotational grazing gives the most even utilisation and allows recovery | ■ Heavy grazing during the first 6–8 weeks<br>■ Heavy grazing in spring once the seed heads begin to form<br>■ Late grazing of semi-dwarf types can make any grain harvesting difficult |
| Chicory | ■ If sown as a specialist finishing pasture, rotational grazing is essential; a 4-paddock system works well<br>■ Aim to maintain height at 5–40cm<br>■ In late summer, allow stands to develop stems and set seed if regeneration is required<br>■ If sown as a component of a mixed pasture, rotational grazing is essential for persistence, but it is likely to decline anyway | ■ Easily removed by set stocking<br>■ Plants very susceptible to overgrazing and trampling when dormant (ie in winter)<br>■ More erect varieties (eg grouse) have higher crowns and are more susceptible to overgrazing |
| Brassicas | ■ Most brassicas are grown to maturity and | Not applicable |

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| | grazed only once so strip grazing is needed to minimise trampling losses<br>▪ Some forage Brassica hybrids are suited to multiple grazing – strip grazing minimises trampling losses and allows more rapid recovery | |

**Source: Making More from Sheep, published by MLA.**